Final Report

Analysis, Comparison, and Contrast of Two Primary Maintenance Contracting Techniques used by the Florida Department of Transportation

FDOT Contract No. BDV34 977-04

Submitted to:

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SI (MODERN METRIC) CONVERSION FACTORS (from FHWA)

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		TEMPERATURE (exact degrees)		
ºF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	ºC
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		FORCE and PRESSURE or STRESS		
lbf	pound force	4.45	newtons	N
lbf/in^2	pound force per square inch	6.89	kilopascals	kPa

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	pound force	lbf
kPa	kilopascals	0.145	pound force per square inch	lbf/in^2

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16. Abstract

The Florida Department of Transportation's (FDOT) Asset Maintenance Contracting Program (AMC) was analyzed during this study to determine if it reduced cost or affected work quality when compared with more-traditional contracts. A survey was conducted of experts from industry, FDOT, and other DOTs to get their opinion on the AMC program. Results showed that if a program like Florida's AMC is implemented properly, industry experts believe it can be successful. FDOT data from 2009-2015 were analyzed to determine quantitatively whether or not the AMC program was efficient. Meta-frontier ratios were developed between AM and non-AM contract types using data envelopment analysis (DEA). Results showed that AMCs consistently performed more efficiently than non-AMCs. Additionally, results showed that AMCs produced slightly significantly higher-quality work than non-AMCs. Subtle (administrative) cost effects were a relatively unimportant variable in the context of overall efficiency. Elimination of quality rating as an evaluative metric did not appear to affect results. In summary, the AMC program appears to be more efficient than more-traditional contracts.

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EXECUTIVE SUMMARY

The Florida Department of Transportation's (FDOT) Asset Maintenance Contracting (AMC) Program was analyzed to determine if it reduced cost or affected work quality when compared to more-traditional contracts. Two metrics were used to evaluate the program – a survey and quantitative analysis. The survey was similar to other surveys in the past that have been used to evaluate other Performance-Based Maintenance Contracting (PBMC) programs. However, unique to this study, private contractors were questioned in addition to state DOT personnel. Results, as determined by Content Analysis and statistical evaluations, showed that if a program like Florida's AMC is implemented properly, people believe it can be successful.

Quantitative analysis consisted of a meta-frontier approach/data envelopment analysis (DEA) of FDOT data from 2009-2015. Group frontiers were computed for both AMC and non-AMC contracts using an input-oriented bootstrapped variable returns to scale (VRS) model. The same model was used to compute overall meta-frontiers. The group frontiers and meta-frontiers were used to compute associated meta-technology ratios (MTRs). While this analysis is similar to a previous analysis used in Virginia to evaluate VDOT's PBMC program, there are subtle differences that make the analysis conducted here more appropriate for Florida such as inclusion of more output variables and the model's input-orientation. Results showed that AMCs consistently produced better results than non-AMCs. Administrative costs were analyzed by adding hypothetical input cost values to non-AMCs. Results again showed that AMCs were more efficient than non-AMCs. Interestingly however, subtle cost effects were relatively minor except for very large added cost values - $10,000,000 per district per year for example. The analysis was rerun a third time to determine the effect of quality rating on efficiency score by eliminating quality as an output so that only physical outputs were measured. Results again showed that the AMCs were consistently more efficient than non-AMCs. Additionally, regardless of the model-specifics, the non-AMCs performed increasingly worse over time. This is due to the fact that as more contracts have become converted to AMCs, the non-AMC dollar value has remained approximately stagnant.

Finally, statistical analysis of quality rating (MRP score) was conducted. Results showed that AMCs produce higher-scoring roadways than non-AMCs. While these differences are slight, they are statistically significant. In conclusion, data shown here appear to show that the AMC program is more efficient than traditional contracting, and the AMC program appears to produce higher-quality output than non-AMCs.

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1 INTRODUCTION

1.1 BACKGROUND STATEMENT

The Florida Department of Transportation (FDOT) has been using Asset Maintenance Contracts (AMCs) since 2000. In general, AMCs are a form of Performance-Based Maintenance Contracting (PBMC). The goal of these performance-based arrangements is to continuously maintain facilities while allowing the contractor (as opposed to the Department) to determine specifically how the maintenance is performed. AMCs are in contrast with "more traditional" contracts which tend to direct contractors or municipalities to perform specific activities via specific scopes of work.

FDOT's AMC program (and more generally PBMCs) has gained popularity in recent years because it tends to shift administrative duties from the Department. Some have argued that this structure yields significant cost savings when compared to traditional contracts.

However data from FDOT's AMC program have yet to be formally evaluated to determine if the AMC actually does yield any cost savings. Equally important, data have yet to be evaluated to determine if work quality is significantly affected when AMC contracts are used.

1.2 PROJECT OBJECTIVES

The objective of the research presented in this report was to determine if the AMC is economically efficient relative to more-traditional contracts without sacrificing quality of work.

1.3 METHODOLOGY

Tasks associated with this research were as follows:

- Task 1 – Information Gathering and Literature Review
- Task 2 – Development of metrics to evaluate FDOT's AMC and WDC programs
- Task 3 – Application of the metrics to FDOT data and experts from industry
- Task 4 – Development of a Draft Final Report
- Task 5 – Development of a Final Report

1.4 REPORT STRUCTURE

1.4.1 Background Information and Literature Review

Chapter 2 presents the results from Task 1. Included are discussions about:

1. Definitions of different contract-types
2. Advantages and disadvantages associated with different contract types
3. Previous domestic examples of PBMCs
4. Previous international examples of PBMCs
5. Meta-frontier analysis
6. Content Analysis (CA)

1.4.2 Evaluation of the FDOT AMC Program

Two approaches were used to evaluate the AMC program:

1. A survey was developed whereby contractors, employees from FDOT, and employees from other state DOTs answered a series of questions about FDOT's AMC and WDC programs. Results were analyzed using CA. Details about the survey are presented in Chapter 3.

2. Meta-frontier analysis was used to quantitatively compare AMCs to non-AM contracts. Details from this analysis are presented in Chapter 4.

3. A brief summary and final recommendations are presented in Chapter 5.

2 LITERATURE REVIEW AND BACKGROUND INFORMATION

As discussed in Chapter 1, the use of PBMCs has increased in recent years. The following is a discussion on:

1. Background associated with traditional contracts and PBMCs
2. Previous PBMC usage both internationally and abroad
3. The Florida AMC program
4. Meta-frontier analysis
5. Content analysis (CA)

2.1 MAINTENANCE DEFINITIONS

Please note – definitions in Section 2.1 refer to global definitions and not necessarily definitions specific to Florida. Florida-specific discussion is included in Section 2.5.

2.1.1 Routine Maintenance

Routine maintenance includes activities that should be performed all year, every year in some form of a cyclical pattern. In the context of roadways, routine maintenance may be further-divided into seasonal work. For example, in the summer vegetation control may be necessary; in the winter, snow maintenance may be required in northern climates. Within the category of "snow control" several activities may be included including plowing, salting, and elevated emergency vehicle response. More broadly, other examples of routine maintenance may include pothole patching, sweeping, cleaning, maintaining guardrails, fence repair, and crack repair (Pakkala 2007).

The scope of required-maintenance contracting will be largely climate-dependent. For example, Virginia – another state that utilizes a form of PBMCs (please see below) – must consider both hot summers and cold winters and road maintenance issues associated with a significant temperature range. In Florida on the other hand, maintenance contracting tends to focus on issues associated with a hot, humid climate (Pakkala 2007).

2.1.2 Periodic Maintenance

Periodic maintenance is less predictable than routine maintenance, and is often more intensive. In the context of roadways, this category includes activities such as resurfacing (although resurfacing is not included in Florida for roadways greater than 1,000 feet), major renovation, or bridge work. Historically, roadway periodic maintenance actives have been contracted individually (Pakkala 2007).

2.2 TRADTIONAL CONTRACTS

Traditional contracts refer to contracts that are completed approximately according to the following algorithm:

1. An agency describes an area where work is required. Agencies are typically an owning entity (such as FDOT), but they can be third-parties.

2. The scope, methods to complete the work, and materials to be used for the work are described by the owner.

3. Contractors are given the opportunity to bid on the project.

4. A winner is awarded based upon the best bid – a combination of cost, maintenance plan, contractor reputation, experience, qualifications, etc. (Please note, in Florida, "best bid" is defined strictly as "low bid).

5. The form of payment depends on the type of contract:

    - Fixed Price: Contractor paid a fixed amount determined before the project begins (called Lump Sum in Florida).

    - Cost plus: Contractor is paid a price per unit of work completed

    - Guaranteed Maximum Price: Contractor paid a price per unit of work completed with the stipulation that the contractor is paid no more than a specified amount (called Budgetary Ceiling in Florida).

2.2.1 Traditional Contracting in Highway Agencies

As mentioned above, examples of maintenance by state agencies may include pothole filling, line painting, resurfacing, trimming vegetation, repairing signage, or litter control. Three common methods are used to address these issues – the work can either be performed in-house, the work may be contracted to a private agency, or the work can be contracted through municipalities (called memoranda of agreement or MOAs in Florida). Usually, any agreements with private agencies are work-directed. Within this work-directed contract (WDC) category, parameters of these agreements may present some variations. In Florida, FDOT splits work-directed contracts into two categories – work document driven contracts and project specific contracts.

2.2.1.1 Work document-driven contracts

In work document driven contracts the contractor is selected based on low bid and the contract describes the focused maintenance activity. As the contract progresses, FDOT issues work documents specifying where and when to do certain activities (Campbell 2009).

2.2.1.2 Project-specific contracts

A project-specific contract is very similar to a work document-driven agreement. The difference between the two contracting methods is that the project-specific agreement explicitly specifies what, when, and where work should be performed in the original agreement (Campbell 2009).

2.2.2 Advantages and Disadvantages of Work Directed Contracting

The heightened level of control associated with work-directed contracting would seem to be an advantage to the government agency – at least preliminarily. However, this high level of control carries with some liability and has the financial risk associated with cost overruns. In particular, this high level of control implies that personnel from the agency must visit roadways regularly to decide when and where work needs to be completed. Furthermore, a high level of control implies that the agency must give the contractor strict scopes and specifications that will require oversight (inspection) throughout the projects. Both these scenarios represent additional human resources that must be devoted to the project by the agency. And these additional human resources could mean an inefficient expenditure of funds (Stankevich 2005).

Beyond potential unnecessary oversight costs associated with human resource allocation, budget philosophy and quality may also be negatively affected when work-directed contracts are used. In a work-directed agreement, the contractor has little, if any, incentive to develop innovative solutions to their project. There is also the "spend it or lose it" mentality towards annual budgets. Due to the structure of the agreement, contractors are incentivized to do exactly as the agency directs as cost effectively as possible. Intuitively, this does not appear to be an issue, but focusing on short term costs and quality as opposed to long term quality and life cycle cost is not good for the Agency in the long run. In addition, the "spend it or lose it" mentality can lead to unnecessary or out of season work being performed, which again, does not positively contribute to long term cost control and quality of an asset (Frost 2001).

2.3 PERFORMANCE-BASED MAINTENANCE CONTRACTS

Conceptually, the purposes of a PBMC are to reduce risk to the government agency and to reduce administrative cost. Whereas a work-directed contract represents step-by-step levels of control, a PBMC is designed such that the contracting agency is only concerned with the end-product. In the context of a highway agency such at the FDOT, this means that the governing variable associated with this contract-type's level of success is the level of service (LOS) provided to the public. LOS – a common parameter used to measure a roadway's effectiveness – includes variables such as pavement quality, vegetation management, order and cleanliness of rest areas, traffic flow, and emergency response.

In a PBMC, the agency will set certain standards for LOS that must be met by the contractor over a specified time-period. Payments are made from the agency to the contractor at an agreed-upon interval (for example, quarterly). An incentive/disincentive structure based upon LOS is used to determine payment amount (in Florida, only disincentives are used). In such an agreement, the contractor is not told what materials or methods to use. Rather, the contractor will use whatever he or she feels is best to maintain the required LOS. As such, the contractor is entitled to independently define what work to performed, where to perform the work, the methods used for the work, and the associated schedule (Radovic et al. 2014).

2.3.1 Advantages and Disadvantages of Performance Based Contracting

Because of the nature of PBMC, there is much greater expenditure certainty. The contractor is typically paid an adjusted lump sum, depending on applicable incentives or disincentives, which allows the road agency enjoys full control of expenditures without unexpected variation orders (Radovic et al. 2014).

The second advantage associated with PBMCs is they may reduce in-house staff, which may in turn increase cost-efficiency. However, this potential advantage comes at a price – staff reduction or layoffs can negatively impact employees. When PBMCs are utilized, it is important to mitigate these potential negative factors (Stankevich 2005).

The third potential advantage, whether perceived or actual, of PBMCs is improved road asset condition and road user satisfaction. As discussed below, much of the literature on the subject claims the condition of the assets improves at some point in the term of a PBMC (Zietlow 2005; Hyman 2009). Other advantages and disadvantages associated with PBMCs are tabulated in Table 2-1:

Table 2-1. Advantages and Disadvantages of Performance Based Contracting

Advantages	Disadvantages
Cost savings	Poor outcome criteria
Fully integrated client services	Longer Tendering
Transferring risks	Reduction in competition
Ability to innovate	Uncertainty in long term
Easier asset management	Loss of control/flexibility
Higher LOS	
Partnering Potential	
Industry development	
Benefit of economy of scales	
Reduced client staffing	
Life cycle costing	
Increase in road user satisfaction	
Less contract administration	
Innovation potential	
Simpler budgeting	

2.3.2 Maximizing Innovation Using PBMCs

Giving contractors the freedom to choose their own methods may incentivize the contractor to employ more sophisticated cost analysis, to try new methods, and to utilize more efficient materials. These effects would all appear to be positive. However, to benefit from these positive factors, typically PBMCs need to be longer-term than traditional contracts (Frost 2001, Zietlow 2005). Most agencies that employ PBMCs are aware of this; therefore, long-term PBMCs are quite common. When PBMCs are of sufficient length, the contractor and the highway agency are able to work together to predict, analyze, and react to potential over or under performance trends. The time available and partnership potential allow the two to explore potential innovations to remedy potential issues or a decline in conditions (Frost 2001).

Additionally, any novel approach carries with it an inherent financial risk. With a short-term contract, it becomes difficult for a contractor to justify assuming this risk. With a longer-term contract however, assuming the risk becomes justifiable because the contractor is able to react and remedy issues resulting from potentially-failed initial trials (Frost 2001). Alternatively, it may be possible with a longer-term contract for the contractor and the agency to partner – thereby more-broadly distributing the risk.

Generally, from a contractor's perspective, a lump-sum PBMC is preferable because they help to minimize financial risk – at least to some extent. From the agency's perspective, the lump-sum technique carries with it some inherent possible quality control issues. Therefore, it is important that the agency pick the contractor based upon best value criteria as opposed to low bid. Using "best value" criteria is even more important when innovation is to be used because a failed innovation with a low bid could lead to default, strain on the relationship, or a lower profit margin for the contractor.

2.4 USE OF PERFORMANCE-BASED CONTRACTING BY HIGHWAY AGENCIES

PBMCs have sparked the attention of many highway agencies throughout the U.S. and the world. Many agencies have attempted to use these contracts, and several of these agencies claim that the contracts are "successful." But, due to the competitive nature of maintenance contracting and a lack of thorough record keeping, there remains little proof of these contracts' success. There are even cases of conflicting results of studies on the same projects.

The information that can be gathered from these past PBMCs is mostly qualitative. Issues that have been previously analyzed qualitatively include contract type and structure, term length, potential for extensions, allocation of risk, reported success by highway agencies, quality incentives/disincentives, and finding a balance in regard to keeping applicable staff motivated and cooperative while implementing the needed changes to workflow and responsibility distribution.

Below, representative examples are given to illustrate the use of performance-based contracts both domestically and internationally. As will be discussed in Section 1.4.3, certain characteristics of the contract tend to lead to success or failure.

2.4.1 International Use of Performance-Based Contracting

Internationally, PBMCs have developed popularity among developing and modern countries. They are being used throughout South America, Africa, and western and eastern Europe. Sweden, Norway, Netherlands, France, Estonia (63% of national roads), Serbia and Montenegro (8% of national roads), South Africa (100% of national roads), Zambia, Chad (17% of all-season roads), and the Philippines are all using PBMCs. The following subsections detail most of the more documented cases (Hyman 2009):

2.4.1.1 Canada

Canadian provinces were among the first to test PBMCs. Many of these pilot contracts were utilized between the later 1980s and 2000s. Most started their programs as attempts to reinvent and/or privatize their governments because of federal pressure to outsource maintenance (Ribreau 2004; Pakkala 2002). Their contract terms usually range from five to ten years although Alberta uses one to three year renewal terms. All of provinces used some form of a best value selection, but some shifted more weight to price than others. All provinces listed (British Columbia, Alberta, and Ontario) are reported to have at least some level of cost savings, but these conclusions were made by judgment and not justified statistically. Overall, most research agrees that the provinces were not affected negatively in terms of cost savings or LOS with these types of contracts. The agencies almost universally claim that the contracts were effective and continue to use them. A discussion of each province follows with a summary table (Table 1-2) at the end of this section.

2.4.1.1.1 British Columbia

British Columbia was the first province to try a PBMC in 1988. This shift was motivated by a shift in the political atmosphere that preferred privatization instead of government control. Existing government employees were offered government employee transfers, retirement, or private sector jobs (Ribreau 2004).

The British Columbian PBMCs initially started with three year terms, moved to five years , and then eight years (5 years + 3 years), (Pakkala 2002). Award criteria were based upon a combination of low-bid and experience/qualifications. During the bid process, low-bid represented 40% of the award criteria while experience/qualifications represented the other 60%. Analysis of cost savings and LOS show some promise, but a study by Stenbeck (2007) claims that costs increased.

2.4.1.1.2 Alberta

Alberta's motivation for exploring PBMCs was to decrease cost without negatively affecting LOS. They began outsourcing their maintenance in 1995. The province is divided into 30 Contract Maintenance Areas (CMAs). Each CMA contained approximately 500 km (approximately 300 miles) of roadways (Pakkala 2002). Using five-year terms, bids were judged based upon target LOS, which included technical criteria, response time, and price. Contractors were limited to working in four CMAs initially, although eventually this limit was increased to seven in 2000. Awards were based 78% on price, and failure to meet agreed-upon LOS criteria led to penalties (Hyman 2009).

2.4.1.1.3 Ontario

Ontario Ministry of Transportation uses Area Management (AM) contracts for approximately 60% of its roads (Skinner 2007). AM terms are three years with two-year extension options. Contractors are allowed to on bid three or four 300-500 km stretches (approximately 200-300 miles) of roadway either as whole or individually. In the early 2000s, the term lengths were changed to five plus three years (Pakkala 2002). The scopes of the contracts included routine maintenance, winter maintenance, and emergency assistance (Hyman 2009). There are several opinions from researchers and Canadian officials claiming preserved LOS and minor cost savings, but quantitative data to support this claim has yet to be published.

Table 2-2. Overview of Canadian Performance-Based Maintenance Contracts

Country/State	Year	Contract Duration	Contract method	Selection Criteria	Cost savings/Proof	LOS/Proof	Overall Success
British Columbia	2003	8 years	Lump Sum	40% price 60% other	Stankevich et al. 2006 and Pakkala 2002 both claim savings up to 10% qualitatively, but Stenbeck 2007 claims cost increase based on regression analysis.	Said to have at least stayed the same(qualitative) (Pakkala 2002).	Government and public seem fine with the change and the government workers have done well, mostly working in the private sector now (Stankevich et al. 2005).
Alberta	2000s	5 years	Unit price	78% price 22% other	Mixed: -qualitatively: reported cost savings from 5-35% (World Bank 2006) (Pakkala 2002) -quantitatively: 28% reduction based on unit price decrease to $3705/km from $5117/km (Bucyk and Lali 2006) Increase based on regression analysis (Stenbeck 2007)	Agency would not disclose	At least as good
Ontario	1996	8 years	Lump sum	90% price 10% other	Qualitative savings reported (Pakkala 2002).	Qualitatively reported increase (Pakkala 2002).	At least as good

2.4.1.2 England

The Highways Agency (HA) of England is the country's state funded department in charge of the major highways. Through the 2000s, the agency began programs to partner with local agencies in an effort to save money and improve the quality of their road network (Pakkala 2002). In the context of maintenance contracting, three models were developed (Figure 2-1).

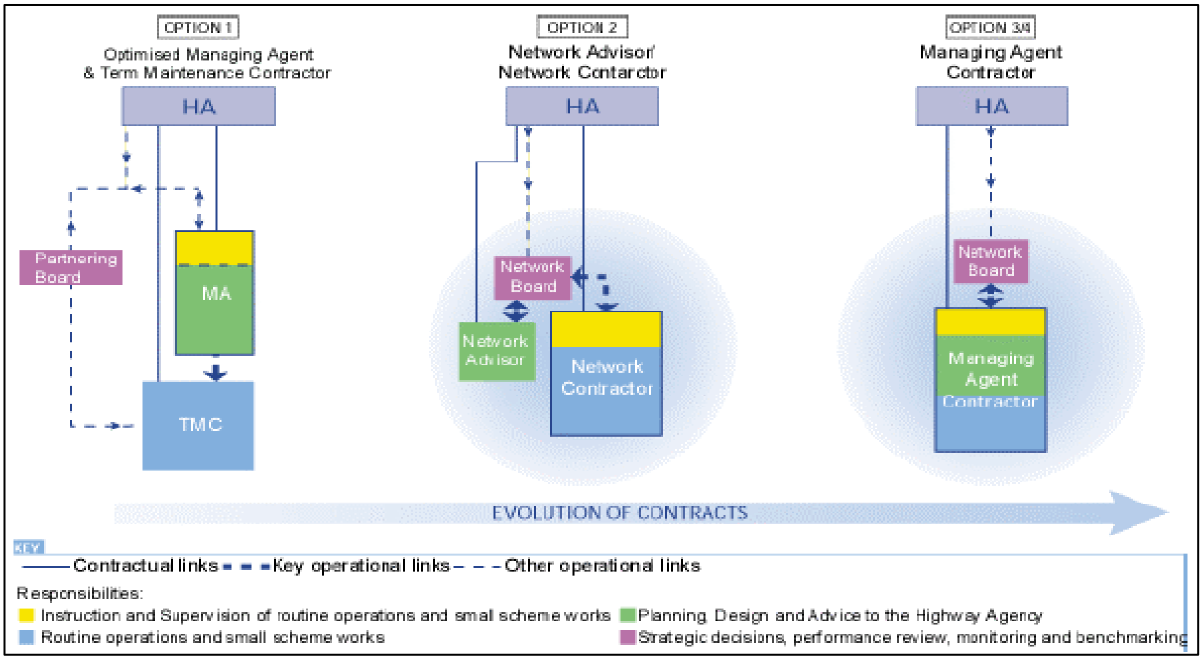


Figure 2-1. England's Maintenance Models (adapted from Pakkala 2002)

For the first model, a managing agent (MA) was selected based upon qualifications. After the MA had been selected, price was negotiated. The MA worked in conjunction with a performing board to set the direction of the work and serve as the project's source of quality control (QC). Work was then delegated from the MA/board to a Term Maintenance Contractor (TMC).

In the second model, as shown, the MA was replaced by a Network Advisor who worked directly below the board and was responsible for day-to-day planning. Meanwhile, QC had been delegated to the network contractor.

The third model shifts responsibilities associated with budgeting, managing, and quality assurance toward the contractor. This third model is the most similar to performance-based contracting because as shown, the board simply sets the strategic direction for the work while the contractor is free to make decisions about the day-to-day operations associated with the contract.

More recently, a new model is under development – Private Finance Managing Agent Contract (PFMAC), which brings in private financing. These contracts are usually used for 15 to 30 year capital projects (as opposed to maintenance contracts). Table 2-3 provides a summary of common contracts in England:

Table 2-3. England's Maintenance Contracts (adapted from Pakkala 2002)

Maintenance Model	Contract Type	Duration	Selection Criteria	Standards
Managing Agent	Unit Price	5 years 3+1+1	80% quality 20% price	Method based
Network Advisor	Unit Price/Lump Sum	5 years 3+1+1	80% quality 20% price	Output Based
MAC	Lump Sum	7 years 5+1+1	80% quality 20% price	Outcome Based
PFMAC	Lump Sum	15-30 years	Negotiated Target	Finance and Outcome based

2.4.1.3 South Pacific

The Australian state of New South Wales conducted a comparative study of PBMCs in 1990. Two maintenance techniques were assigned for 100 km (approximately 60 mile) stretches of roadway. One stretch was maintained by in-house staff while the other was maintained by a private contractor (Stankevich et al. 2005).

Segal et al. (2003) determined that in the first year, the work by the private contractor achieved 16% cost savings, 22% productivity improvement, and 13% asset condition improvement. These findings prompted the creation of a 10-year, $130 million fence-to-fence performance-based contract covering 450 km (approximately 280 miles) of roadway (Segal et al. 2003). This project was so well-liked (and apparently successful) that Australia created many other true and hybrid PBMCs throughout the country, including more contracts in New South Wales, Tasmania, and Southern and Western Australia (Zietlow 2005a).

New Zealand also initiated a PBMC in 1998. They used ten-year contracts that focused on management, pavement condition, and user experience as their performance measures. The performance measures were divided into two sets: (1) measures that focused on management and implementation; and (2) measures that focused on long-term quality of the roads. Qualitative evidence and agency reports claim cost savings and improved LOS. The contracts were still in use as of 2006 (Stankevich et al. 2005). Additionally, a hybrid style contract, which uses traditional selection, but adds out-come-based activities for periods between three and five years was developed and implemented (Pakkala 2002).

The Australia and New Zealand cases are somewhat unique in that quantitative analysis has been conducted to approximate cost savings associated with their unique contracts. These data are summarized in Table 2-4 and Table 2-5.

Table 2-4. Australia's Cost Savings (adapted from Hyman)

Area	**Source**	**Cost Reduction**
New South Wales, Tasmania, Western Australia	Pakkala 2002	10 to 35%
Sydney, New South Wales	Frost 2001	38% compared to schedule of rates contracts
Southern Tasmania	Frost 2001	20% compared to schedule of rates contracts
South Perth	Frost 2001	25% compared to schedule of rates contracts
Mid North Region	Frost 2001	30% compared to schedule of rates contracts
Western Australia	Frost 2001	15 to 20%

Table 2-5. New Zealand's Cost Savings

Contract	Source	Savings
10 year, lump sum, performance-specified, rehabilitation and maintenance	Reason Public Institute	20% based on audits
	World Bank	Reduction according to General Manager at Transit New Zealand
	Highway Maintenance Contracting	17 to 30% in professional services costs; at least 25% over conventional model
10 year, lump sum, performance-specified(PCMS-001)	Pekka Pakkala	Initial of about 25%, between 14 and 20% after

2.4.1.4 Finland and Sweden

Until the late 1990s, the Finnish Road Administration (Finnra) performed most maintenance work using in-house staff. In 2001, this practice was changed. Three-year lump-sum contracts for periodic maintenance were implemented; and unit price contracts for routine activities including line marking, resurfacing, lighting, etc. were introduced (Pakkala 2002). Each section with one of these PBMC-style contracts was dubbed a “network area.”

As of 2002, Finnra was using 99 network areas for 16,570 km (approximately 10,000 miles) of roadway (Figure 2-2). This approach has received some criticism, and many have suggested that

Finnra would be better served by utilizing other contract-types. However, Pakkala (2002) writes that Finnra has experienced 7-10% cost savings on new maintenance projects; but the three year term may to be too short. A summary of the evolution of Finnra contracting is presented in Figure 1-3.

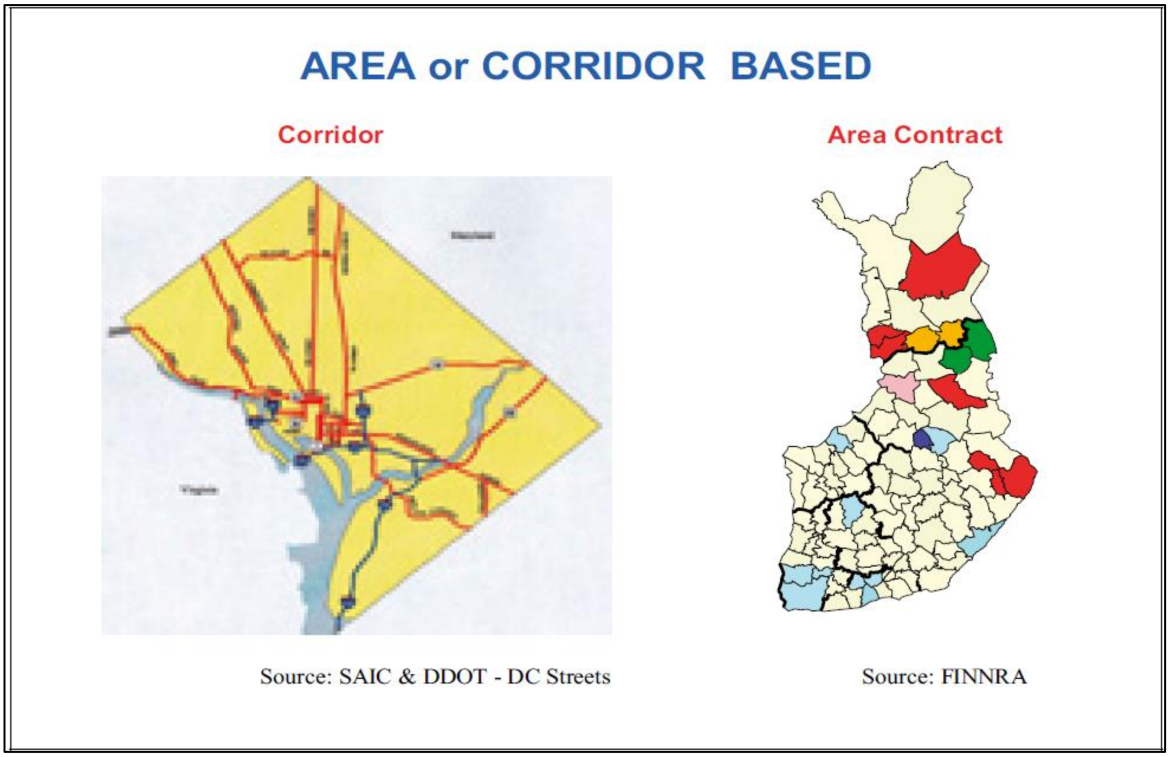


Figure 2-2. Summary of the Evolution of Contracting in Finland (adapted from Pakkala 2002)

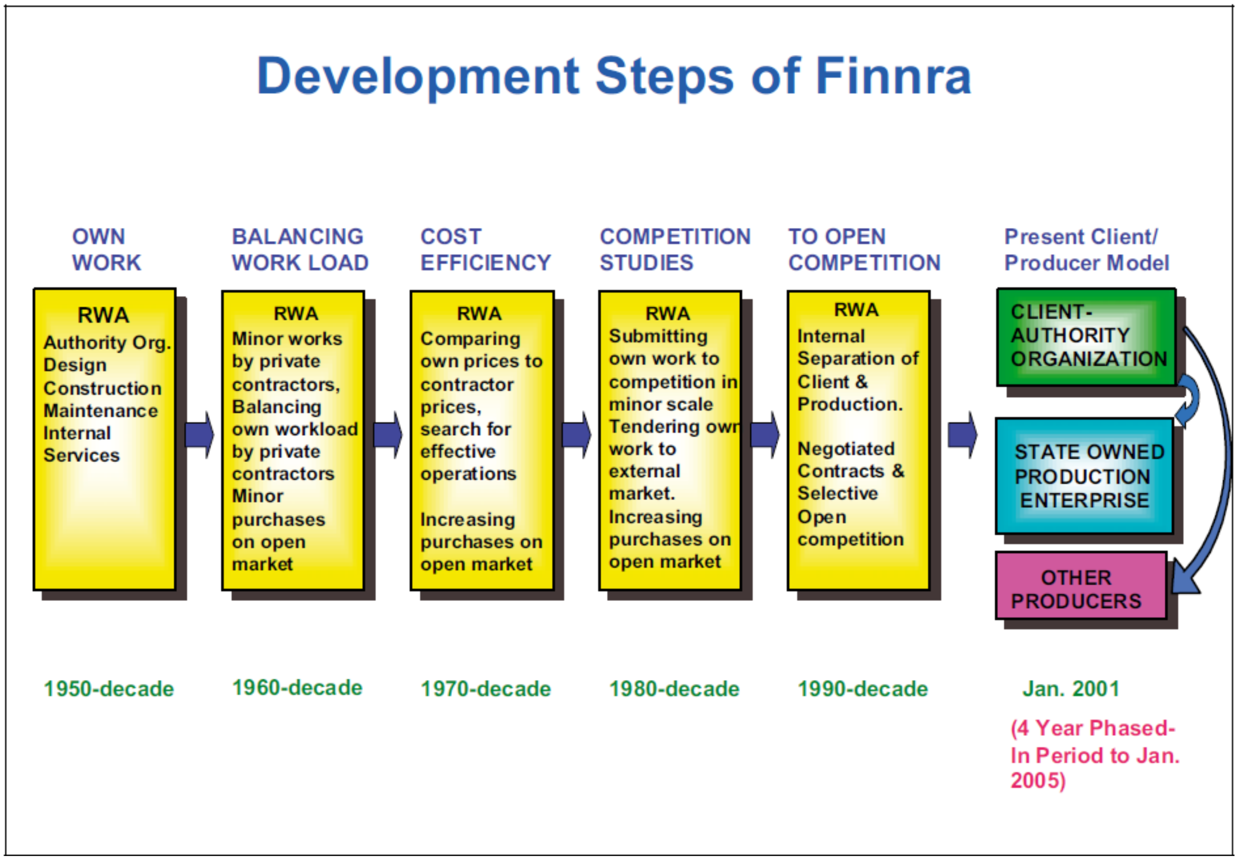


Figure 2-3. Developmental Stages of Finnra (adapted from Pakkala 2007)

Sweden has a similar administrative structure to Finland and also uses performance-based contracting. Their most-commonly used and successful model is a six plus two year lump-sum contract based 90% on pricing (and the remaining 10% on qualification). Sweden uses these contracts for general maintenance activities and have shown savings between 20-25% (Pakkala 2002).

2.4.1.5 South America/Africa

PBMCs are of particular interest to many developing countries because of their perceived benefits. Dr. Gunter Zietlow has extensively documented PBMC contracting in the developing world, and he has helped to implement these style contracts in several countries, particularly in South America.

Argentina played a major role in starting the wave of PBMCs in South America in 1995 using two separate contract-types – kilometer-per-month contracts and Contrato de Recuperacion y Mainteniniento (CREMA) contracts. The kilometer-per-month contracts were broken into three parts: maintenance work, site installation, and emergency work (Cabana et al. 1999). Maintenance was paid based on $/month/km. Site installation contracts were lump-sum and unit price was used for emergency work. Each contract contained an associated penalty structure if quality was insufficient. The contracts were considered successful because only one percent of total contract amount was ever withheld in penalties (Cabana et al. 1999).

CREMA contracts were designed to rehabilitate and maintain roads of varying levels of condition. The highway agency was tasked only with conducting routine checkups and assessing needed penalties to contractors. These contracts greatly increased the quality of the roadways and were reported to have lowered costs as well. For countries with roadways averaging poor conditions, this style of contract incentivized the contractor to perform quality, lasting work, while reducing the man hours needed by the agency to assess, analyze, and bid each problem (Zietlow 2005b).

A CREMA-style system was implemented in Uruguay as well throughout the mid-1990s. In 1996 Uruguay established contracts both nationally and at the municipal level. Employees in the Ministry of Public Works were encouraged to establish companies to compete for projects. This allowed the Ministry of Public Works to reduce its payroll. Failed companies were given the option to reabsorb into the department for the first year. The contracts were similar to Argentina's in that contractors were to perform rehabilitation and maintenance on the roads for five years (Zietlow 2005b).

The city of Montevideo also created a PBMC for 140 km (approximately 87 miles) of its city roadways. These contracts were based upon three-year terms with an optional three-year extension period. Little quantitative data exist on these contracts, but they appear to be successful enough, because the city continued and expanded the program (Zietlow 2005b).

The use of PBMCs in Chad is another example of a developing country implementing PBMCs and noticing a drastic improvement in roadway usability. Until recently, many of the roads in Chad were inaccessible during the rainy season due to flooding and erosion. In 2001, a project funded by the World Bank retained a French contractor and a Cameroonian engineer to restore the road network via a four-year, 440 km (approximately 275 mile) section of previously-unpaved roadway. While little cost and LOS information were published, the roads were operable year-round after the implementation of the contracts (Zietlow 2005b).

2.4.2 Use of Performance-Based Contracting by National and State Highway Agencies

The third-world cases discussed above generally involve roads with low LOS. In these cases, the success of the PBMC-structure is measured by an increase in LOS. In the United States, most roads have relatively high LOS. Therefore, success associated with the PBMC is measured as a balance between maintaining/marginally improving LOS and minimizing cost.

During the late 1970s and early 1980s, there were some attempts domestically to implement PBMC-style agreements. For example, California made an attempt to award a PBMC in the late

1970s for public streets, but this effort failed due to litigation. The Pennsylvania Department of Transportation (PennDOT) also made an attempt to award a PBMC in the late 1980s, but was suppressed by unions and tort issues (Hyman 2009).

Since the 1990s however, there has been some success on a state-level of awarding PBMCs. Some of the first states to adopt this structure include Virginia, Florida, and Texas (Hyman 2009). More recently, other states have implemented PBMCs – Massachusetts, Oklahoma, and the District of Columbia for example. The following is a summary of these recent domestic examples:

2.4.2.1 Virginia

One of the first PBMCs awarded in the United States was in Virginia in 1996. The Virginia Department of Transportation (VDOT) received a bid to fully maintain fence to fence, including winter maintenance, 251 miles of roadways. A five-year extendable contract was awarded. Results showed marginal LOS improvement (Segal et al. 2003; Stankevich et al. 2006).

2.4.2.2 Texas

Two types of maintenance contracts were developed by the Texas Department of Transportation (TxDOT) in the late 1990s – total maintenance of highways and rest area contracts. Development of these contracts was collaborative. TxDOT joined with stakeholders, maintenance personnel, districts, and potential bidders for creating performance measures, standards, contractor responsibility, specifications, and ways to calm personnel who felt negatively affected by the proceedings.

By 1999, the total maintenance contract covered 180 miles of interstates with standards on operations, maintenance, traffic, and response time. TxDOT reported costs savings, fewer required inspections, less contractual documentation through the course of the term, and successful contractor innovation (Hyman 2009).

Prior to implementation of the rest area contracts, TxDOT consistently noticed that its picnic and rest areas were in poor condition. During the first year of the rest area contracts (two-year term contracts), incentive pay was approximately equal to penalty deductions. However, the state saw the average rating of rest areas rise from 73% to 91% (Sims 2004).

2.4.2.3 Washington D.C.

In 1998, the District of Columbia Department of Public Works (DCDPW), in association with the Federal Highway Administration (FHWA), awarded a five-year $69 million performance-based contract for 75 miles of the national highway system within the district. The focus of this contract was to improve LOS which was measured via a detailed performance measuring system broken into approximately 170 categories on a 0 to 100 scale (Hyman 2009; Robinson and Raynault 2005). The contract included performance-based incentives/disincentives. The scope of the contract included: pavement, drainage, roadside, traffic safety, bridges, curb and gutter, tunnels, vegetation, snow and ice control, pavement markings, traffic signs, and highway lighting. The contractor was in charge of monitoring maintenance as part of its quality control plan. The DCDPW, along with a third party, inspected each month and graded each element as poor, fair, or good. A comprehensive evaluation was conducted each year to decide whether the contractor earned an award or needed improvement. No cost savings were evaluated, but LOS steadily improved to an acceptable level over the course of the contract (Hyman 2009; Segal 2003).

2.4.2.4 Massachusetts

The state highway department of Massachusetts created a pilot outsourcing maintenance project in Essex County in 1992. Ribreau (2004) concluded that lax oversight and poor contractor performance led to many problems. In a study conducted after the completion of the project, investigators found that 35% of the work that was supposed to have been outsourced was performed by state workers in an apparent attempt to improve and artificially inflate the value of the program. Another report, the State Auditor's Report on the Privatization of the Maintenance of State Roads in Essex County October 7, 1992 to October 6, 1993, issued July 19, 1995, showed that the project lost the state over a million dollars. Since then, no other PBMC or outsourcing project has been attempted (Ribreau 2004) by Massachusetts.

2.4.2.5 Florida

The Florida AMC Program is made up of three contract-types: corridor contracts focused on limited access highways; geographic contracts for multiple types of transportation facilities; and limited focus contracts. Between July 2000 and December 2008, FDOT entered into 61 AM contracts totaling $1.74 billion.

AMC performance is scored via FDOT's Asset Maintenance Contractor Performance Evaluation Report (AMPER) which includes elements from its Maintenance Rating Program (MRP). These tools will be discussed in detail in Section 2.5, but to summarize, the contractor must meet a minimum score on the AMPER rating.

2.4.2.6 Oklahoma

In 2001, the Oklahoma DOT also attempted to implement PBMCs, although these efforts were unsuccessful. In the end, the contractor backed out of their agreement. This led to lawsuits and settlements. The consensus on this example is that the contracts were hastily written and agreed upon without proper preparation (Ribreau et al. 2004).

2.4.2.7 North Carolina

The North Carolina DOT created its first PBMC in 2007. Per 2005 legislation, the agency selected an area that was understaffed, but had new contracting potential to create a pilot project covering 700 lane miles of Routes I-85, I-485, I-77, and I-277. The contract was five years using a two-step "best value" selection process. The contract end date was revised from July 2012 to July 2009 due to conflicting interpretations of performance targets and assessment criteria. The agency held meetings with personnel from all levels to better define targets and assessment methods. They also changed mowing and litter control from performance-based to unit-based pay items and on October 15, 2009, they advertised the new contract (Hoffman 2010).

2.4.3 Summary of PBMC Use

The use of PBMCs has been accelerating in recent years. In addition to the representative examples presented above, by 2005, 35 countries, including Canada, United States, Sweden, Netherlands, Norway, France, Estonia, Serbia, Montenegro, South Africa, Zambia, Chad, Philippines, Finland, Uruguay, Argentina, Tanzania, Vietnam, Australia, New Zealand, and the United Kingdom utilized some form of PBMCs. Additionally, the following American states have attempted or are currently using some form of PBMC: California, Pennsylvania, Florida, Georgia, Virginia, Texas, Utah, Oklahoma, New Mexico, Idaho, and Maryland. With the exception of the aforementioned domestic examples, little domestic data could be found to evaluate these contracts' levels of success. Perhaps as a result, PBMCs' potential benefits or drawbacks are still hotly debated due to inconsistency of the scarce data that exist and the sparse quantitative analysis of these programs.

However, from the examples shown above, qualitatively, some consistency has been established in terms of "successful" versus "unsuccessful" performance-based contracts. Most contracts deemed "successful" by their users use lump sum payments with balanced incentives and disincentives applied for exceeding and failing to meet requirements. The incentive/disincentive approach appears to entice the contractor to accept the inherent risk associated with a performance-based agreement. Additionally, an incentive/disincentive structure lends itself to a certain level of partnering between the agency and the contractor. This leads to mutual cooperation – another common aspect of successful performance-based agreements.

Planning and training are also key elements to the success of PBMCs. Texas and Oklahoma are two antithetical examples of these points. TxDOT demonstrated a high-level of understanding of the complexity of the managerial skill needed to implement performance-based contracts. They put forth much effort in developing documents, easing fears of the employees, and preparing the contractor. Conversely, the contract in Oklahoma was rushed and the contractor was underprepared. The result was that in Oklahoma, the case fell quickly into litigation.

The National Cooperative Highway Research Program published the report "NCHRP20-24(61): Issues and Practices in Performance-Based Maintenance and Operations Contracting" in 2010. The report drew most of its conclusions from a survey issued to several state and Canadian provincial transportation departments. The survey received 37 responses, 13 of which had experience with PBMC. The states with experience and who intend to continue their program are: Florida, Georgia, Illinois, Kentucky, Maryland, Michigan, Nevada, North Carolina, Ontario, Tennessee, Texas, Utah, and Virginia. Oklahoma and South Carolina were the only respondents with experience who have no interest in pursuing more PBMC use at the time. Fifteen of the respondents with no experience claimed interest in learning about a PBMC program and possibly implementing one in the future. These states were: Alabama, Arizona, California, Colorado, Connecticut, Hawaii, Idaho, Louisiana, Massachusetts, Mississippi, Missouri, New York, Pennsylvania, and Wyoming. The rest had neither experience nor interest in PBMCs.

The states with no interest in PBMC cited several reasons. Some of these reasons may change given sufficient time. Examples of these reasons include too much cultural change, lack of experience (agencies and contractors), no training, and no legal ability. Some reasons that may be more difficult to overcome are as follows (Hoffman 2010):

- Estimating challenges
- Potential initial loss of quality
- Insufficient contractor capacity
- Inability to achieve needed competition
- Bonding or warranty requirements
- Loss of control
- Worry over lifecycle cost increase
- Fear of job loss
- Union concerns
- Difficulty to secure funds needed for long term projects
- Concern for contractor management and response
- Problems associated with contract failure

The state DOTs who were satisfied with their PBMC programs, were interviewed more thoroughly. The consensus among these interviews was that initial motivating factors for PBMC implementation included legislative and managerial requirements/recommendations, potential LOS increase, reducing costs, improved efficiency, risk shifting, and need for a long term asset management approach. Most states did not require legislative changes. However North Carolina had to make changes allowing for longer bond terms, Florida for contractor selection, and Michigan to allow warranties on pavements. Employee concern agencies took several different approaches to mitigate negative effects associated with involving staff in decision making and contract document creation. To address contractor concerns, agencies consulted with local contractors and the contractors did the same for smaller contractors (Hoffman 2010).

In addition to the survey, the investigators held an executive forum with eleven DOTs represented and nine contractors/consultants with PBMC experience. After discussing each of their experiences with PBMC, the owner and industry representatives ranked the strengths, weaknesses, and challenges associated with PBMC. Tables ranking these responses may be found in Appendix A (Hoffman 2010).

The investigators also proposed strategies for PBMC advancement based on the results. The key elements for PBMC advancement are as follows: establish PBMC as a long-term; create a sustainable approach; address employee morale; develop agency guidelines and performance standards; and determine actual cost and performance levels. For the first item, the forum suggests executive level support, establishment of federal funding eligibility, development of model documents/philosophies, creation of managerial change plans for transitioning from traditional contracting to PBMC, and development of an outreach plan. To address morale, the forum suggests training at all employment levels, involving employees in all developments, and creating education/communication programs. In developing agency guidelines, the forum highlighted the need for administration manuals, sharing of full case histories, clear end-result performance measures and standards, and an information database. Finally, the forum states cost relative to performance level, accounting protocol, industry performance standards, and an outreach program are all needed to determine cost and performance standards (Hoffman 2010).

Based on the finding of the report, the investigators offer recommended actions and considerations for the future of PBMC. Items not discussed to this point are the following (Hoffman 2010):

- Engagement between like personnel between states
- A systematic methodology for assessing public versus private sector costs
- Sharing of innovative technique trial data
- Application of PBMC principles to in-house maintenance activities

2.5 FLORIDA’S DEPARTMENT OF TRANSPORTATION HIGHWAY MAINTENANCE CONTRACTING

Florida’s PBMC program was mentioned briefly in Section 2.4.2.5, although based upon the nature of this report; a more in-depth discussion is warranted. The FDOT uses three types of maintenance contracting: work directed contracts (WDCs), the aforementioned AMCs, and the aforementioned MOAs. Using FDOT documents Maintenance Contract Administration, Inspection, & Reporting, Procedure No. 375-020-002 and Performance Based Maintenance Contracting, Procedure N0. 375-000-005, the following sub-sections discuss how these two types of contracts are awarded, monitored, and evaluated by the department.

2.5.1 Work Directed Contracting

As discussed in Section 2.2.1, FDOT divides WDCs into work document driven and project specific contracts. For these contracts, contractors must provide proof of eligibility by completing an experience form. FDOT has nine of these *Experience Forms (Form Nos. 850-070-01 through 09)* depending on the scope of work for nine specific types of work. After determining a qualified pool of applicants from these experience forms, the contract is usually assigned based upon low bid. The scope and specifications of the contract are then given to the contractor in the form of the *Contract Maintenance Work Document, Form 375-020-05*.

2.5.1.1 Contactor Selection

Road and Bridge Contract Procurement, Procedure No. 375-000-001 explains the bid opening, review, and award of WDCs Depending on the project size, a set of databases are reviewed to ensure that the contractors are eligible to work for FDOT. The low bidder is then scrutinized to ensure that he or she has the capacity for the project. Finally, the technical review committee makes the final decision to accept the low bid or reject all bids.

2.5.1.2 Contract/Contractor Evaluation

Maintenance Contract Administration, Inspection, & Reporting, Procedure No. 375-020-002, details responsibilities/roles of all parties involved, types of maintenance contracting, contractor requirements, pre-project proceedings, notification procedures, inspection procedures, payment procedures, contractor performance rating, etc. Section 8.2 of the document describes the inspection procedure for WDCs. It explains that no payments should ultimately be withheld from the contractor, but payments and acceptances by the department should not take place until the work is done to the specification of the contract and is approved by the department.

Inspections for WDC maintenance contracts are made using *Contract Maintenance Work Document, Form 375-020-05, Daily Report of Maintenance Project, Form No. 375-020-01* (*Daily*), and *Maintenance Project Weekly Summary, Form No. 375-020-02* (*Weekly*). Once a contract has reached completion, the Maintenance Project Manager shall evaluate the contractor using *Contractor Field Performance Rating on Maintenance Contracts, Procedure No. 850-070-002*. Results of the forms listed in this section, along with other provided data, will be used to create and implement analysis for WDC contract performance.

2.5.2 Maintenance Rating Program and Handbook

The maintenance rating program (MRP) was implemented in April of 1985 as a guide for the evaluation of transportation assets. As mentioned previously, roadway, roadside, traffic services, drainage, and vegetation are rated on a scale from 0 to 100. Within these broad categories, several sub-categories are scored and summated to obtain an average overall category score. The mechanism for assigning these scores varies based upon four possible road-types classification – rural limited access roads, rural arterials, urban limited access roads, and urban arterials.

Guidelines for assigning scores are documented in the FDOT MRP Handbook – a comprehensive guide detailing all information needed for FDOT personnel to perform quality control. More specifically, the MRP handbook explains the criteria for selecting where and how many quality samples should be taken depending on the, facility type and general minimum guidelines. In the original MRP, length of road was not a factor; however, FDOT is in the process of making road length a factor for the purposes of evaluating AMCs. It also details how often surveys should be taken.

The Data Collection section of the handbook explains the general organization of a sample crew and their responsibilities. It also lists the standard equipment a sample crew should carry. A sample coding example sheet is given with instructions based upon asset-type (Appendix A).

The majority of the handbook is the Maintenance Rating Program Standards section. It is broken into sub-categories of roadway, roadside, traffic services, drainage, vegetation and aesthetics, clear zone vegetation, critical element consistency check form, data entry, and output report. Several example photographs are included to demonstrate how to take measurements and specific pass/fail criteria. It also explicitly outlines how different road elements should be rated and how they are classified. This survey allows FDOT to know how their assets and contractors are performing, and it allows for a comparison among different contract-types and/or contractors.

2.5.3 Performance Based Contacting

Performance Based Maintenance Contracting, Procedure No. 375-000-005 details FDOT's process for the development, administration, and implementation of PBMCs, similar to its work-directed counterpart. It explains that within the AMC category are three types of contracts: corridor contracts focused on core roadways, geographic contracts with multiple transportation facility types, and limited focus contracts which focus on one type of facility (rest areas, weigh stations, welcome centers, and fixed/movable bridges). FDOT's website defines asset maintenance as a performance based contracting method whereby the Department contracts with private or public entities for the management and performance of the maintenance of the transportation facility components of specific roadway corridors or entire geographic areas. FDOT also uses best-value performance (BVP) contracts which are similar to AMCs, but have smaller scopes and shorter terms (three to ten years whereas AMCs are seven to fourteen). Lastly, low bid performance (LBP) contracts are similar to BVP, but use low bid selection and two to five year terms with extensions.

2.5.3.1 Contactor Selection (AMC & BVP Contacts only)

A Technical Evaluation Committee (TEC), along with the help of applicable/needed technical experts, evaluates the contractors technical proposals and assign a score for each based on the criteria set forth in the request for proposal (RFP). The total proposal score is evaluated based on the following criteria:

- Technical Score = (Average Technical Score) x 70%
- Price Score = 100 x (Lowest Bid / Proposer's Bid) x 30%

Total Proposal Score = Technical Score + Price Score

2.5.3.2 Contract/Contractor Evaluation

<u>2.5.3.2.1 AMPER Scale</u>

The Asset Maintenance Contractor Performance Evaluation Report (AMPER) is the method by which AM contractors are evaluated. Like the MRP, the overall minimum acceptable score for the AMPER is a 70. The AMPER consists of five sections: performance measures (20%), rest areas (20%), bridges and ancillary structures (25%), MRP (20%), and contractor performance rating (15%). As shown, the MRP score is an element of the AMPER score. AMPER scores are computed every six months.

<u>2.5.3.2.2 AMPER Issues and Development</u>

In 2013, FDOT conducted an evaluation of their AMC with the contractor DeAngelo Brothers, Inc. (DBI Services Inc.) to determine whether DBI's performance truly complied with the Department's statutes, procedures, and requirements; or whether their consistently low AMPER scores were accurate. FDOT determined that DBI was consistently failing the performance measures section of the AMPER. The Department concluded that allowing contractors to be judged on overall scores can overshadow consistent problems and failures to perform. As a result, the Department determined that individual section scores that are failing should be met with corrective action.

2.6 META-FRONTIER ANALYSIS

2.6.1 Introduction

Since the late 1980s, studies have been conducted to use quantitative Data Envelopment Analysis (DEA) to measure performance of highway maintenance contracts. Fallah-Fini et al. (2012) discuss several of these efforts including analysis in Ontario, Canada (Cook et al. 1990; Cook et al. 1994; Kazakov et al. 1989); New Zealand (Rouse and Chiu 2008; Rouse et al. 1997); and Virginia (de la Garza et al. 2009; Fallah-Fini et al. 2009; Ozbek et al. 2010; Ozbek 2007). Fallah-Fini et al. (2012) point out that highway projects are heterogeneous in terms of their methods, performance measures, and resources. As a result, Fallah-Fini et al. (2012) used a non-parametric meta-frontier framework to analyze Virginia's PBMC vs. non-PBMC data. Interestingly, their results showed that traditional contracts were more efficient than PBMCs in Virginia. The following is a discussion of some of the concepts used by Fallah-Fini et al. that will be used throughout this study.

2.6.2 Data Envelopment Analysis

To understand the meta-frontier approach, a discussion of DEA becomes necessary. DEA is essentially a tool whereby processes (usually called Decision Making Units or DMUs) with multiple inputs and/or multiple are rated relative to one another. A rating of 1.0 equates to an "efficient" DMU while a DMU's distance from 1.0 refers to its relative inefficiency.

2.6.2.1 Introduction to DEA – the CCR Model

Given a simple process with one input and one output, its efficiency is easily computed as:

$$efficiency = \frac{output}{input} \tag{2-1}$$

In the context of a job-specific maintenance contract, this could be cost per cubic yards of concrete for example. However, when multiple inputs and outputs are present, as is the case with Florida's AM program, computing efficiency becomes more complicated. One possible alternative is to use weighted efficiency:

$$weighted\ efficiency = \frac{weighted\ sum\ of\ output}{weighted\ sum\ of\ inputs} \tag{2-2}$$

Mathematically, this is represented as:

$$weighted\ efficiency = \frac{u_1 y_{1j} + u_2 y_{2j} + \cdots}{v_1 x_{1j} + v_2 x_{2j} + \cdots} \tag{2-3}$$

where u_1 is the weight given to output i; y_{1j} is the amount of output 1 from unit j; v_1 is the weight given to input 1; and x_{1j} is the amount of input 1 to unit j. Of course, the issue immediately becomes rating the units in the process.

Charnes, Cooper, and Rhodes (1978) proposed that each unit should adopt a set of weights which shows it as favorably as possible when compared with the other units. Efficiency of a target unit, j_0 can be obtained as a solution to the following problem:

$$\max(h_0) = \frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}} \tag{2-4}$$

Subjected to:

$$\frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \leq 1 \ ; \ \ u_r, v_i \geq \epsilon \tag{2-5}$$

for each unit *j*.

The *u*'s and *v*'s are constrained relative to some small positive number so as to avoid ignoring any inputs or outputs. The solution to this expression, *h* represents the process, *j*'s efficiency. An efficiency of 1.0 means that process *j* is relatively efficient when compared with the other processes. If *j*'s efficiency is less than 1.0, it means that another process is relatively more efficient than *j*. Equations 2-4 and 2-5 are more commonly known as the CCR model, and they may be converted to a linear program (LP):

$$\max(h_0) = \sum_r u_r y_{rj_0} \tag{2-6}$$

Subjected to:

$$\sum_i v_i x_{ij_0} = 1 \text{ (or any arbitrary constant)} \tag{2-7}$$

$$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0, \ \ j = 1,2,3, \ldots n \tag{2-8}$$

$$u_r, v_i \geq 0 \tag{2-9}$$

Or in simpler notation (Scharr and Sherry 2008):

$$\max(v, u) = u y_0 \tag{2-10}$$

$$-vX + uY \leq 0 \tag{2-11}$$

Subjected to:

$$v x_0 = 1 \tag{2-12}$$

$$v \geq 0, u \geq 0 \tag{2-13}$$

To improve computational performance, this is usually converted to its dual:

$$\min(\theta, \lambda) = \theta \quad (2\text{-}14)$$

$$\theta x_0 - X\lambda \geq 0 \quad (2\text{-}15)$$

Subjected to:

$$Y\lambda \geq y_0 \quad (2\text{-}16)$$

$$\lambda \geq 0 \quad (2\text{-}17)$$

These equations can be solved using a computer. This approach is known as the Charnes, Cooper, Rhodes (CCR) model. Graphically, the results from this model for the relatively simple case of two outputs and one input result in illustrations of the form of Figure 2-4:

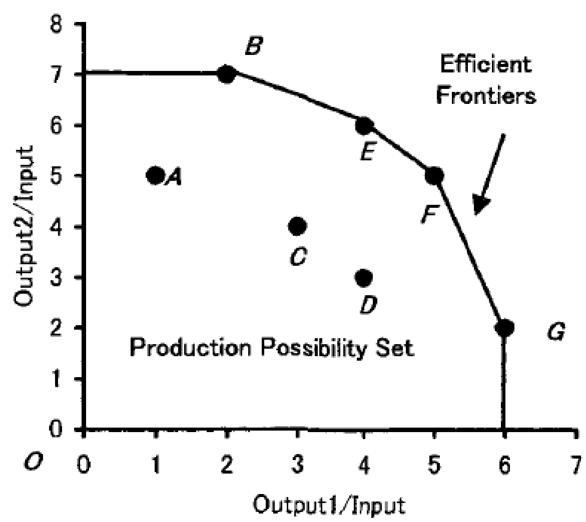


Figure 2-4. Illustration of CCR DEA for Simple One Input, Two-Output Case (adapted from Cooper et al. 2007)

In Figure 2-4, segment BEFG represents the "efficient frontier" while the "inefficient data" are "enveloped" (hence the name DEA) by the efficient segments. Or, an even simpler case is the situation with one input and one output:

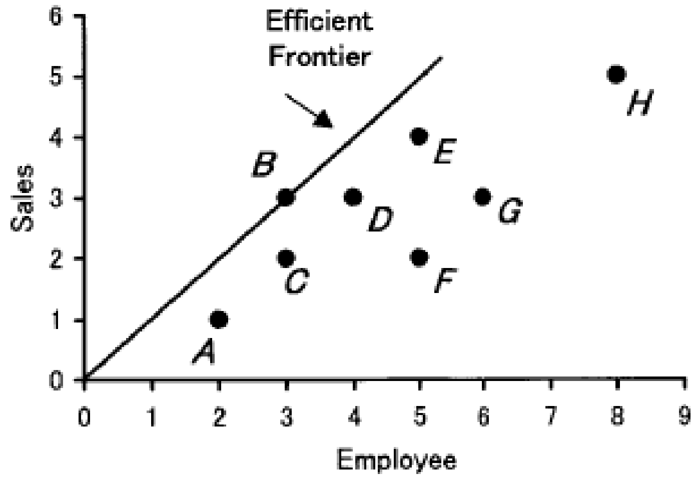


Figure 2-5. Illustration of CCR DEA Results for Simple One Input, One Output Case (adapted from Cooper et al. (2007)

In Figure 2-5, the efficient frontier is denoted by the segment running through point B while the inefficient points (A, C, D, E, F, G, H) are enveloped by the efficiency line. This illustration allows one to easily determine how to improve the efficiency of the inefficient DMUs. For example, to improve the efficiency of process A, either one employee should be fired (thereby shifting A to the leftward, toward the efficient frontier), or the employees in A need to make more sales (thereby shifting A upward, toward the efficiency frontier) to make process A efficient.

2.6.2.2 Input Oriented vs. Output Oriented

Section 2.6.2.1 assumed an input-oriented (i-o) CCR model. During an input-oriented approach, one assumes that outputs remain constant and efficiency may be decreased/increased by changing the DMUs' inputs. An alternative solution to the CCR model exists that is output-oriented (o-o). During the o-o case, the DMUs' efficiencies may be changed by changing the DMUs' output quantities.

During the Fallah-Fini et al. (2012) study, an o-o approach was used whereby their models' input was cost and their outputs were "lane miles served" and "change in pavement condition." Their justification for this approach was that maintenance budgets are limited and road authorities cannot maintain all road sections. As such, road authorities must choose which sections to maintain and higher priority roads are given preference. This effect was captured in their "lane miles served" output variable. Road authorities also determine the type of improvements made to their roads. This results in different changes of LOS and was captured in their output variable "change in pavement conditions." Given the limited budget, quality may decrease if more roads are maintained. Thus, road authorities in effect control outputs. Or put another way, for a static budget, output can only be improved by increasing efficiency.

In Virginia, the Fallah-Fini et al. (2012) output argument for an o-o approach certainly is credible especially because at the time of their study, Virginia's PBMC program was relatively new and used infrequently (Fallah-Fini et al. cite approximately 25% of Virginia's roadways).

In Florida, the AMC program is already well-established. Additionally, FDOT's meticulous data-keeping in recent years yields a slightly different set of inputs/outputs that may be more appropriate for a Florida DEA model. In particular, since 2009, FDOT has regularly produced Bar Charts (Appendix C) that show maintenance expenditures in a number of categories on a district-by-district level. Variables tracked include:

1. Mileage on rural roads (RR)
2. Mileage on urban roads (UR)
3. Facilities maintenance (FM)
4. Rest area security (RAS)
5. Bridge inspections (BI)
6. Bridge maintenance (BM)
7. Ancillary structures (AS)
8. Funding (FUND)

During the Fallah-Fini et al. (2012) study, outputs consisted only of the roads where maintenance was occurring (although it was unclear how they quantified where maintenance occurred during PBMCs since PBMC maintenance by definition is left up to the contractor). Thus, their outputs were dynamic with a ceiling – i.e. more funds would lead to more maintenance until the maximum number of roads in each DMU zone (i.e. county) was reached.

In Florida, because of its well-established AMC program, it is not necessarily correct to only use roads on which maintenance is occurring. Rather, the outputs associated with AMCs should correspond to all components of the AMC – items 1 through 7 above. For example, in a given district, a certain AMC may consist of maintenance of a number of bridges, a certain number of miles of road, several rest areas, and several ancillary structures. FDOT is paying for maintenance of these structures whether or not they actually need maintenance. In an AM program, the contractor decides how and when to perform the work. Thus, for AMCs, the output is static in that there are a limited number of roads/bridges/ancillary structures/rest areas/etc. within a DMU zone that can be maintained. Furthermore, it would not be possible to track exactly "where" or "how much" work occurred within a contract zone under AMC conditions.

Similarly, the balance of the roadway components in a district that are not covered/maintained by AMCs must by definition be covered by non-AMCs. As such, non-AMC output is also static and is represented by the quantity of an output item in a district minus that district's AMC output item.

The assumption here is that the correct outputs for Florida are not “miles where work was conducted” but rather “miles covered by contract-type.” It follows then that the only way to increase/decrease efficiency would be to reduce/increase spending. While this distinction is subtle, it is important because as a result, it means that an i-o model is more appropriate in Florida.

The exception to this line of thinking is road rating which in Florida is represented by MRP score in that if contractors were performing inefficiently, they could potentially improve the quality of their work to make their contract more efficient. Inarguably, road rating should be an output in a Florida DEA model (as it was with the Virginia model). However, as will be shown in Chapter 4, rating differences for AM versus non-AMCs are relatively similar (although still statistically significant). And, interestingly the AMCs actually scored better than non-AMCs. Regardless, as will be shown in Chapter 4, due to the similar MRP scores, their overall effects on efficiency are relatively minor. For details about the o-o’s mathematics, the reader is referred to Cooper et al. (2007).

The additive model is another DEA model that is often found in the literature. Its approach is a combination of i-o and o-o. Again, since the appropriate analysis for Florida’s AMC program is i-o, the reader is referred to Cooper et al. (2007) for details about the additive approach.

2.6.2.3 The BCC Model

The issue with the CCR model is that it assumes constant returns to scale (CRS = Constant Returns to Scale; Returns to Scale = RTS). CRS means that more of an input linearly corresponds to more output (as in Figure 2-5). However, it is not difficult to envision a process where an increase in input causes a nonlinear increase in output. This is known as variable returns to scale (VRS). The appropriate tool to measure change in input/output under these conditions is to measure relative change in input/output (as opposed to absolute change). In economic terms, this is known as “elasticity” – a well-known phenomenon in economic processes.

Banker, Charnes, and Cooper (1984) developed a model to account for VRS (known as the BCC model). Essentially, the model is the same as the CCR model except that the convexity condition is applied as an additional constraint. Mathematically, Eq. 2-17 is replaced by:

$$e\lambda \geq 1 \tag{2-18}$$

This gives the model’s frontiers piecewise, linear, concave characteristics (Scharr and Sherry 2008; Figure 2-6).

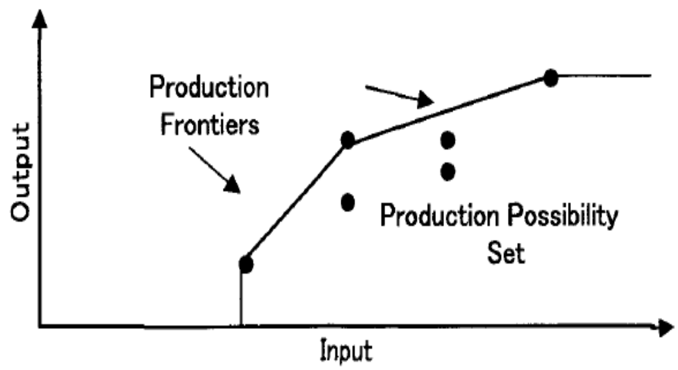


Figure 2-6. Illustration of BCC DEA Results for Simple One Input, One Output Case (adapted from Cooper et al. (2007)

Ozbek (2007) points out that CRS models are really just a special case of VRS models and that most processes do not obey CRS linear behavior. As Fallah-Fini et al. (2012) note, Rouse et al. (1997) showed that scaling plays a significant role in highway maintenance operations. Fallah-Fini et al. (2012) noted that for their o-o approach, their output variables are bounded. Maximum "lane miles served" is the maximum number of lane miles in a contract zone while maximum change in level of service is bound by the rating scale. In Florida, for an i-o approach, input bounds must be examined. The lower limit of cost is fairly obvious and equals zero. The upper limit of cost is the maintenance budget. This limiting bound must be taken into account; therefore and a VRS frontier is needed to analyze the Florida data.

2.6.2.4 Group vs. Meta-Frontiers

Next, the difference between group and meta-frontiers must be explicitly discussed. A "frontier" is a general term that refers to the envelope around a number of DMU efficiency scores as shown in Figure 2-6 for example. For processes that are relatively homogeneous, running DEA using one frontier is appropriate. In other words, all DMUs' input/output pairs are run through the DEA model and each DMU will yield an efficiency score.

As discussed previously, performance targets, methods, and resources may differ between PBMCs and non-PBMCs. In the context of DEA, this is important in that using one frontier may not be appropriate. Instead, it may be more correct to use a non-parametric meta-frontier method.

The concept of a meta-frontier is similar to the concept of a single frontier. During a meta-frontier algorithm, first each group of DMUs is rated relative to one another. In the context of Florida's program, this means that AMCs are rated relative to other AMCs while non-AMCs are rated relative to other non-AMCs. Then, the meta-frontier is estimated by enveloping the two group frontiers. Mathematically, this means running the DEA assuming a single frontier regardless of contract-type. An illustration of this is shown in Figure 2-7:

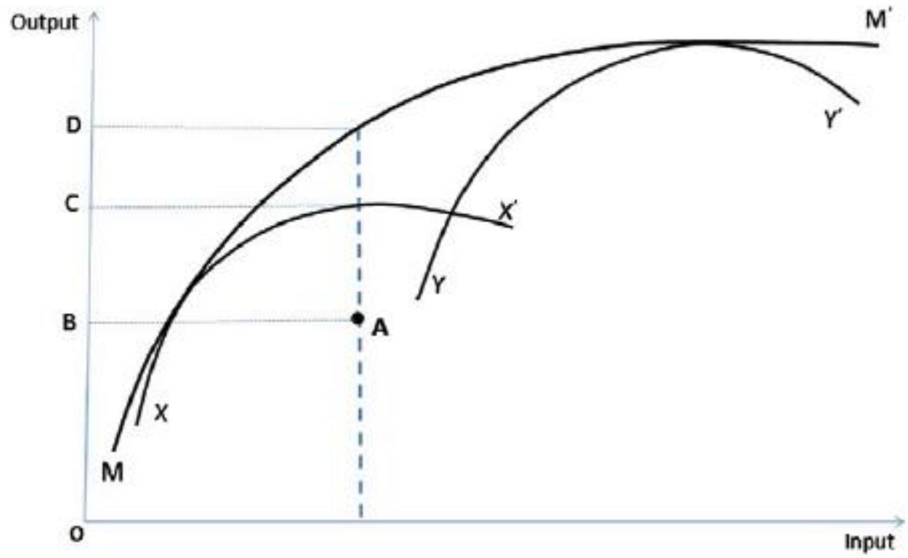


Figure 2-7. Illustration of Meta-Frontiers (adapted from Fallah-Fini et al. 2012)

The resultant efficiency scores with respect to group frontiers refer to the amounts of cost reduction that could be achieved (assuming an i-o model) or the amounts of increased output that can be achieved (assuming an o-o model). For example, if an AMC received a group efficiency score of 0.62, this would mean that this particular contract cost should be reduced by 38% while maintaining the same level of output in order to become efficient relative to the other AMCs.

The resultant efficiency scores with respect to the meta-frontier refer to the amount of cost reduction that could be achieved relative to all contracts (in the case of an i-o model) or the amount of output increase that could be achieved relative to all contracts (in the case of an o-o model) if best practices associated with both groups are employed. Of course, this number is simply theoretical because AMCs and non-AMCs both utilize different methods.

The ratio between the meta-efficiency score and group efficiency is known as the meta-technology ratio (MTR) or technology gap ratio (TGR). This number represents the relative productivity of the contract. A higher MTR means that a contract is closer to performing according to best practices relative to all groups. In this study, the research team members are interested in finding which contract group – AMC or non-AMC produces the highest overall mean MTR.

2.6.2.5 Bootstrapping with DEA

One possible issue with DEA is that like all statistics, a relatively small number of data points are being used to estimate the population's behavior. In the context of DEA, a small number of data points are being used to develop and approximate the efficiency frontiers. To address this issue, Simar and Wilson (1998) developed a smoothed bootstrapping algorithm for DEA. Bootstrapping, is a common technique used in statistics to better-approximate a statistic's population behavior that was based upon limited samples through the use of resampling.

The Simar and Wilson procedure is complicated (for an in-depth analysis of the model's mathematics, please refer to Simar and Wilson 1998), but Walden (2006) summaries the procedure excellently. As Walden (2006) discussed, the assumption behind the bootstrapped approach is that the known bootstrap distribution will be similar to the population's distribution if the data known generating process (DGP) is consistent with the unknown DGP (Walden 2006).

The algorithm for the process is summarized by Walden (2006):

1. Solve the original DEA and obtain efficiency scores $(\theta_1, \theta_2 \ldots \theta_n)$

2. Let β_i be a sample generated from θ_i

3. Take the samples, β_i and generate smooth values for bootstrapped efficiency, θ_i^* by using the following random number generator:

$$\tilde{\theta}_i^* = \begin{cases} \beta_i^* + h\epsilon_i^* & \text{if } \beta_i^* + h\epsilon_i^* \leq 1 \\ 2 - \beta_i - h\epsilon_i^* & \text{otherwise} \end{cases} \tag{2-18}$$

4. Adjust the smooth sample according to:

$$\theta_i^* = \overline{\beta^*} + \frac{(\tilde{\theta}_i^* - \bar{\beta}^*)}{\sqrt{1 + h^2/\hat{\sigma}^2}} \tag{2-19}$$

   where $\bar{\beta}^*$ is the mean of β^*

5. Adjust original efficiency using θ_i/θ_i^*

6. Use the results from (5) to resolve the original DEA to obtain $\bar{\theta}_k^*$

7. Repeat steps 1 through 6 *N* times to yield *N* estimates for efficiency. In other words, each DMU will yield *N* efficiency approximations.

8. Correct for bias by subtracting each DMU's bootstrapped mean from the original efficiency approximation. This gives overall bootstrapped efficiency.

9. To compute confidence intervals, use the bootstrapped data to find the α quantile of the bootstrapped sample where α is the significance level.

Note that this algorithm is computationally intensive. Simar and Wilson (1998) cite Hall (1986) who suggested that 1,000 samples should ensure adequate coverage for bootstrap-associated confidence intervals. Similarly, Walden (2006) used 1,000 samples during his analysis.

2.6.2.6 Potential Issues with DEA

While DEA appears to lend itself well to the problem of rating contracts with multiple inputs/outputs relative to one another, the process is not without its issues. In particular, DEA results are directly dependent upon user-selected inputs and outputs in that if the correct inputs and/or outputs are not chosen, the frontiers associated with DEA may be poorly estimated.

2.7 CONTENT ANALYSIS

Content Analysis (CA) is defined in Krippendorf (1980) as "a research technique for making replicable and valid inferences from data to their context" and cites another study Berelson (1952) defining it as "a research technique for the objective, systematic, and quantitative description of the manifest content of communication." In its most basic form, content analysis is simply counting the occurrences of words or phrases within a text or group of texts and making inferences based on the data collected (Krippendorf 1980). While this is true, content analysis has the ability to be much more thoughtful than this. Content Analysis should follow some form of the steps listed below.

- Data making
    - Unitization
    - Sampling
    - Recording
- Data reduction
- Inferences
- Analysis

The following subsections are in summary of Klaus Krippendorff's *Content Analysis: An Introduction to its Methodology* (1980).

2.7.1 Inferences

2.7.1.1 Systems

A system is a conceptual device to describe a portion of reality consisting of variable state components, relations, and transformations. Within a system, several occurrences can be searched for and used to make inferences about the system on a micro or macro level such as: trends (change over a period of time), pattern (the logical relation between elements of a given genre), and differences. Each of these occurrences can also be combined to make further inferences about data (Krippendorff 1980).

2.7.1.2 Standards

Standards also offer a platform on which to conduct analysis. Standards allow users to establish what and how good something is or to evaluate an object to the given standard. Identification offers a more either/or quality in allowing a user to characteristics of an object to decide what it is and/or means. The audit of data relative to a standard is similar to evaluation, but puts more focus on the data as a whole (Krippendorff 1980).

2.7.1.3 Indices and Symptoms

Indices and Symptoms are another useful tool for making inferences on data. The idea of an index or symptom is that something that can be observed is known to have causation to something else. The most common example of this would be symptoms searched for and/or found by a doctor in the evaluation of a patient. In a more general sense, an investigator can search for a known indicator of something or observe correlation to make further inference (Krippendorff 1980).

2.7.1.4 Linguistic Representations

A discourse is language within a systematic exposition which is concerned with a limited portion of reality. To analyze a body of texts as a discourse involves relationships between two or more sentences provided they bear knowledge on the reality the body represents. A few examples of discourse are: a sequence of editorials, international exchanges of an official character, personal documents, interview transcripts, social interaction, etc. The most basic form a discourse analysis is looking at the denotations and connotations the words convey. Researchers may also make inferences to draw a map of the territory of a certain discourse (Krippendorff 1980).

2.7.1.5 Communications

Communications are messages that are exchanged between interlocutors. Communications can modify relationships, create cause and effect situations, and change the dynamics of behavior through the course of a given exchange. While these changes can be difficult or sometimes impossible to observe, it is still a small part of content analysis which can be implemented (Krippendorff 1980).

2.7.1.6 Institutional Processes

Institutions occur in a variety of genres such as journalism, politics, education, arts, etc. Each institution stems from some focus, but still retains its own unique gatherings, guidelines, legalities, structure, etc. Observations and inferences can be made on a variety of things based on written and/or oral data within an institution or how things may differ when occurring in or out of an institution (Krippendorff 1980).

2.7.2 Analysis Design

Content analysis tends to be sequential in nature, but can be designed a few different ways. The most rudimentary of which is design to estimate. This design is to estimate some phenomena in the context of the data. The idea is the analyst is to utilize all knowledge of the system to interpret one set of data without help from any other methods. A more advanced type is design to test the substitutability. Here, two or more methods are applied to the same data so that the two results can be compared for reliability or to see which method is more effective. Finally is the design to test hypotheses. This method is the comparison of the results of content analysis about a phenomena not inferred by the technique (Krippendorff 1980).

2.7.3 Data Making

2.7.3.1 Unitizing

Content Analysis units can be divided into sampling, recording, context, and units of enumerations, which will all be introduced in this section. Sampling units are those parts of observed reality that are regarded independent of each other. In other words, pieces of data from a stream of data are put into like groups as opposed to being analyzed as a whole. Recording units are separately described and can therefore be regarded as separately analyzable parts of a sampling unit. They differ from sampling units in that they are achieved as a result of a descriptive effort. Context units set limits to the contextual information that may enter the description of a recording unit. They delineate that portion of the symbolic material that needs to be examined in order to characterize a recording unit. Lastly, units of enumeration give content analysis a quantitative characteristic by numerically accounting for frequency, physical size, time, or typography characteristics (Krippendorff 1980).

2.7.3.2 Sampling

Sampling can be described by two major characteristics: type and size. The following table explains the different types of sampling which can be conducted.

Table 2-6. Types of Sampling (adapted from Krippendorff 1980)

Sampling Type	Description
Random	Assuming no prior knowledge about the phenomena, units are selected with some form of randomization tool(dice, roulette wheel, random number generator, etc.)
Stratified	Dividing the potential data into subpopulations based on some defining characteristic and implementing random sampling on each subgroup.
Systematic	Selecting every k^{th} unit of data from a population.
Cluster	Choosing some group of data and using that entire group as the sample population.
Varying Probability	Assigning probability to each unit of data based on some previously established criterion, and random sampling occurs which the probabilities set.
Multistage	Using a combination of sampling procedures.

Choosing a sample size has no set answer. It is essentially the balance between getting a sample large enough to represent the entire population while being too large in terms of overwhelming the analyst team. This constraint can be due to time and/or team size (Krippendorff 1980).

2.7.3.3 Recording

Recording is one of the basic methodological problems in the social sciences. It is a necessary consequence of the fact that content analysis accepts unstructured material, but should not be confused with content analysis of which it is a part. Recording instructions for content analysis should explicitly contain: the characteristics of the observers, employed in the recording process, the training and preparation these observers undergo to prepare themselves to qualify for the task, the syntax and semantics of the data language used including, when necessary, an outline of the cognitive procedures to be employed in placing messages into categories, and the administration of the data sheets (Krippendorff 1980).

2.7.4 History and Development of Content Analysis

CA got its start in the early 1900s, primarily as a means of analyzing news media. News publications being the predominant source of information of the time, it was important to develop a means of analyzing this rather qualitative and opinionated data in a quantitative manner. An interesting example is the work of Singer (1950). The work sought to analyze different New York

Newspapers on their reporting of the 1949 Peace Conference at the Waldorf-Astoria. Singer (1950) was able to conclude, using a form of CA, that quite a bit of the media coverage of the event was editorialized or false. This allowed authorities to hold the responsible parties accountable for their actions.

There are other forms of media with which CA is utilized. Specifically, Jones (1950) sought to classify and catalogue the main topics of all motion pictures produced by a company. CA has recently found a new subject matter with the rise in popularity of social media. Wang & Zhou (2015) used CA to analyze how National Basketball Association (NBA) clubs use social media to build different relationships with the public. These are only a few examples of the wide range of qualitative data CA has the ability to analyze in a quantitative manner.

2.8 PROFESSIONAL SURVEYS REGARDING PBMC

As discussed in the previous sections of this chapter, Hyman (2009) and Hoffman (2010) present the history, development, and implementation of PBMC world-wide. They also include surveys and committee discussions on the subject. Hoffman (2010) described the survey that was sent to 37 transportation agencies throughout the United States and Canada. Interviews were also conducted with DOT personnel of Virginia, Florida, Texas, Oklahoma, North Carolina, California, Georgia, Kentucky, Maryland, Michigan, Mississippi, Missouri, Nevada, Ontario and Pennsylvania. Contractors who provide PBMC services were also included to gauge the views and opinions of the private sector.

According to the survey, twelve of the thirty-seven responding agencies have tried PBMC and wished to continue its use, while another fifteen of the respondents were interested in this approach or learning more about it. The remaining agencies expressed no interest in PBMC at this time.

The surveys and interviews show that the primary reasons for utilizing PBMC are as follows:

- Augmenting in-house capacity where shortfalls exist
- Responding to expressions of interest and support from legislative bodies, chief executives, and top management within the agency
- Reducing costs and improving efficiency
- Raising the level of service (LOS) provided to customers
- Shifting risk and liability from the state to the private sector

Reasons for skepticism with regard to PBMC were:

- State government philosophy opposing outsourcing
- Opposition by front line employees and their unions, who may see it as a threat to jobs

- Operational managers and technical staff who perceive a loss of control over operations and methods
- Contractors vested in current contracting procedures who feel they will lose work
- Lack of training
- Challenges in estimating in-house and contractor costs
- Loss of quality sometimes observed in the first years of a long-term contract
- Concern that life cycle costs will increase
- The need to secure substantial funds through the budgetary process for large, multi-year contracts
- Concerns about the contractor’s ability to effectively handle reactive maintenance such as snow and ice control, repair of traffic control devices, and incident and emergency response
- The challenges of reassuming the responsibility for maintenance if the contractor fails to perform, especially if the contracting agency sells off its equipment and lays off maintenance staff.

3 SURVEY AND SURVEY RESULTS

3.1 INTRODUCTION

The first evaluative metric used to describe FDOT's AMC program was development and distribution of a detailed survey. The survey was developed and distributed online via Qualtrics (2016) to several parties with expertise on FDOT's AMC program. While surveys have been conducted in the past, the respondent pool from this study was somewhat unique. Specifically, the following groups were targeted:

- High-level state employees from out-of-state from states who were familiar with PBMC-style programs. Hoffman (2010) already analyzed these opinions to a large extent. The goal was to give these states the opportunity to update their data.

- A broad spectrum of employees from FDOT. Rather than obtaining an "official opinion" from a maintenance head of a DOT, investigators solicited opinions from several employees who are intimately involved in both the AMC and WDC programs.

- Private consultants and contractors. Most unique to this project's survey, the opinions of contractors who had performed work in the AMC program or had bid a job for the AMC program were solicited. As of the date of this report, this is the first known PBMC survey that targeted to people working in the private sector.

The survey is presented in Appendix B. Beyond the survey, interviewees were given an opportunity to confidentially answer follow-up interview questions. These questions were as follows:

1. Briefly describe your experience with performance-based maintenance contracting (PBMC).
2. In your opinion, what do you feel are the most important advantages and disadvantages of PBMC?
3. Discuss/explain the best and worst PBMC contract structures in your opinion.
4. What do you think are the best incentive/disincentive ranges (as % of contract amount), explain. Should they change as a function scope size?
5. Discuss/explain what the best contract terms and renewal terms are in your opinion.
6. How should the responsibilities and day to day activities of the contracting agency and the contractor change when switching from a traditional contracting method to PBMC?
7. FDOT personnel only: In your opinion, is the AMPER score a good measure of contract performance? What are the key advantages and disadvantages?
8. Open discussion and survey follow-up/explanation

In total, 201 professionals were contacted and 103 responded yielding a total response rate of 51 percent. For the out-of-state group, representatives were contacted from DOTs from California, Georgia, Iowa, Texas, Utah, and Virginia. To ensure confidentially, contractor company/employee names have been omitted from this report. Table 3-1 summarizes responses from each group:

Table 3-1. Survey Response Rates

Group	Surveys Sent	Surveys Completed	Survey Response %	Interviews
Other DOTS	10	5	50%	2
FDOT	103	50	48%	3
Contractors	47	27	57%	3

3.2 RESPONSE ANALYSIS METHODOLOGY

3.2.1 Statistical Analysis

Descriptive statistics generated by the online survey application Qualtrix were used to analyze the survey's numerical responses, which comprised a majority of the survey data. One-way ANOVA and Tukey HSD (honest significant difference) post hoc tests with a 95% confidence interval were used to compare the three categories of respondents for each question using the sample size, mean, and standard deviation. Resulting p-values less than 0.05 indicated a significant difference between the groups.

3.2.2 Content Analysis (CA)

3.2.2.1 Interviews

Text survey responses and interview results were analyzed using CA. As discussed in Section 2.7.4, CA is a dynamic field which has been used to analyze text from newspapers to social media in a variety of ways. For this report, the following content analysis techniques were developed:

A hybridized methodology developed in Brown et al. (2011) called "*content analysis with stance indications*" is used as a starting point. The method is a computer-assisted quantitative technique to determine the professionals' feelings regarding a number of separate thematic areas. The original themes chosen are as follows:

- Increase cost
- Decrease cost

- Increase Level of service (LOS)
- Decrease LOS
- Other, irrelevant to analysis or does not fit any other theme

The first four themes reflect the purpose of the analysis; to determine FDOT's Asset Maintenance Contracts (more specifically performance-based maintenance contracts) effect on cost and LOS for any given asset. During the execution of the method, it became apparent that the selected themes were too narrow in scope, and more themes needed to be added to realize the full benefit of the content analysis. The finalized list of themes were as follows:

- Factors affecting cost
- Factors affecting LOS
- Scoping
- Assessment and performance measures
- Procurement and bidding
- Contract management and control
- Other, irrelevant to analysis or does not fit any other theme

Two members of the research team completed the analysis process. The process, which uses Microsoft Word™ and Excel™, was adapted from Brown et al. (2011), and is as follows:

1. Start with sample word from compiled and filtered list.
2. Place cursor at top of page of paginated file.
3. Using the "Editing/Find" button under Home tab in Word, click "more" button.
4. Click on "find all word forms" option.
5. Type word into dialogue box.
6. Under Reading Highlight button, select "Highlight all".
7. Scroll through document to find each highlighted word.
8. Once at the highlighted word, determine which of the seven thematic regions is most closely associated with the word meaning or inference.
9. Use Excel scoring sheet (provided separately) to sort each score into one of seven themes.
10. Once all word or word form occurrences were covered, the total number of checks for each theme was recorded.
11. Go back to the start of the document and place cursor at the top of journals.
12. Repeat steps 1-13 for all words
13. The themes were ranked with the theme with the most tallies first and the theme with the least last.

3.3 RESULTS

3.3.1 Statistical Analysis

The numerical data from the survey responses was divided into the three groups mentioned above (FDOT, contractors, and other DOTs). As shown in Appendix B, a standard Likert scale was used for the survey answer choices as follows:

- Completely Disagree = 1
- Somewhat Disagree = 2
- Neutral = 3
- Somewhat Agree = 4
- Completely Agree = 5

A summary of the questions, responses, and statistical data from the survey are presented in Tables 3-1 and 3-2 on the following pages. The significant results of the one-way ANOVA and Tukey HSD (honest significant difference) post hoc tests are discussed below. Raw data are presented in Appendix B.

3.3.1.1 Question 1

As indicated in Appendix B and Table 3-2, the first question asked respondents about their opinions of different contract-types. More specifically, the question said, "Please indicate your position on whether or not the following types of maintenance contracts typically have successful outcomes." Results showed that the following question and group pairs were observed to have statistically significant differences in opinion:

- FDOT vs. Contractors for unit-price contracts ($p = 0.0017$)
- FDOT vs. Contractor for work-order oriented contracts ($p = 8.01 \times 10^{-8}$)

These results appear to indicate that FDOT personnel are more confident in the success of unit-price and work-order oriented contracts than the Contractors group.

Table 3-2. Survey Questions 1 and 2

	FDOT			Contractor			Other DOT		
Question 1: Contract Type Success	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses
PBMC	3.56	1.01	43	4.13	0.97	23	3.4	1.14	5
Unit-Price	4.11	0.84	44	3.38	0.97	24	4.4	0.55	5
Lump Sum	4.07	0.78	45	3.68	0.99	25	3.6	1.14	5
Work-Order Oriented	4.55	0.63	44	3.38	0.97	24	4	0.71	5
Question 2: Statement Agreement	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses
PBMC results in cost savings	3.5	1.05	50	4.52	0.64	27	3.2	0.84	5
PBMC requires less administration	3.5	1.13	50	4.07	1	27	3.4	1.14	5
PBMC increases innovation potential	3.42	1.14	50	4.37	0.93	27	4	1.22	5
PBMC results in improved LOS	2.76	1.04	50	4.11	0.89	27	3	1.22	5
PBMC allows for more stable budget forecasting	3.76	1.02	50	4.44	0.93	27	4.2	0.84	5
PBMC requires less in-house staff	3.9	1.09	50	4.26	1.06	27	3.8	1.1	5
For PBMC, cost savings are not realized until at least one year into contract	2.96	0.92	50	3.26	1.26	27	2.8	1.48	5
For PBMC, Level of Service increase is not realized until at least one year into contract	2.72	0.95	50	3.22	1.19	27	3	1.58	5

Table 3-3. Survey Questions 3 and 4

	FDOT			Contractor			Other DOT		
Question 3: PBMC Type Success	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses
Area wide PBMC covering a subunit of the state for one activity or related group of activities	3.44	1.11	50	3.3	1.41	27	3.4	0.55	5
Area wide PBMC for more than one activity or related group of activities	3.66	1.02	50	4.04	1.13	27	3.6	0.55	5
Area wide PBMC covering all or most activities within a subunit state	3.86	1.07	50	4.59	0.75	27	3.4	1.52	5
PBMC for selected activities within a corridor	3.58	1.07	50	3.89	1.09	27	3.4	1.34	5
PBMC for fence-to-fence maintenance covering all activities in corridor	4.02	1.04	50	4.7	0.82	27	3.4	1.52	5
Question 4:	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses	Mean	Stan. Dev.	Responses
Percentage of work to be done by principle contractor	58.65	19.13	49	52.74	23.15	27	54.4	27.33	5
Possible incentive amount (percent of contract)	23.86	24.05	50	24.44	19.88	27	33	38.34	5
Possible disincentive amount (percent of contract)	45.8	31.4	50	24.52	17.84	27	44.4	37.24	5

3.3.1.2 Question 2

As indicated in Appendix B and Table 3-2, the second survey question dealt with effects of performance-based maintenance programs. Specifically, the question read, "Please indicate your position on the following statements" while available responses dealt with PBMC versus other contract-types. The following group pairs were observed to have significantly significant differences in opinion:

- FDOT vs. Contractors for "PBMC result in cost savings" ($p = 0.0000186$)
- FDOT vs. Contractors for "PBMC increases innovation potential" ($p = 0.000401$)
- FDOT vs. Contractors for "PBMC results in improved LOS" ($p = 2.2E\text{-}07$)
- FDOT vs. Contractors for "PBMC allows for more stable budget forecasting" ($p = 0.005044$)

Holistically, it would appear that respondents were more confident in PBMC's budget forecasting, lower in-house staff requirements, and cost savings than they were regarding LOS. These factors are noted in previous literature. For example, recall from Chapter 2 that Radovic et al. (2014) cited contract length as a means for stabilized budgeting. Hyman (2009), Stankevich (2005), and Zietlow (2005a) reported staff reduction and cost savings as prominent advantages of PBMC. The Contractor group was significantly more confident in the items listed above than FDOT personnel.

3.3.1.3 Question 3 and Question 4

As indicated in Appendix B and Table 3-3, questions 3 and 4 were more group-specific, in-depth questions about performance-based maintenance contracting. For these questions, the following question and group pairs are observed to have statistically significant differences in opinion:

- FDOT vs. Contractors for "Area wide PBMC covering all or most activities within a subunit state" ($p = 0.002255$)
- FDOT vs. Contractors for "PBMC for fence-to-fence maintenance covering all activities in corridor" ($p = 0.004231$)
- Other DOT vs. Contractors for "PBMC for fence-to-fence maintenance covering all activities in corridor" ($p = 0.008194$)

Analyzing the data as a whole, respondents were most confident in "PBMC for fence-to-fence maintenance covering all activities in corridor". The other contract types averaged above "neutral", but not significantly. All three groups averaged above "Neutral" for fence-to-fence contracts, but the Contractors group was significantly more confident than the other groups regarding the contract type's success. As discussed in Chapter 1, fence-to-fence style contracts are often a popular form of PBMC, and these styles of contracts have been used "successfully" in Virginia and Australia (Segal et al. 2003).

There was no statistical difference between the three groups regarding the minimal percent of work that should be done by the contractor. In fact, all three groups had a wide range of values for this question.

3.3.1.4 Question 5

For question 5 (PBMC-type experience), all three groups report having the most experience with "PBMC for fence-to-fence maintenance covering all activities in corridor". The FDOT group reported "PBMC for selected activities within a corridor" as the second and "Area wide PBMC for more than one activity or related group of activities" as the third type of contract they have the most experience with. The Contractor groups reported the same two contracts as second and third, but in the reverse order.

3.3.1.5 Other Questions

The following results are reported from the rest of the question responses:

- Contractors group recommends between six and fourteen year term lengths
- Other DOT group consider the following to be the predominant reasons for not using PBMC: lack of cost savings, poor contractor selection process, and level of service either the same or worse.

3.3.2 Content Analysis

The textual data was prepared by paginating all interview responses (8 total interviews) and relevant survey responses (open discussion question responses from all survey respondents) into one word document. The responses contained 7390 words. A word counter application, wordcounter.net, was used to count the words that occurred most frequently. The list of words and their respective percentages of the total text was as follows:

- Contractor, contractors (1.75 %)
- Contract, contracts (1.95 %)
- Work (1.03 %)
- Performance (0.99 %)
- Maintenance (0.65 %)
- PBMC (0.64 %)
- Cost, costs (0.57 %)
- Risk (0.42 %)
- Expectations (0.37 %)

- Good (0.35 %)
- Scope (0.32 %)
- Term (0.42 %)
- Clear (0.3 %)

This represented approximately 10% of total word count. Two coders (Co-PI Brown and Graduate Assistant Fuller) scored each word or word group into one of the general themes discussed in Section 3.2.2.1 (with lowest scores representing highest rating). The theme which scored the majority of the words was "most dominant" from a CA perspective. At the end of the process, all scores were summed to determine which theme was "most important" based upon the independent coders' average results (Table 3-4).

Table 3-4. Averaged Coder Ranks

	Coder 1	Coder 2	AVG Score
Factors affecting cost	6	3	4.5
Factors affecting LOS	7	6	6.5
Scoping	1	4	2.5
Assessment and Performance measures	3	1	2
Procurement and Bidding	4	7	5.5
Contract management and control	2	2	2
Other	5	5	5

The top three themes, as identified by the rank averaging, were contract management and control, assessment and performance standards, and scoping; which received averaged ranks of 2, 2, and 2.5 respectfully.

3.4 DISCUSSION

3.4.1 Contract Management and Control

The nature of PBMCs is such where some amount of control is shifted from the contracting agency to the contractor. The amount of control-shift and redistribution of management responsibilities between the two parties is where conflict tends to arise. Since the contractor is responsible for measuring performance of the asset and deciding when and how he or she is going to perform the work, it is intuitive that most of the control and management responsibilities is theirs. Nevertheless, the contracting agency is responsible for ensuring any given asset is safely fulfilling its purpose to the public. The inherent implication is that both parties must understand and adhere to the contractual requirements they agreed to. For this to happen, it is beneficial for the agency and contractor to establish a strong trusting relationship to realize the benefit of PBMC.

Based on the text analyzed, most respondents seem to have a good understanding of the points made, but more progress needs to be made. For example, contractors should make sure they are not taking advantage of the control by basing their work around when an asset will be assessed by the agency, but rather base their work around efficiently and consistently maintaining the asset. On the other hand, the agency personnel should, at least initially, trust the contractor to manage the asset ethically because spending excess time and resources overseeing the contractor negates the desired benefit of the contract and creates a relationship of distrust. The consensus of the responses is that the risk should always remain shared to some extent, but the entity with the greatest ability to manage the control and risk should hold the majority. Also, partnering at the beginning of the contract could be beneficial to improving overall trust between agency and contractor staff. Lastly, staff training was mentioned as important by both agency and contractor respondents given the fact that this procurement approach is still new. Training has the benefit of acclimating employees with little PBMC experience to the requirements and expectations of each party.

3.4.2 Assessment and Performance Standards

With regard to assessment and performance measures, the two most overwhelmingly mentioned characteristics are clear and measureable. These characteristics are important for both agency and contractor because both parties need to clearly understand the assessment and performance requirements so there is no discrepancy between the Level of Service the contractor is trying to maintain and what the agency is assessing. Similarly for measurability, ambiguous criterion will lead to conflict and possibly litigation if the two parties have the ability to perceive the standards differently. Similar conclusions were reached by Hoffman et al. (2010). Also, the use of incentives and disincentives should be clearly delineated in the scope of work and there should be a “meeting of the minds” between agency and contractor senior staff on how each will be applied during the term of the contract.

3.4.3 Scoping

The results of scoping were similar to the previous section in that the scope needs to be clearly stated. The ability to interpret scope responsibilities of the contractor on any amount of a spectrum will typically lead to conflict and distrust which does not benefit the contract. Different contractors have different capacities to perform work and these considerations should be taken into account and understood by both parties before a contract is ultimately awarded.

3.5 SURVEY CONCLUSIONS

A considerable amount of the novel results were rendered from the two analysis techniques used in this study while others were in general agreement with conclusions made by others highlighted previously. The following new conclusions are drawn from this research effort (conclusions in agreement with previous literature were cited previously in the appropriate section).

- Contractors surveyed and interviewed are notably more confident in the success of PBMC than the agency personnel participants
- Comprehensive cost and performance data needs to be kept in order to quantitatively compare the various contracting types successfully
- Highway agencies are encouraged to perform detailed estimates of their respective administrative costs for various contract types because this is a difficult factor to estimate post factum
- As PBMC is new and unique, agencies and contractors without experience would benefit from partnering in order to minimize the chance of contract default or failure
- The risk associated with PBMC should always remain shared, with the majority of the risk falling on the entity with the greatest capacity to manage it
- The scope, assessment methods, and performance measures of a PBMC, or any maintenance contract for that matter, should be clear, measurable, and unambiguous to avoid conflict and relationship strains.

4 DATA COMPARISON

4.1 INTRODUCTION

Recall from Chapter 2, the Fallah-Fini et al. (2012) study found that in Virginia, their PBMC program was less efficient than non-PBMCs. A number of reasons were given for this. First, Fallah-Fini et al. (2012) pointed out that Virginia's PBMC program was relatively new while traditional contracts had been used for many years. As a result, "best practices" associated with non-PBMCs have already been well-established while contractors need time to establish "best practices" for PBMCs. Secondly, Fallah-Fini et al. pointed out that their model was based heavily on LOS. They suggested that Virginia might want to use other criteria to evaluate roadways other than LOS because it would better-fit the purpose of a PBMC. In this chapter, following Fallah-Fini et al. (2012) a meta-frontier approach was used to estimate Florida's AMC efficiencies relative to its non-AMCs.

4.2 METHODOLOGY

As discussed in Chapter 2, the weakness of any DEA model is that the selected inputs/outputs have a significant effect on the efficiency results. If incorrect inputs or output are chosen, results may not accurately reflect true efficiency. Or, more subtly, if all inputs/outputs are not accurately captured or are not really indicative of the DMUs' underlying processes, results will similarly be negatively affected.

4.2.1 Fallah-Fini et al. (2012)

As discussed in Chapter 2, during this project, much like the Fallah-Fini et al. (2012) study, DEA models were applied to FDOT data to develop group frontiers, meta-frontiers, and associated MTRs. The input to the DEA algorithms, cost, was the same criterion that was used by Fallah-Fini et al. (2012). This input criterion should be fairly obvious for all sorts of PMBC/AMC analyses. However, the outputs used during this study were different from the outputs used by Fallah-Fini et al. (2012).

As stated in Chapter 2, Fallah-Fini et al. (2012) used "lane miles served" and a "pavement condition" variable as outputs. Their "pavement condition" variable was change in Critical Condition Index (CCI) – the condition of a road section with respect to the load-related and non-load-related distresses. The former output quantifies the amount of work completed while the latter output quantifies quality. Their argument for using pavement condition's derivative was that Virginia was paying for maintenance; therefore conditions should improve.

The distance scale used by Fallah-Fini et al. (2012) was relatively, advantageously small in that they were able to analyze data on a county-by-county, year-by-year basis such that within a given county in a given year, all PBMC contracts were grouped into a "super-PBMC" while non-PBMCs were grouped into a "super-non-PBMC." Additionally, as discussed in Chapter 2, their input/output pairs consisted of mileage *where work was conducted* and not necessarily *miles of road under contract*. This subtle distinction is important.

These input/output pairs were used to compute group frontiers, an estimated meta-frontier, and associated MTRs. Bootstrapping was used to improve the statistical relevance of their results. After MTRs had been estimated, Fallah-Fini et al. (2012) went on to draw correlations between efficiency scores and various uncontrollable factors – terrain, weather, traffic load, and contract-type.

4.2.2 Modified Method

The Fallah-Fini et al. (2012) methodology was excellent, but it can be improved because of FDOT's excellent record keeping. In particular, Florida has recognized that roadways should be measured not just according to LOS (or CCI), but in terms of other factors. As stated in Chapter 2, since 2009, FDOT has been tracking cost expenditures and quantities according to each contract-type on a district-by-district scale associated with the following items:

1. Mileage on rural roadways (RR; miles)
2. Mileage on urban roadways (UR; miles)
3. Facility maintenance (FM; i.e. maintenance of rest areas, etc.; number of facilities)
4. Rest area security (RAS; number of facilities)
5. Bridge inspections (BI; square feet of bridge deck)
6. Bridge maintenance (BM; square feet of bridge deck)
7. Ancillary structure maintenance (AS; number of structures)
8. Quality rating (MRP scores)

Data of these quantities for items 1 through 7 and associated funding are presented in tabular form below:

Table 4-1. Bar Chart Data for AMCs (FUND is in millions of dollars)

	District	1	2	3	4	5	6	7	8
	RR	329	370	629	307	399	69	147	103
	UR	87	355	313	298	37	100	90	135
	FM	6	17	14	1	8	0	5	0
	RAS	6	0	14	1	8	0	5	0
	BI	18477	0	12395	7955	3000	13220	24182	0
	BM	12737	0	10235	7709	2917	13220	18983	0
	AS	1444	0	578	419	250	418	1632	0
2010 Bar Chart (FY0809)	**FUND**	21.69	23.51	20.32	18.73	14.77	10.86	15.42	8.37
	RR	329	343	624	275	539	65	167	103
	UR	87	355	266	324	83	106	70	133
	FM	8	30	19	1	12	0	5	0
	RAS	6	0	14	1	8	0	5	0
	BI	18658	0	9034	7983	3118	13290	26210	0
	BM	12925	0	8483	7713	3036	13290	21169	0
	AS	1405	0	480	460	265	435	1981	0
2012 Bar Chart (FY1011)	**FUND**	22.53	22.72	19.68	18.87	12.84	10.71	17.15	9.41
	RR	401	909	625	275	544	79	176	150
	UR	125	512	269	346	89	106	144	198
	FM	8	30	19	5	14	0	5	0
	RAS	6	17	14	5	10	0	5	0
	BI	18690	1546	8983	10798	3075	13361	27920	0
	BM	13672	1546	8459	10518	2989	13361	23027	0
	AS	1586	252	469	503	285	425	1973	0
2014 Bar Chart (FY1213)	**FUND**	23.03	21.03	22.54	18.86	17.89	10.89	13.54	9.35
	RR	395	913	805	244	657	109	145	157
	UR	125	415	410	386	298	342	282	193
	FM	7	30	19	5	14	0	5	0
	RAS	6	17	14	5	10	0	5	0
	BI	19012	1547	9034	15758	3182	13960	26824	1333
	BM	13171	1547	13758	11308	4451	13960	21761	1333
	AS	1697	274	649	1148	313	607	1526	8
2015 Bar Chart (FY1314)	**FUND**	24.69	23.31	21.52	21.92	18.22	10.44	16.86	9.26
	RR	395	924	401	210	807	88	199	152
	UR	125	379	381	421	93	191	503	198
	FM	7	30	19	5	14	0	5	0
	RAS	5	17	14	5	10	0	5	0
	BI	19479	1547	5497	14210	3003	13899	27002	1547
	BM	13872	1547	9407	14243	3247	13899	27002	3148
	AS	3089	275	1200	1154	355	727	3340	8
2016 Bar Chart (FY1415)	**FUND**	25.67	28.20	25.63	26.41	20.89	11.53	15.96	11.55

Table 4-2. Bar Chart Data for Non-AMCs (FUND is in millions of dollars)

	District	1	2	3	4	5	6	7	8
	RR	674	1366	1079	0	442	61	93	47
	UR	776	467	371	773	1242	470	745	171
	FM	0	0	0	4	2	0	0	8
	RAS	0	17	0	4	2	0	0	8
	BI	0	26988	11434	15698	18973	9760	2084	9074
	BM	0	24444	8554	11861	14183	6454	2084	9074
	AS	0	2390	925	1999	1833	1017	0	1454
2010 Bar Chart (FY0809)	**FUND**	29.01	43.03	34.67	34.18	51.52	14.45	27.61	38.54
	RR	666	1394	1084	0	220	62	47	47
	UR	753	465	413	610	1118	423	734	173
	FM	0	0	0	4	2	0	0	8
	RAS	0	17	0	4	2	0	0	8
	BI	0	27842	14908	15944	19092	10225	0	9096
	BM	0	25140	10353	11856	14587	6496	0	9096
	AS	0	2424	632	2368	1884	1640	0	1536
2012 Bar Chart (FY1011)	**FUND**	35.57	50.07	32.79	40.09	55.56	22.33	28.54	25.49
	RR	594	827	1096	0	215	48	37	0
	UR	715	308	410	588	1112	423	659	108
	FM	0	0	0	0	0	0	0	8
	RAS	0	0	0	0	0	0	0	8
	BI	0	26296	14959	13097	19135	10069	0	9096
	BM	0	23594	10378	9051	14634	6424	0	9096
	AS	0	2439	734	2639	2006	1761	0	1485
2014 Bar Chart (FY1213)	**FUND**	40.85	56.17	35.12	44.21	48.62	22.87	30.92	20.45
	RR	512	747	912	48	0	0	0	0
	UR	806	480	282	535	987	206	597	128
	FM	0	0	0	0	0	0	0	8
	RAS	0	0	0	0	0	0	0	8
	BI	0	26669	15290	9584	19781	9565	0	9093
	BM	0	24057	7137	8884	13857	5715	0	9093
	AS	0	2487	675	2168	2150	1856	0	2204
2015 Bar Chart (FY1314)	**FUND**	31.28	46.87	38.96	28.77	44.79	23.69	27.26	21.20
	RR	512	736	1303	82	0	22	0	5
	UR	806	516	304	500	1101	319	345	123
	FM	0	0	0	0	0	0	0	8
	RAS	0	0	0	0	0	0	0	8
	BI	0	27046	19034	11293	20401	10082	0	9222
	BM	0	24259	9810	6092	15274	6175	0	7621
	AS	0	4170	1070	4549	3437	4236	0	1288
2016 Bar Chart (FY1415)	**FUND**	38.63	49.33	36.94	31.31	51.36	23.67	27.08	37.98

It would appear that the physical quantities shown here (items 1 through 7) may be more in-line with the “analysis beyond LOS” that Fallah-Fini et al. (2012) were discussing. Indeed, rarely would “lane miles served” accurately describe actual output from any of FDOT’s AMCs because in Florida, AMCs may consist of several items from 1 through 7 above that are fundamentally independent from mileage.

Likewise, it would appear that MRP score does a more-appropriate job of capturing the “spirit” of the AMC program than LOS in that the purpose of the program is not really to significantly improve the condition of roadways. Rather, the purpose of the AMC is to keep roads at a certain minimum standard throughout the year. The AMC-specific AMPER score would also be an appropriate rating methodology in Florida, but the only way to compare AMCs to non-AMCs is to rate each contract type according to the same scale. As per the discussion in Chapter 2, non-AMCs are not rated via AMPER scale.

Thus, items 1 through 7 were used along with MRP score (please see below) as the models’ outputs.

Following Fallah-Fini et al. (2012) the technique used during this study was to group contract-types by some sort of contract zone. In Florida, the only feasible methodology for doing this was to use a district-wide scale such that all AMCs within a certain district per year were lumped together in a “district-wide super-AMC.” Likewise, all non-AMCs within a given district in a given year were lumped together as a “district-wide super-non-AMC.” The disadvantage to this approach was that relating MTRs to uncontrollable factors was not possible on such a scale because within a district, variables such as weather, terrain, or traffic load are almost certainly highly-variable due to the districts’ large size (Figure 4-1). While this is one instance where the Fallah-Fini et al. (2012) approach might be better than the approach presented here, it is the only solution that will work in Florida because many Florida contracts span multiple counties within a district. As a result, arbitrarily splitting up cost between these counties would not be possible without making some very crude, unverifiable assumptions.

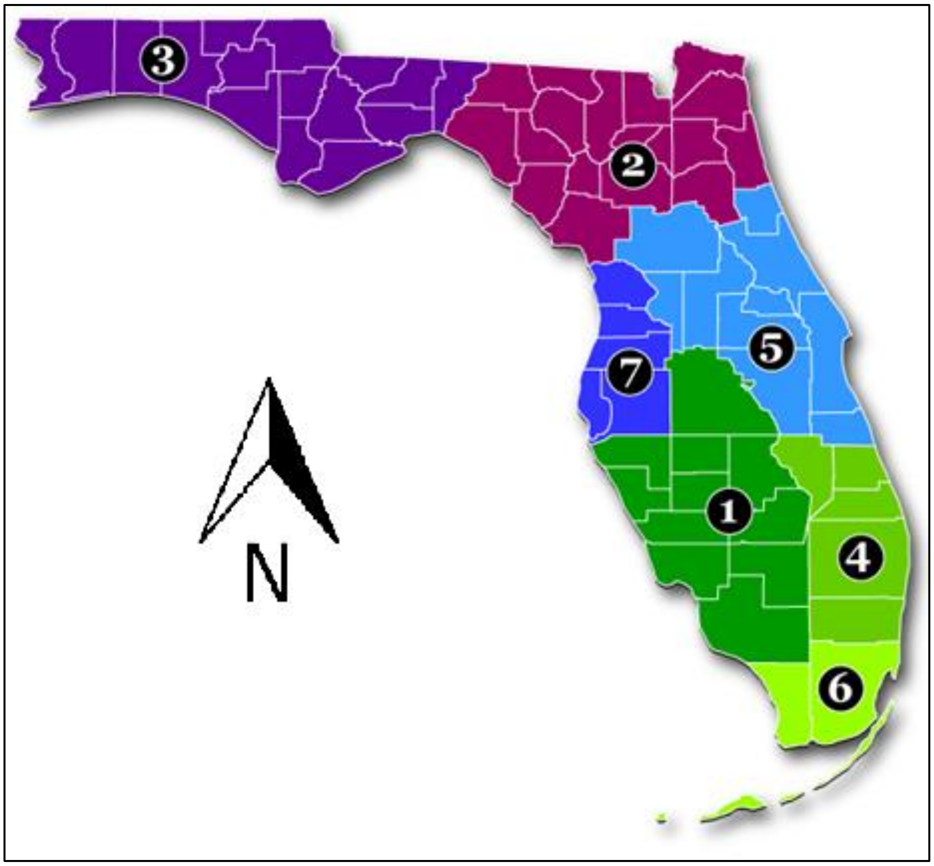


Figure 4-1. FDOT District Map

As alluded to in Chapter 2, the "super-contracts" outputs were assumed to be static in that if a physical maintenance item in a district was not covered by an AMC, it was by definition assumed to be covered by a non-AMC. Thus, cost could increase (until the ceiling was met) to cover more maintenance. Or, put another way, the driving factor behind the modeling conducted here was cost savings rather than increasing output. As implied here and discussed in Chapter 2, this means that an i-o DEA analysis was used.

Table 4-1 and Table 4-2 provide 80 sets of inputs/outputs for meta-frontier computation and 40 input/outputs for computation of the group frontiers (8 districts times 5 years times 2 contract types). This is a fairly limited number of data points, but as discussed by Cooper et al. (2007), a rule of thumb for DEA application is that the number of DMUs need to exceed the maximum of the product of inputs/outputs or three times the sum of inputs/outputs. In the case of analysis in this report, this means that more than 27 DMUs are required for each group frontier computation.

4.2.3 Inflation

Using cost as an input for a multi-year DEA analysis assumes that all dollars are equivalent from year-to-year. Of course, this is not the case because of inflation. Another point of departure from the Fallah-Fini et al. (2012) study was that in Florida, inflation was taken into account. Inflation methodology was based upon consumer price index (CPI) so that all funds were converted to 2016 dollars (http://data.bls.gov/cgi-bin/cpicalc.pl).

4.2.4 The Effect of Quality

As stated above, MRP score captures the "spirit" of the AMC program more accurately than a strict LOS estimate. As such, raw MRP data were obtained for each roadway per district per year and used to compute average MRP score in their respective districts during each year studied (Table 4-3 and Table 4-4).

Table 4-3. MRP Score Summary for AMCs

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	87.91	92.39	91.14	89.10	89.63	90.03
2	83.68	81.85	78.10	79.62	81.81	81.01
3	80.89	79.34	84.93	87.18	86.78	83.82
4	85.95	87.02	86.24	84.92	83.18	85.46
5	88.56	89.49	88.75	89.77	88.33	88.98
6	88.13	87.99	89.41	90.06	84.83	88.08
7	89.35	87.95	89.76	90.12	91.22	89.68
8	94.67	93.97	92.78	92.26	90.63	92.86
Mean	87.39	87.50	87.64	87.88	87.05	
				Overall Mean =		87.49
				Overall Std. Dev. =		3.82

Table 4-4. MRP Score Summary for Non-AM Contracts

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	86.30	89.40	89.96	89.07	91.50	89.24
2	80.11	80.49	77.39	79.30	81.81	79.82
3	86.55	85.07	87.31	87.07	87.57	86.71
4	84.54	89.02	88.54	89.45	87.29	87.77
5	85.06	84.47	83.46	85.27	82.08	84.07
6	82.13	84.03	87.75	85.81	84.96	84.94
7	82.93	84.98	90.02	90.17	91.00	87.82
8	87.37	87.48	82.16	84.97	80.55	84.51
Mean	84.37	85.62	85.82	86.39	85.84	
				Overall Mean =		85.61
				Overall Std. Dev. =		2.96

It should be noted that these scores were computed from FDOT "mainframe" data (MF). In addition to the MF data, FDOT keeps a separate set of AM MRP scores known as the "MRP Scorecard System" (MRPSS). As shown on the MRP data sheet in Appendix A, the MRP sub-components are given 'Yes" (Y) or "No" (N) scores to signify whether or not the contractor adequately performed the specified work in that sub-category. When AMCs are scored, a third option is to rate a subcomponent with an "X." The X signifies that there was an issue with the sub-component, but this issue was not the contractor's fault.

Additionally, in order to make MRP scores more statistically significant, the MRPSS scores are computed at more points than the MRP MF scores. And, in the MF, an X is not a possible value. In a strict sense, an X score in the context of MRPs should really be considered an N score because if a non-AMC were to be used, the issue associated with the X would be addressed.

After conducting their analysis, investigators became aware of this X vs. N potential issue. To address this, the scores above (Table 4-3) were compared with mean scores from the MRPSS where MRPSS Xs were replaced with Ns. Fortuitously, no statistical difference was found. In fact, the MRPSS mean score was slightly higher than the MF mean score – 87.49 for MF vs. 87.75 for MRPSS. This led to a Kruskal-Wallis p-value of 0.83 which is implies that the probability that the means are not from the same population is very low (i.e. 17%). In other words, there was no significant statistical difference between MF scores and MRPSS scores with X replacement. The reason for this is that inclusion of more data points results in enough added Y scores to more than balance out the inclusion of X scores. Thus, investigators concluded that the data in Table 4-3 was sufficient and analysis did not need to be repeated.

4.2.5 DEA Model Runs and Analysis

4.2.5.1 Model Runs with MRP Scores

To summarize, DEA model runs were conducted using an i-o model and the following output/input groups:

Input:

- Inflated cost (cost in 2016 dollars)

Outputs:

- Mileage on rural roads = RR
- Mile on urban roads = UR
- Facilities maintenance = FM
- Rest area security = RAS

- Bridge inspections = BI
- Bridge maintenance = BM
- Ancillary structures = AS
- MRP Score

As stated in Chapter 2, based upon previous literature, VRS models were assumed throughout this study. Following several authors in the literature, each bootstrap model run was repeated for 1,000 repetitions. Group frontiers and meta-frontiers were computed for both the bootstrapped and non-bootstrapped model. Additionally, upper and lower bounds were computed using 95% confidence intervals. Bootstrapped results were used to compute MTRs. Appropriate means were taken throughout.

4.2.5.2 The Effects of "Subtle" Costs

Many have argued that "subtle cost" savings are a major advantage of PBMCs. People have pointed out that outsourcing contract management from the government to private contractors allows the government to save funds by reducing its role in administration. Contractors will be forced to absorb these duties. Theoretically, the contractor has incentive to perform these duties more efficiently than the government because of competition. Therefore, overall cost should decrease under a PBMC program.

It is very difficult to take these subtle administrative costs into account quantitatively, and as will be shown below, even without taking these subtle effects into account, Florida's AMCs, on average, perform much more efficiently than traditional contracts. In principle though, each "subtle component" represents a dollar amount. Investigators ran an analysis whereby these subtle factors were assumed to cost the department $500,000, $1,000,000, $2,500,000, $5,000,000, and $10,000,000 per district per year when traditional contracts were used. Mathematically, these dollar amounts were simply added to the cost input for non-AMCs. This analysis represents some possibilities if it were possible to accurately describe the subtle cost impact and probably covers a realistic range of likely administrative cost savings that might accrue. Once again, for each case, group frontiers, meta-frontiers, and MTRs were computed and compared with raw data.

4.2.5.3 The Effect of MRP Score

As stated in Section 4.2.2, the criticism in using an i-o method may be that MRP scores are not truly "static." As will be shown below, AMCs actually score statistically better MRP scores than non-AMCs. Some may wonder whether or not this tends to "push" AMCs toward a better score when the i-o model is used. To account for this a series of runs was conducted whereby MRP score was eliminated as an output.

4.2.5.4 Statistics

Once MTR scores had been computed, Kruskal-Wallis tests were conducted to compare MTR means between the AM and non-AM contract types to determine if their mean MTR scores were significantly different from one another. A Kruskal-Wallis test was also conducted to analyze mean MRP score difference between contract types.

4.2.5.5 Graphical Analysis

Additionally, graphs were prepared whereby mean MTR score was plotted as a function of year using both statewide and district-wide data. Best-fit least squares regression lines were fit to the data in order to establish MTR trends over time.

4.2.5.6 Programming Method

Initially, investigators programmed their own algorithm in MATLAB. Results were checked with known example problem answers and results from the University of Queensland's Centre for Efficiency and Productivity Analysis' Data Envelopment Analysis (Computing) Program (DEAP) – a well-known DEA code that has been used since the 1990s. Results compared well with one another.

In researching methods for implementation of the bootstrapping algorithms, investigators found a suite of programs written by Alvarez et al. (2016) of Universidad Autonoma de Madrid (UAM) – DEA Toolbox. DEA Toolbox is a series of MATLAB codes that computes CCR/BCC models, their bootstrap variants, and many other tools common in DEA. These codes were much more efficient computationally than codes written by investigators, and their results were correct when compared with DEAP and investigators' codes. As a result, DEA Toolbox was used for computations throughout this study.

4.3 RESULTS

4.3.1 Model Runs with MRP Score and without Administrative Costs Added

Group frontiers, bootstrapped group frontier scores, and associated upper/lower-bound confidence intervals are presented in Table 4-5 and Table 4-6. Meta-frontier scores, bootstrapped meta-frontier scores and associated upper/lower bounds are presented in Table 4-7 and Table 4-8. Bootstrapped results are presented by district/year from Table 4-9 through Table 4-12. MTR results are presented in Table 4-13 and Table 4-14. Graphical results are presented from Figure 4-2 through Figure 4-3 with error bars denoting upper/lower 95% confidence interval bounds.

4.3.2 Model Runs with MRP Scores and with Administrative Costs Added

To be concise, only the MTRs from the subtle cost analysis are presented here in tabular form (Table 4-15 through Table 4-24). Statewide graphical data are presented from Figure 4-4 through Figure 4-8.

4.3.3 Model Runs without MRP Scores

MTR results for the case without MRP scores are presented from Table 4-25 through Table 4-26. Graphical data are presented in Figure 4-9 and Figure 4-10.

Table 4-5. Group Frontiers for AMCs

DMU	Efficiency	Boostrapped Efficiency	Bootstrap Lower Bound (95% Confidence Interval)	Bootstrap Upper Bound (95% Confidence Interval)
AMC 2009 D1	0.59	0.56	0.53	0.59
AMC 2009 D2	0.62	0.58	0.54	0.61
AMC 2009 D3	1.00	0.88	0.71	0.99
AMC 2009 D4	0.60	0.57	0.54	0.59
AMC 2009 D5	0.83	0.78	0.72	0.82
AMC 2009 D6	0.87	0.83	0.78	0.86
AMC 2009 D7	0.79	0.75	0.70	0.79
AMC 2009 D8	1.00	0.87	0.71	0.99
AMC 2011 D1	1.00	0.87	0.71	0.99
AMC 2011 D2	1.00	0.88	0.71	0.99
AMC 2011 D3	0.98	0.92	0.87	0.97
AMC 2011 D4	0.62	0.58	0.55	0.61
AMC 2011 D5	1.00	0.90	0.81	0.99
AMC 2011 D6	0.92	0.89	0.83	0.92
AMC 2011 D7	0.76	0.72	0.66	0.76
AMC 2011 D8	0.93	0.87	0.76	0.93
AMC 2013 D1	1.00	0.87	0.71	0.99
AMC 2013 D2	1.00	0.87	0.71	0.99
AMC 2013 D3	0.92	0.85	0.77	0.91
AMC 2013 D4	0.70	0.66	0.64	0.70
AMC 2013 D5	0.89	0.83	0.77	0.88
AMC 2013 D6	0.94	0.89	0.83	0.93
AMC 2013 D7	1.00	0.88	0.72	0.99
AMC 2013 D8	1.00	0.92	0.86	0.99
AMC 2014 D1	0.65	0.61	0.56	0.65
AMC 2014 D2	1.00	0.87	0.71	0.99
AMC 2014 D3	1.00	0.87	0.71	0.99
AMC 2014 D4	0.64	0.61	0.58	0.64
AMC 2014 D5	1.00	0.87	0.71	0.99
AMC 2014 D6	1.00	0.89	0.78	0.99
AMC 2014 D7	0.86	0.80	0.72	0.85
AMC 2014 D8	1.00	0.92	0.87	0.99
AMC 2015 D1	1.00	0.87	0.71	0.99
AMC 2015 D2	1.00	0.87	0.71	0.99
AMC 2015 D3	1.00	0.87	0.71	0.99
AMC 2015 D4	0.54	0.50	0.46	0.53
AMC 2015 D5	1.00	0.88	0.72	0.99
AMC 2015 D6	0.93	0.88	0.83	0.92
AMC 2015 D7	1.00	0.87	0.71	0.99
AMC 2015 D8	0.82	0.77	0.73	0.81
Average =	0.89	0.80	0.71	0.88
Standard Dev. =	0.15	0.12	0.10	0.15

Table 4-6. Group Frontier Results for Non-AMCs

DMU	Efficiency	Boostrapped Efficiency	Bootstrap Lower Bound (95% Confidence Interval)	Bootstrap Upper Bound (95% Confidence Interval)
Non-AMC 2009 D1	1.00	0.94	0.85	1.00
Non-AMC 2009 D2	1.00	0.94	0.83	1.00
Non-AMC 2009 D3	0.88	0.85	0.82	0.88
Non-AMC 2009 D4	1.00	0.95	0.88	1.00
Non-AMC 2009 D5	1.00	0.94	0.83	1.00
Non-AMC 2009 D6	1.00	0.94	0.83	1.00
Non-AMC 2009 D7	0.94	0.92	0.89	0.94
Non-AMC 2009 D8	0.63	0.61	0.57	0.63
Non-AMC 2011 D1	1.00	0.96	0.90	0.99
Non-AMC 2011 D2	1.00	0.93	0.83	1.00
Non-AMC 2011 D3	1.00	0.96	0.93	1.00
Non-AMC 2011 D4	1.00	0.94	0.83	1.00
Non-AMC 2011 D5	0.91	0.88	0.84	0.90
Non-AMC 2011 D6	0.83	0.80	0.76	0.83
Non-AMC 2011 D7	0.93	0.90	0.87	0.93
Non-AMC 2011 D8	1.00	0.94	0.83	1.00
Non-AMC 2013 D1	0.84	0.81	0.77	0.84
Non-AMC 2013 D2	0.81	0.79	0.76	0.81
Non-AMC 2013 D3	1.00	0.95	0.90	1.00
Non-AMC 2013 D4	0.79	0.76	0.72	0.78
Non-AMC 2013 D5	1.00	0.96	0.91	1.00
Non-AMC 2013 D6	1.00	0.95	0.87	1.00
Non-AMC 2013 D7	0.92	0.89	0.85	0.92
Non-AMC 2013 D8	1.00	0.94	0.83	1.00
Non-AMC 2014 D1	1.00	0.94	0.85	0.99
Non-AMC 2014 D2	1.00	0.97	0.93	1.00
Non-AMC 2014 D3	0.82	0.79	0.76	0.81
Non-AMC 2014 D4	1.00	0.94	0.83	1.00
Non-AMC 2014 D5	1.00	0.95	0.85	1.00
Non-AMC 2014 D6	0.90	0.87	0.83	0.89
Non-AMC 2014 D7	1.00	0.95	0.89	1.00
Non-AMC 2014 D8	1.00	0.94	0.83	1.00
Non-AMC 2015 D1	1.00	0.94	0.84	1.00
Non-AMC 2015 D2	1.00	0.94	0.83	1.00
Non-AMC 2015 D3	1.00	0.94	0.84	0.99
Non-AMC 2015 D4	1.00	0.93	0.83	0.99
Non-AMC 2015 D5	1.00	0.94	0.83	1.00
Non-AMC 2015 D6	1.00	0.94	0.83	1.00
Non-AMC 2015 D7	1.00	0.94	0.83	1.00
Non-AMC 2015 D8	1.00	0.94	0.83	1.00
Average =	0.95	0.91	0.83	0.95
Standard Dev. =	0.08	0.07	0.06	0.08

Table 4-7. Meta-Frontier Results for AMCs

DMU	Efficiency	Boostrapped Efficiency	Bootstrap Lower Bound (95% Confidence Interval)	Bootstrap Upper Bound (95% Confidence Interval)
AMC 2009 D1	0.59	0.55	0.51	0.58
AMC 2009 D2	0.62	0.57	0.52	0.61
AMC 2009 D3	1.00	0.90	0.83	0.99
AMC 2009 D4	0.60	0.56	0.53	0.59
AMC 2009 D5	0.83	0.76	0.70	0.82
AMC 2009 D6	0.87	0.82	0.76	0.86
AMC 2009 D7	0.79	0.73	0.68	0.78
AMC 2009 D8	1.00	0.83	0.64	0.99
AMC 2011 D1	1.00	0.84	0.66	0.98
AMC 2011 D2	1.00	0.83	0.66	0.99
AMC 2011 D3	0.98	0.91	0.84	0.96
AMC 2011 D4	0.62	0.57	0.54	0.61
AMC 2011 D5	1.00	0.87	0.78	0.98
AMC 2011 D6	0.92	0.87	0.81	0.91
AMC 2011 D7	0.76	0.70	0.62	0.76
AMC 2011 D8	0.93	0.84	0.71	0.93
AMC 2013 D1	0.88	0.79	0.69	0.87
AMC 2013 D2	1.00	0.83	0.65	0.99
AMC 2013 D3	0.92	0.83	0.72	0.90
AMC 2013 D4	0.70	0.65	0.62	0.69
AMC 2013 D5	0.89	0.81	0.75	0.88
AMC 2013 D6	0.94	0.87	0.81	0.93
AMC 2013 D7	1.00	0.83	0.66	0.99
AMC 2013 D8	1.00	0.90	0.83	0.99
AMC 2014 D1	0.65	0.60	0.55	0.64
AMC 2014 D2	1.00	0.84	0.67	0.98
AMC 2014 D3	1.00	0.84	0.65	0.99
AMC 2014 D4	0.64	0.60	0.55	0.63
AMC 2014 D5	1.00	0.84	0.67	0.99
AMC 2014 D6	1.00	0.86	0.76	0.98
AMC 2014 D7	0.86	0.78	0.68	0.85
AMC 2014 D8	1.00	0.90	0.84	0.98
AMC 2015 D1	1.00	0.84	0.66	0.99
AMC 2015 D2	1.00	0.83	0.66	0.99
AMC 2015 D3	1.00	0.83	0.65	0.99
AMC 2015 D4	0.54	0.49	0.45	0.53
AMC 2015 D5	1.00	0.87	0.75	0.99
AMC 2015 D6	0.93	0.86	0.81	0.92
AMC 2015 D7	1.00	0.84	0.66	0.99
AMC 2015 D8	0.82	0.76	0.71	0.81
Average =	0.88	0.78	0.68	0.87
Standard Dev. =	0.15	0.12	0.10	0.15

Table 4-8. Meta-Frontier Results for Non-AMCs

DMU	Efficiency	Boostrapped Efficiency	Bootstrap Lower Bound (95% Confidence Interval)	Bootstrap Upper Bound (95% Confidence Interval)
Non-AMC 2009 D1	1.00	0.88	0.79	0.98
Non-AMC 2009 D2	1.00	0.84	0.66	0.98
Non-AMC 2009 D3	0.79	0.72	0.65	0.78
Non-AMC 2009 D4	0.82	0.77	0.72	0.81
Non-AMC 2009 D5	1.00	0.84	0.67	0.99
Non-AMC 2009 D6	0.93	0.87	0.83	0.92
Non-AMC 2009 D7	0.93	0.88	0.84	0.92
Non-AMC 2009 D8	0.36	0.34	0.33	0.36
Non-AMC 2011 D1	1.00	0.89	0.79	0.99
Non-AMC 2011 D2	1.00	0.83	0.65	0.98
Non-AMC 2011 D3	0.93	0.86	0.80	0.92
Non-AMC 2011 D4	0.51	0.47	0.42	0.51
Non-AMC 2011 D5	0.85	0.77	0.66	0.84
Non-AMC 2011 D6	0.56	0.52	0.48	0.55
Non-AMC 2011 D7	0.92	0.88	0.84	0.91
Non-AMC 2011 D8	0.58	0.55	0.52	0.57
Non-AMC 2013 D1	0.80	0.73	0.66	0.79
Non-AMC 2013 D2	0.56	0.51	0.47	0.55
Non-AMC 2013 D3	0.95	0.86	0.74	0.94
Non-AMC 2013 D4	0.45	0.42	0.38	0.45
Non-AMC 2013 D5	1.00	0.93	0.83	0.99
Non-AMC 2013 D6	0.57	0.52	0.47	0.56
Non-AMC 2013 D7	0.76	0.70	0.64	0.75
Non-AMC 2013 D8	0.75	0.72	0.68	0.74
Non-AMC 2014 D1	1.00	0.87	0.78	0.98
Non-AMC 2014 D2	0.65	0.59	0.52	0.64
Non-AMC 2014 D3	0.68	0.63	0.58	0.67
Non-AMC 2014 D4	0.61	0.56	0.51	0.60
Non-AMC 2014 D5	0.95	0.89	0.82	0.94
Non-AMC 2014 D6	0.55	0.51	0.48	0.54
Non-AMC 2014 D7	0.76	0.71	0.65	0.75
Non-AMC 2014 D8	0.79	0.72	0.63	0.78
Non-AMC 2015 D1	1.00	0.84	0.67	0.99
Non-AMC 2015 D2	1.00	0.83	0.66	0.99
Non-AMC 2015 D3	1.00	0.84	0.66	0.98
Non-AMC 2015 D4	1.00	0.83	0.66	0.99
Non-AMC 2015 D5	1.00	0.84	0.66	0.98
Non-AMC 2015 D6	1.00	0.86	0.73	0.99
Non-AMC 2015 D7	0.42	0.38	0.36	0.42
Non-AMC 2015 D8	0.40	0.38	0.37	0.40
Average =	0.80	0.71	0.63	0.79
Standard Dev. =	0.21	0.17	0.15	0.20

Table 4-9. Group Frontier Efficiency Results for AMCs by District/Year

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.56	0.87	0.87	0.61	0.87	0.76
2	0.58	0.88	0.87	0.87	0.87	0.81
3	0.88	0.92	0.85	0.87	0.87	0.88
4	0.57	0.58	0.66	0.61	0.50	0.59
5	0.78	0.90	0.83	0.87	0.88	0.85
6	0.83	0.89	0.89	0.89	0.88	0.87
7	0.75	0.72	0.88	0.80	0.87	0.80
8	0.87	0.87	0.92	0.92	0.77	0.87
Mean	0.73	0.83	0.85	0.81	0.81	
				Overall Mean =		0.80
				Overall Std. Dev. =		0.12

Table 4-10. Group Frontier Efficiency Results for Non-AMCs by District/Year

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.94	0.96	0.81	0.94	0.94	0.92
2	0.94	0.93	0.79	0.97	0.94	0.91
3	0.85	0.96	0.95	0.79	0.94	0.90
4	0.95	0.94	0.76	0.94	0.93	0.90
5	0.94	0.88	0.96	0.95	0.94	0.93
6	0.94	0.80	0.95	0.87	0.94	0.90
7	0.92	0.90	0.89	0.95	0.94	0.92
8	0.61	0.94	0.94	0.94	0.94	0.87
Mean	0.88	0.91	0.88	0.92	0.94	
				Overall Mean =		0.91
				Overall Std. Dev. =		0.07

Table 4-11. Meta-Frontier Efficiency Results for AMCs by District/Year

	Year					
District	2009	2011	2013	2014	2015	Mean
1	0.55	0.84	0.79	0.60	0.84	0.72
2	0.57	0.83	0.83	0.84	0.83	0.78
3	0.90	0.91	0.83	0.84	0.83	0.86
4	0.56	0.57	0.65	0.60	0.49	0.57
5	0.76	0.87	0.81	0.84	0.87	0.83
6	0.82	0.87	0.87	0.86	0.86	0.86
7	0.73	0.70	0.83	0.78	0.84	0.78
8	0.83	0.84	0.90	0.90	0.76	0.85
Mean	0.71	0.80	0.81	0.78	0.79	
				Overall Mean =		0.78
				Overall Std. Dev. =		0.12

Table 4-12. Meta-Frontier Efficiency Results for Non-AMCs by District/Year

	Year					
District	2009	2011	2013	2014	2015	Mean
1	0.88	0.89	0.73	0.87	0.84	0.84
2	0.84	0.83	0.51	0.59	0.83	0.72
3	0.72	0.86	0.86	0.63	0.84	0.78
4	0.77	0.47	0.42	0.56	0.83	0.61
5	0.84	0.77	0.93	0.89	0.84	0.85
6	0.87	0.52	0.52	0.51	0.86	0.66
7	0.88	0.88	0.70	0.71	0.38	0.71
8	0.34	0.55	0.72	0.72	0.38	0.54
Mean	0.77	0.72	0.67	0.68	0.73	
				Overall Mean =		0.71
				Overall Std. Dev. =		0.17

Table 4-13. MTR Results for AMCs by District/Year

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.98	0.96	0.90	0.98	0.96	0.96
2	0.97	0.95	0.95	0.97	0.95	0.96
3	1.02	0.99	0.97	0.96	0.95	0.98
4	0.98	0.98	0.98	0.98	0.98	0.98
5	0.98	0.97	0.98	0.96	1.00	0.98
6	0.98	0.98	0.98	0.97	0.98	0.98
7	0.98	0.97	0.95	0.97	0.96	0.97
8	0.95	0.97	0.98	0.98	0.98	0.97
Mean	0.98	0.97	0.96	0.97	0.97	
				Overall Mean =		0.97
				Overall Std. Dev. =		0.02

Table 4-14. MTR Results for Non-AMCs by District/Year

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.93	0.93	0.90	0.93	0.89	0.92
2	0.89	0.89	0.65	0.60	0.89	0.78
3	0.85	0.89	0.90	0.79	0.89	0.86
4	0.81	0.50	0.55	0.60	0.89	0.67
5	0.89	0.88	0.97	0.94	0.89	0.91
6	0.93	0.65	0.55	0.59	0.92	0.73
7	0.96	0.97	0.78	0.74	0.41	0.77
8	0.56	0.58	0.76	0.77	0.41	0.62
Mean	0.85	0.79	0.76	0.75	0.77	
				Overall Mean =		0.78
				Overall Std. Dev. =		0.17

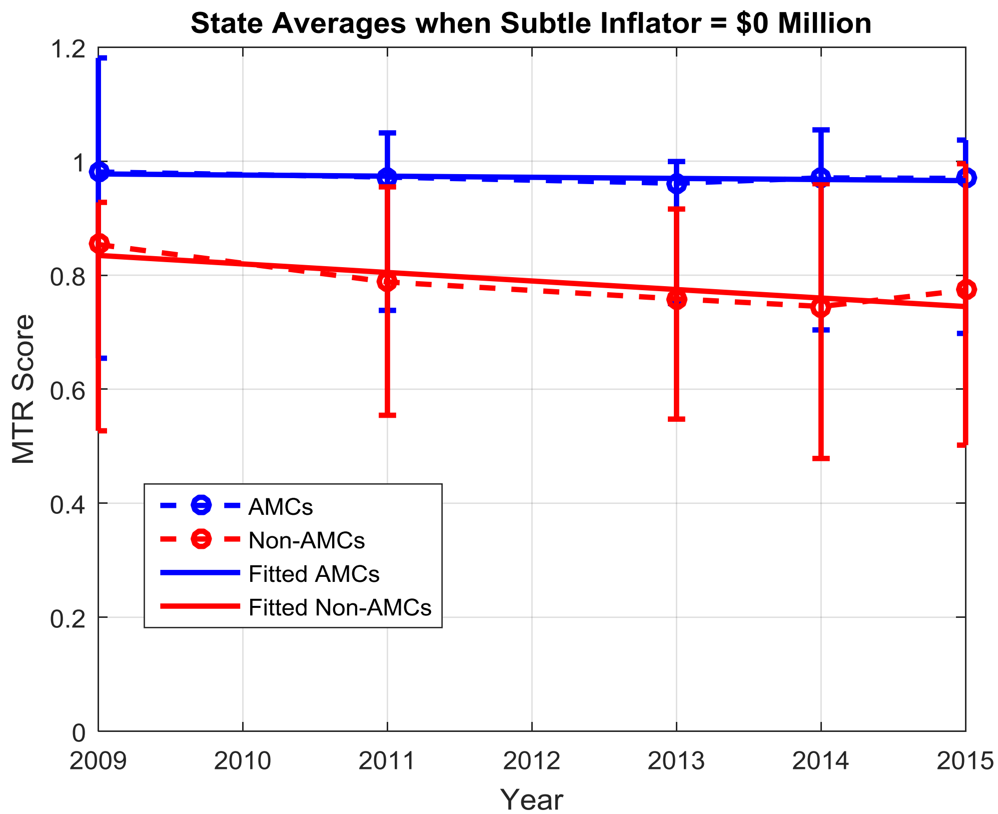


Figure 4-2. State Average MTR Scores over Time

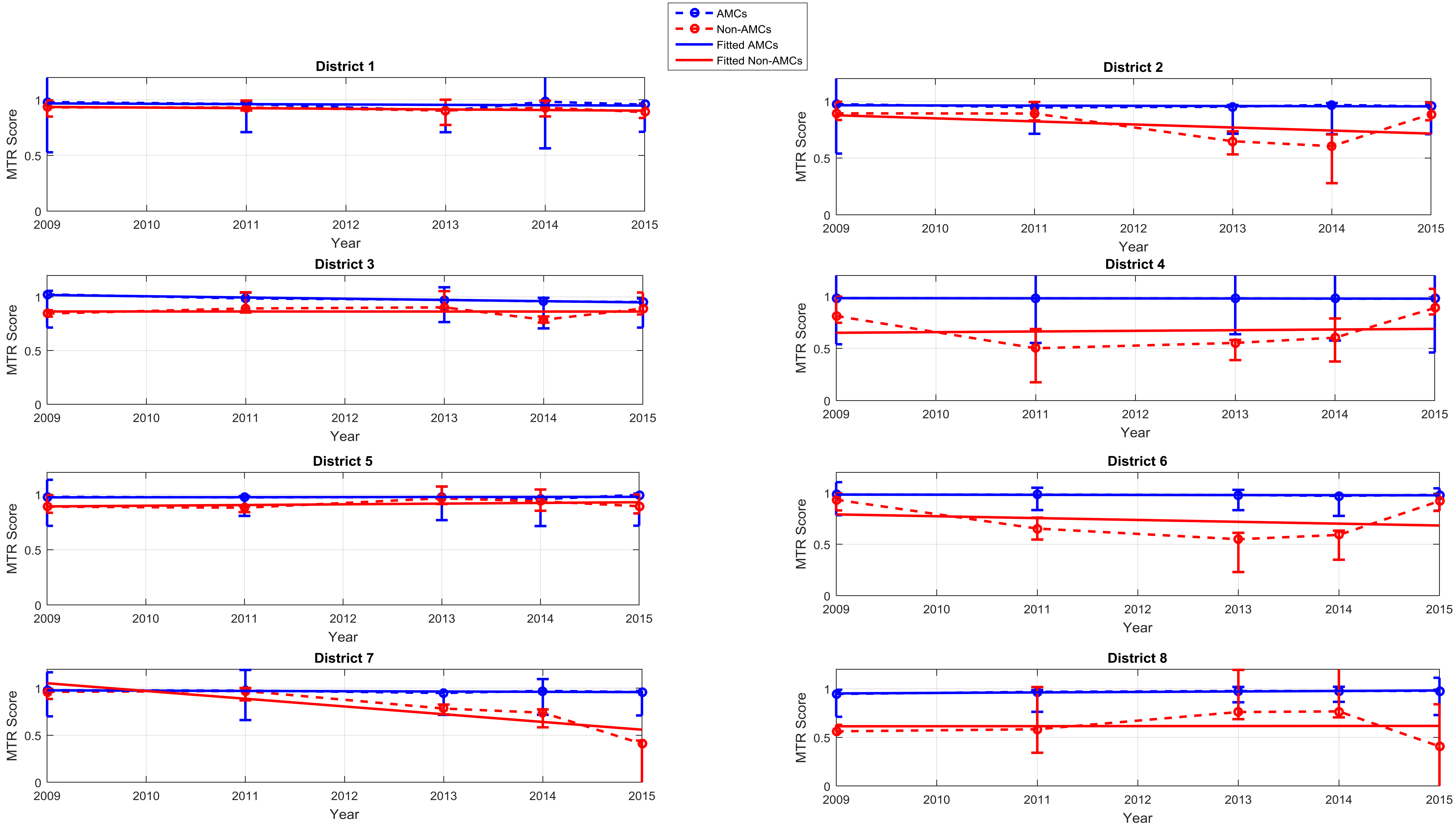


Figure 4-3. District MTR Scores over Time

Table 4-15. AMC MTR Results for Admin Cost = $500k/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.98	0.96	0.90	0.98	0.96	0.96
2	0.98	0.97	0.95	0.96	0.96	0.96
3	1.03	0.98	0.98	0.96	0.95	0.98
4	0.98	0.98	0.98	0.98	0.98	0.98
5	0.98	0.97	0.97	0.95	1.00	0.97
6	0.99	0.99	0.98	0.98	0.98	0.98
7	0.98	0.98	0.96	0.97	0.96	0.97
8	0.96	0.97	0.98	0.98	0.98	0.97
Mean	0.98	0.97	0.96	0.97	0.97	
				Overall Mean =		0.97
				Overall Std. Dev. =		0.02

Table 4-16. Non-AMC MTR Results for Admin Cost = $500k/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.93	0.93	0.90	0.93	0.89	0.92
2	0.89	0.88	0.65	0.60	0.89	0.78
3	0.84	0.88	0.90	0.78	0.89	0.86
4	0.80	0.50	0.55	0.59	0.89	0.67
5	0.88	0.87	0.96	0.94	0.89	0.91
6	0.90	0.64	0.54	0.58	0.92	0.71
7	0.96	0.97	0.78	0.73	0.40	0.77
8	0.55	0.57	0.74	0.75	0.40	0.60
Mean	0.84	0.78	0.75	0.74	0.77	
				Overall Mean =		0.78
				Overall Std. Dev. =		0.17

Table 4-17. AMC MTR Results for Admin Cost = $1M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.98	0.96	0.90	0.98	0.95	0.95
2	0.98	0.95	0.95	0.95	0.96	0.96
3	1.02	0.98	0.97	0.96	0.94	0.98
4	0.98	0.98	0.98	0.98	0.98	0.98
5	0.98	0.97	0.97	0.95	1.00	0.97
6	0.98	0.98	0.98	0.97	0.98	0.98
7	0.98	0.97	0.95	0.96	0.94	0.96
8	0.95	0.97	0.98	0.98	0.98	0.97
Mean	0.98	0.97	0.96	0.97	0.97	
				Overall Mean =		0.97
				Overall Std. Dev. =		0.02

Table 4-18. Non-AMC MTR Results for Admin Cost = $1M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.93	0.92	0.90	0.93	0.88	0.91
2	0.89	0.89	0.64	0.60	0.88	0.78
3	0.83	0.88	0.89	0.77	0.89	0.85
4	0.80	0.49	0.54	0.58	0.89	0.66
5	0.88	0.87	0.96	0.94	0.89	0.91
6	0.87	0.62	0.52	0.56	0.91	0.70
7	0.96	0.97	0.77	0.72	0.39	0.76
8	0.54	0.56	0.72	0.73	0.40	0.59
Mean	0.84	0.77	0.75	0.73	0.77	
				Overall Mean =		0.77
				Overall Std. Dev. =		0.17

Table 4-19. AMC MTR Results for Admin Cost = $2.5M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.98	0.95	0.90	0.98	0.95	0.95
2	0.97	0.95	0.94	0.93	0.94	0.95
3	1.02	0.98	0.97	0.95	0.95	0.98
4	0.98	0.98	0.98	0.98	0.97	0.98
5	0.97	0.97	0.96	0.94	1.00	0.97
6	0.98	0.98	0.97	0.97	0.98	0.97
7	0.97	0.97	0.95	0.96	0.95	0.96
8	0.95	0.96	0.97	0.97	0.98	0.97
Mean	0.98	0.97	0.96	0.96	0.96	
				Overall Mean =		0.96
				Overall Std. Dev. =		0.02

Table 4-20. Non-AMC MTR Results for Admin Cost = $2.5M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.93	0.92	0.89	0.92	0.88	0.91
2	0.88	0.88	0.64	0.59	0.87	0.77
3	0.82	0.86	0.88	0.75	0.88	0.84
4	0.77	0.48	0.53	0.55	0.88	0.64
5	0.88	0.86	0.95	0.92	0.88	0.90
6	0.79	0.57	0.49	0.53	0.92	0.66
7	0.95	0.96	0.75	0.70	0.37	0.75
8	0.51	0.53	0.67	0.68	0.38	0.55
Mean	0.82	0.76	0.73	0.70	0.76	
				Overall Mean =		0.75
				Overall Std. Dev. =		0.18

Table 4-21. AMC MTR Results for Admin Cost = $5M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.97	0.93	0.90	0.97	0.94	0.94
2	0.97	0.92	0.94	0.93	0.94	0.94
3	1.00	0.97	0.96	0.94	0.94	0.96
4	0.97	0.97	0.97	0.97	0.97	0.97
5	0.97	0.96	0.97	0.93	0.98	0.96
6	0.98	0.97	0.97	0.96	0.97	0.97
7	0.97	0.97	0.94	0.96	0.94	0.95
8	0.94	0.96	0.96	0.97	0.97	0.96
Mean	0.97	0.96	0.95	0.95	0.96	
				Overall Mean =		0.96
				Overall Std. Dev. =		0.02

Table 4-22. Non-AMC MTR Results for Admin Cost = $5M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.92	0.91	0.88	0.92	0.86	0.90
2	0.87	0.87	0.63	0.58	0.86	0.76
3	0.79	0.83	0.86	0.71	0.87	0.81
4	0.74	0.46	0.50	0.51	0.87	0.62
5	0.87	0.86	0.94	0.90	0.86	0.88
6	0.70	0.51	0.44	0.47	0.91	0.61
7	0.90	0.90	0.72	0.65	0.34	0.70
8	0.47	0.48	0.60	0.61	0.36	0.50
Mean	0.78	0.73	0.70	0.67	0.74	
				Overall Mean =		0.72
				Overall Std. Dev. =		0.19

Table 4-23. AMC MTR Results for Admin Cost = 10M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.96	0.91	0.89	0.96	0.92	0.93
2	0.96	0.92	0.93	0.92	0.93	0.93
3	0.98	0.97	0.95	0.93	0.91	0.95
4	0.97	0.97	0.97	0.96	0.95	0.96
5	0.96	0.95	0.96	0.92	0.96	0.95
6	0.97	0.97	0.96	0.95	0.97	0.96
7	0.96	0.96	0.92	0.94	0.92	0.94
8	0.92	0.94	0.95	0.96	0.96	0.95
Mean	0.96	0.95	0.94	0.94	0.94	
				Overall Mean =		0.95
				Overall Std. Dev. =		0.02

Table 4-24. Non-AMC MTR Results for Admin Cost = $10M/(District-Year)

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.92	0.89	0.85	0.91	0.84	0.88
2	0.84	0.84	0.61	0.56	0.84	0.74
3	0.74	0.79	0.83	0.66	0.85	0.77
4	0.70	0.42	0.45	0.44	0.85	0.57
5	0.84	0.83	0.91	0.86	0.84	0.86
6	0.55	0.42	0.37	0.39	0.90	0.53
7	0.82	0.82	0.64	0.56	0.29	0.62
8	0.40	0.41	0.50	0.50	0.32	0.43
Mean	0.73	0.68	0.64	0.61	0.72	
				Overall Mean =		0.67
				Overall Std. Dev. =		0.20

Table 4-25. AMC MTR Results when MRP Data are Eliminated

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.99	0.99	0.99	0.99	0.92	0.97
2	0.98	0.98	0.96	0.96	0.95	0.97
3	1.04	0.99	0.99	0.96	0.90	0.97
4	0.99	0.99	0.99	0.98	0.98	0.98
5	0.99	0.99	0.98	0.98	0.99	0.99
6	0.99	0.99	0.99	0.98	0.98	0.98
7	0.99	0.98	0.96	0.98	0.97	0.98
8	0.98	0.98	0.98	0.98	0.98	0.98
Mean	0.99	0.98	0.98	0.98	0.96	
				Overall Mean =		0.98

Table 4-26. Non-AMC MTR Results when MRP Data are Eliminated

	Year					
District	**2009**	**2011**	**2013**	**2014**	**2015**	**Mean**
1	0.97	0.94	0.92	0.98	0.98	0.96
2	0.93	0.93	0.65	0.61	0.93	0.81
3	0.85	0.88	0.87	0.86	0.96	0.88
4	0.83	0.59	0.70	0.69	0.93	0.75
5	0.92	0.90	0.98	0.95	0.92	0.94
6	0.96	0.71	0.71	0.71	0.95	0.81
7	0.97	0.98	0.96	0.95	0.64	0.90
8	0.59	0.62	0.80	0.80	0.43	0.65
Mean	0.88	0.82	0.82	0.82	0.84	
				Overall Mean =		0.84

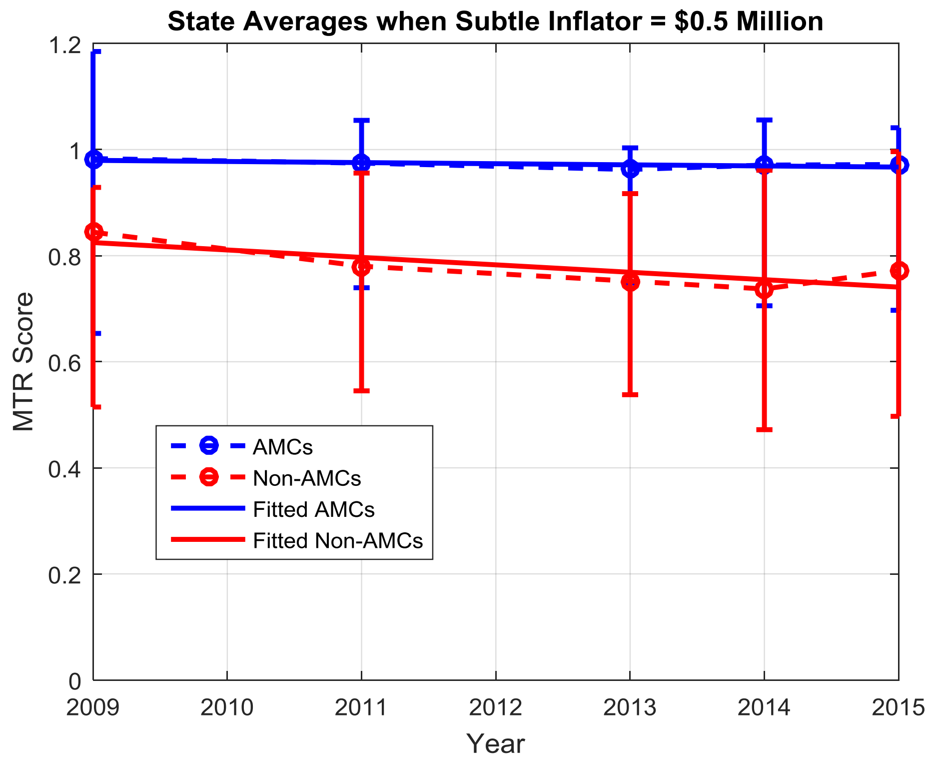


Figure 4-4. State Average MTR Scores over Time Adding $500k/(District-Year)

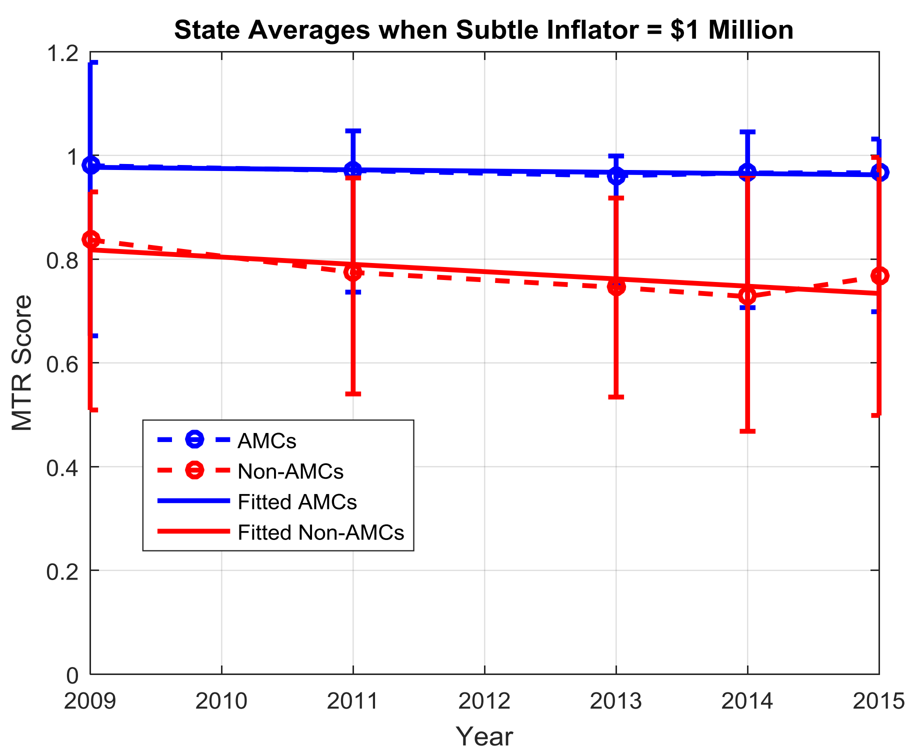


Figure 4-5. State Average MTR Scores over Time Adding $2.5M/(District-Year)

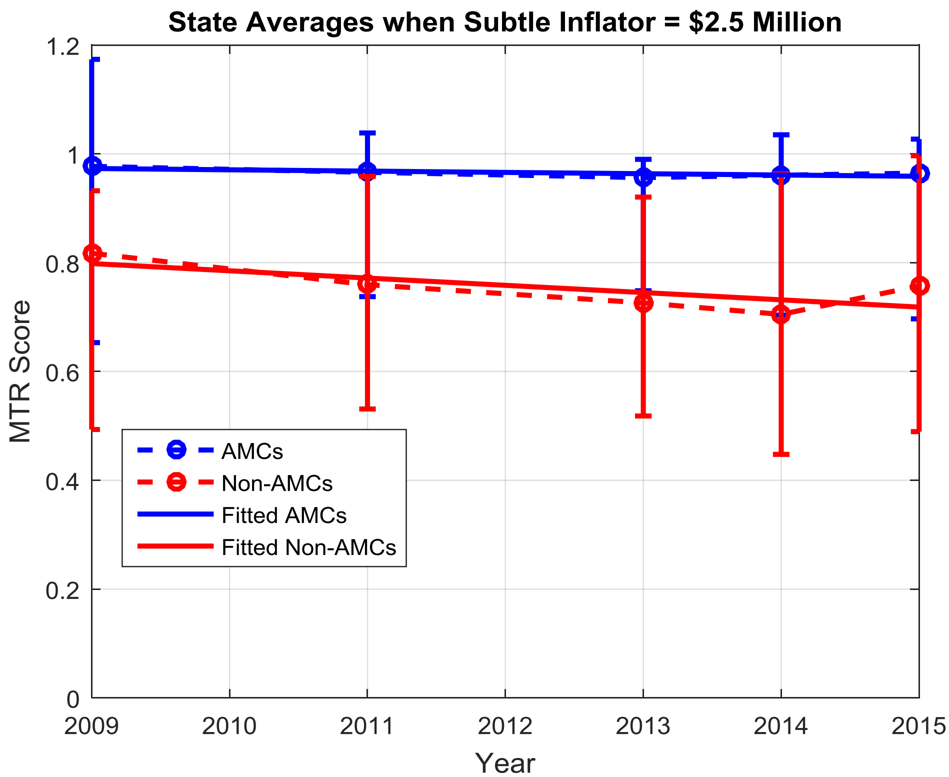


Figure 4-6. State Average MTR Scores over Time Adding $1M/(District-Year)

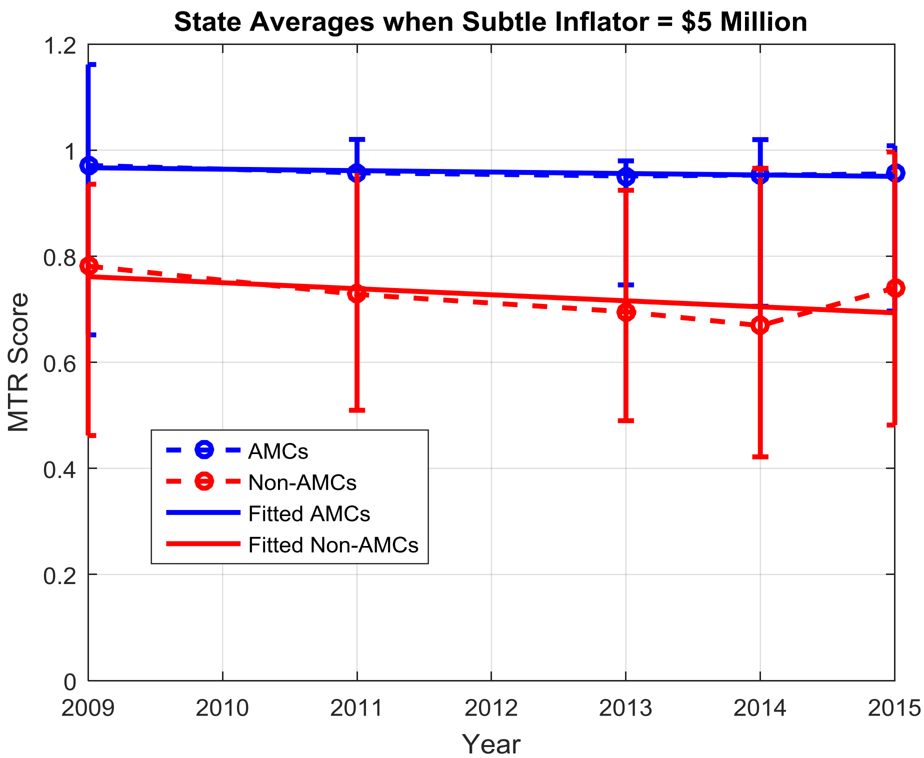


Figure 4-7. State Average MTR Scores over Time Adding $5M/(District-Year)

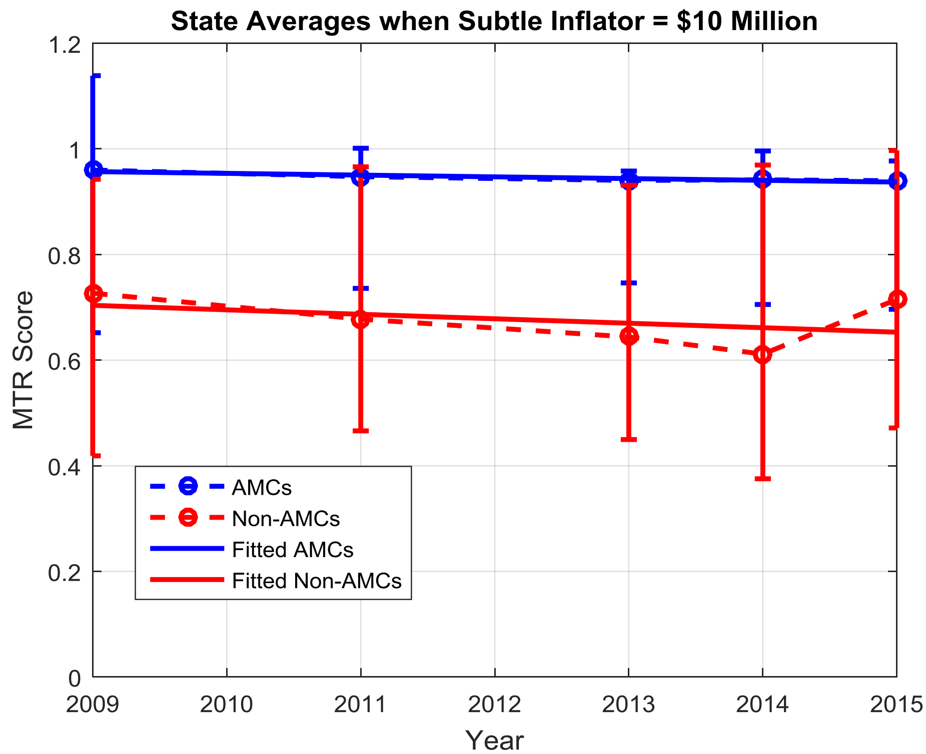


Figure 4-8. State Average MTR Scores over Time Adding $10M/(District-Year)

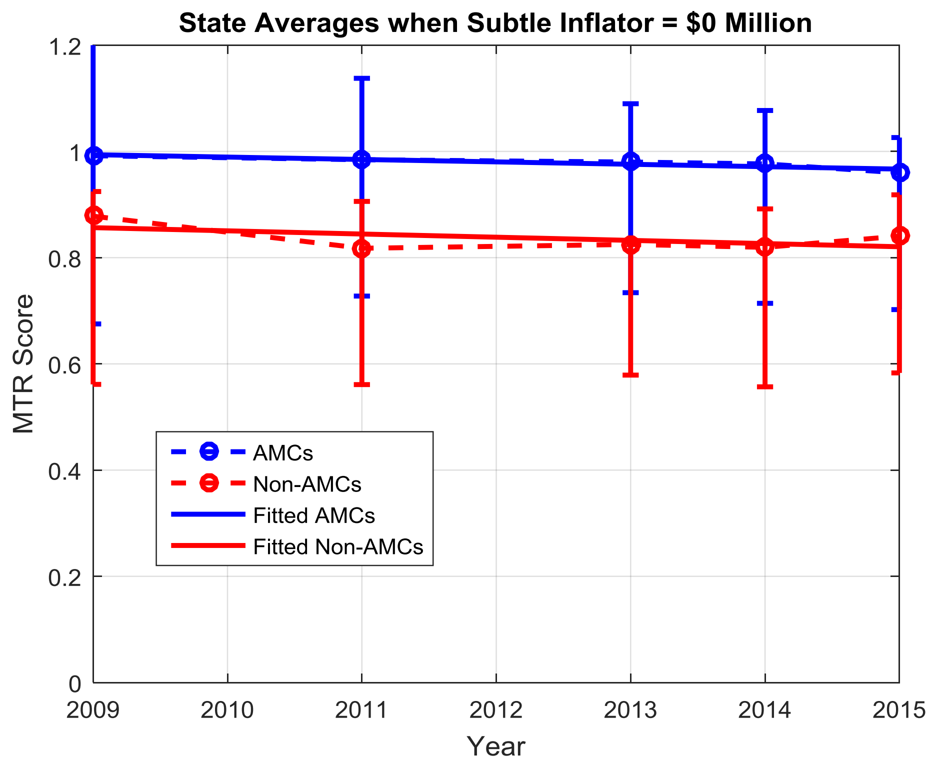


Figure 4-9. MTR Scores when MRP Score Removed as Output

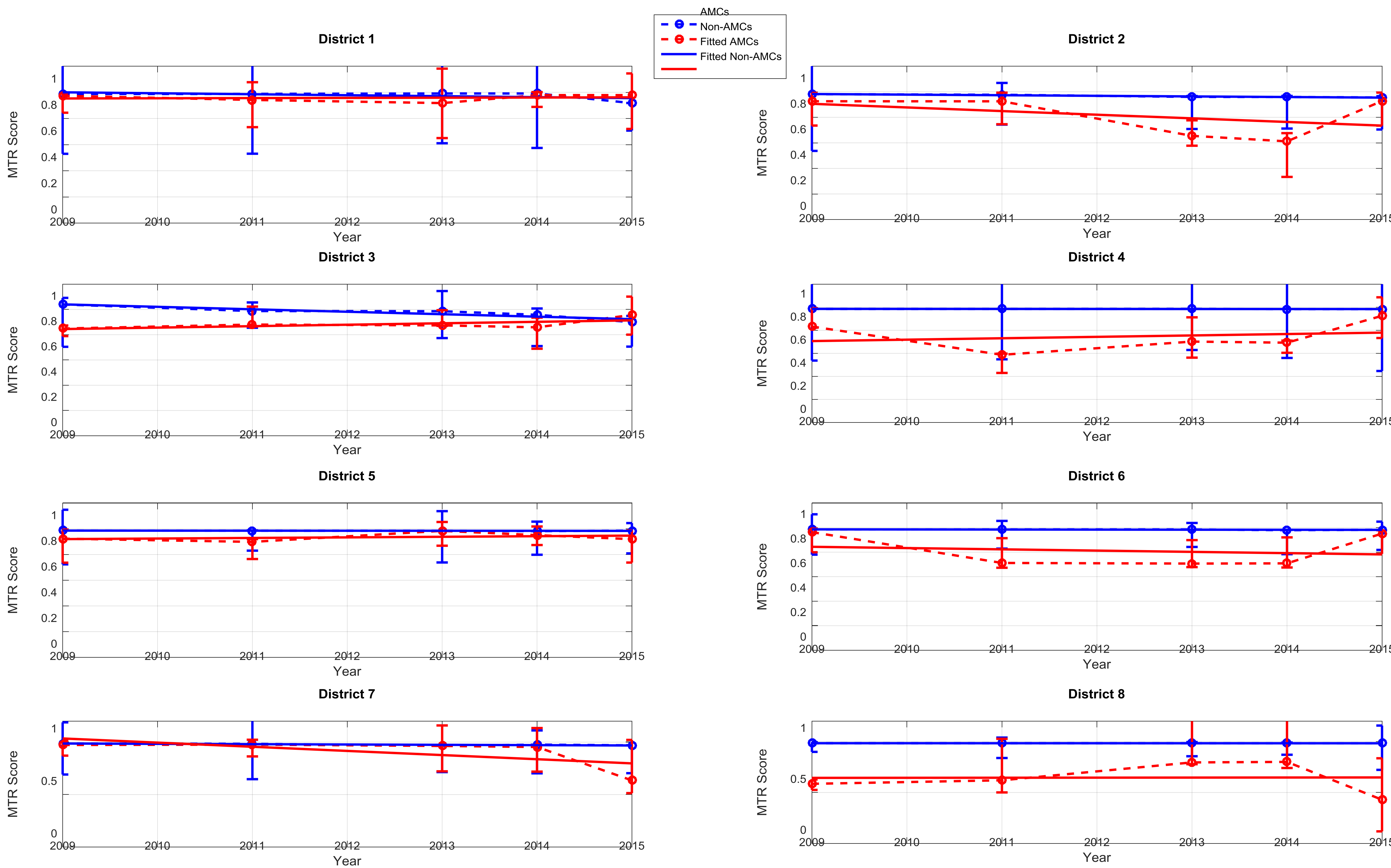


Figure 4-10. District MTR Results when MRP Score Removed

4.4 DISCUSSION

As shown from the data, mean MRP score appeared to be consistently higher for AMCs than it was for non-AMCs. As stated above, a Kruskal-Wallis test was used to compare the mean MRP score from each contract-type:

Table 4-27. Kruskal-Wallis Test Results for MRP Data

Source	**SS**	**df**	**MS**	χ^2	**P** $\geq \chi^2$
Data	2,856.1	1	2,856.05	5.29	0.0215
Error	39,803.9	78	510.31		
Total	42,660	79			

where Source is the source of variability; SS is the sum of squares due to each source; df is the degrees of freedom associated with each source; MS is the mean squares for each source, which is the ratio of SS/df; χ^2 is the critical value; and P > χ^2 is the probability that the test statistic can take a value greater than or equal to the critical value. As shown, the mean MRP score is statistically significant at an α value of 0.05 since 0.0215 is less than 0.05 in this case.

Additionally, as shown in the data, MTRs from AMCs were consistently higher than MTRs from non-AMCs. While the confidence intervals (i.e. upper and lower bounds) for MTRs did overlap to some extent, overlapping confidence interval bounds does not necessarily imply statistical significance. Again, a Kruskal-Wallis test was used to compare the mean MTR score between contract-types:

Table 4-28. Kruskal-Wallis Test Results for MTR Data

Source	**SS**	**df**	**MS**	χ^2	**P** > χ^2
Data	28,501.3	1	28,501.3	52.78	3.73063e-13
Error	14,158.8	78	181.5		
Total	42,660	79			

As shown, the probability that the test statistic can take a value greater than or equal to the critical value is very low. This indicates that AMCs produce statistically significant higher MTR scores than non-AMCs.

The implication for high MTR scores is discussed in-depth by Fallah-Fini et al. (2012). To summarize, districts with high MTRs are playing a more important role in constructing the meta-frontier than districts with low MTRs. Put another way, high MTR scores imply high tangency between the meta-frontier and the group frontier. Since AMCs have been shown to produce statistically higher MTR scores than non-AMCs, it can be concluded that AMCs are more efficient than non-AMCs.

Similar to the Fallah-Fini et al. (2012) study, bootstrapping plays a critical role in these computations. An examination of non-bootstrapped results (Table 4-5 through Table 4-8) shows many non-bootstrapped group and meta-frontier efficiency scores of 1.00. These DMUs are not 100% efficient, but rather, they just appear to be efficient due to the small sample size.

Additionally, DEA results allow inefficiency to be examined. The 2014 District 8 Non-AMC DMU will be used as an example. It showed a bootstrapped group efficiency of 0.94, a meta-frontier efficiency of 0.72, and an associated MTR of 0.77. This implies that on average, this particular contract-year should have cost 6% less in order for it to be efficient relative to the other non-AMCs using non-AMC technology. The meta-frontier score of 0.72 means that cost could be cut by 28% assuming no restrictions in regulations associated with contract-type (a hypothetical scenario). The MTR score of 0.77 means that the maximum efficiency that can be achieved with this contract is 77% of the meta-technology frontier (i.e. the most you could hope to get would be 77% of a hypothetical situation without restrictions or regulations based upon contract type).

Put another way, examination of the scores shown here show efficiency both within and between technology groups. Using the example above for instance, it is clear that the District 8 Non-AMC DMU performs relatively efficiently compared with other non-AMCs (94% efficiency). However, when compared with non-AMCs, the contract does not perform as well (only 77% efficiency). This is because it only performs with 72% efficiency relative to the meta-frontier thereby yielding an MTR of 77%. This may be compared with another contract – say the 2013 AMC District 1 contract which had a group efficiency of 87%, a meta-efficiency of 79%, and an associated meta-technology ratio of 90%. In other words, the 2013 D1 AMC was 87% efficiency relative to other AMCs and 79% efficient relative to the meta-frontier, yielding a meta-technology score of 90% efficiency. The percent difference between MTRs then is 15.5% which indicates that the 2013 D1 AMC is 15.5% more efficient than the 2014 D8 non-AMC relative to the meta-frontiers computed here.

Statewide, on average, the percent difference between MTRs for AMCs vs. non-AMCs is 21.7%. This indicates that for the data shown here, statewide, the AMC program is 21.7% more efficient than non-AMCs. However, it is important to note that if more data were to be included in this analysis, this 21.7% would undoubtedly change because the group frontiers, meta-frontiers, and associated MTRs would "move" to accommodate more/less efficient data. Therefore, the 21.7% should only be taken as a snapshot in time.

District-wide results (summarized in Figure 4-3) interestingly show that in almost all cases, district MTRs were higher for AMCs than non-AMCs. This again supports the hypothesis that the AMC program is functioning as designed.

The subtle cost analysis showed minor effects. As expected, as administrative costs were added to districts' non-AMC contract cost, their MTRs decreased due to a decrease in meta-frontier efficiency scores. However, it is interesting to note that the subtle cost savings must be relatively large to have significant tangible effect on overall results. Kruskal-Wallis tests were conducted on subtle cost data. Results showed that there was no statistical difference in MTR scores at the 95% confidence limit until the $10,000,000 per district per year value was added to the cost data. This would appear to indicate that the goal of the AMC program should not be to focus on the subtle cost-savings, but rather to ensure through competition that the best price is achieved on the contract relative to the output. Or, put another way, if the DOT is interested in cost savings, the correct route to follow would be to try to reduce the cost of the non-AMCs or convert the non-AMCs to AMC.

However, FDOT should be careful with the replacement option. The reason non-AMCs scored poorly relative to AMCs is that the non-AMCs simply yielded fewer outputs per dollar. Examination of the statewide and district-wide graphs shows that over time, the efficiency of the non-AMCs is becoming increasingly worse. This is due to the fact that over time, several aspects of non-AMCs have been converted to AMCs. But, the cost of the non-AMCs remained relatively stable from 2009-2015. As output decreases from non-AMCs, this cost should concomitantly decrease. The fact that this is not happening could be due to the fact that there are an increasingly fewer number of non-AMCs that can be won. Contractors may be increasing their profit margins on these more-traditional contracts to make up for the fewer number of them. This is the opposite of the "competition should drive down price" argument, but the data do not show a decrease in non-AMC price.

This stabilization of non-AMC price could also be due to the economy. The years analyzed in this study were during the recovery period after the "Great Recession." While CPI was used to take inflation into account, CPI does not account for general robustness of an economy. In other words, as the economy improves, there are more construction jobs. If profits/prices are too low, contractors might not bid on state roadwork. Therefore, prices may have had to remain high in order to get contractors to do the work. It will be interesting to continue to analyze data for the next several years to determine if these results are caused by the recession or if they are independent of this.

Elimination of the MRP scores (Table 4-25 and Table 4-26) had little effect on overall results in that AMCs were still more efficient than non-AMCs. It is true that the mean MTR did increase when MRP was eliminated (mean MTR = 0.84 vs. mean MTR of 0.78). However, the associated Kruskal-Wallis test to compare means produced the following results:

Table 4-29. Kruskal-Wallis Test Results for MTR Data

Source	**SS**	**df**	**MS**	χ^2	**P >** χ^2
Data	24,290.4	1	24,290.4	44.98	1.98768e-11
Error	18,369.1	78	235.5		
Total	42,669.5	79			

Therefore, even without considering MRP scores, AMCs still score more efficiently on average than non-AMCs.

Investigators were curious as to whether or not using output orientation would affect results. Results from the o-o model were similar in that AMCs still produced statistically significantly higher MTRs than non-AMCs. Similar checks were made using the CRS approach. Again, results were the same – AMCs produced significantly higher MTRs than non-AMCs.

Results here raise the obvious question as to why this analysis appears to show that the AMC program functions well in Florida, but a similar analysis showed that Virginia's PBMC program functioned poorly. There are a number of plausible explanations for this. As Fallah-Fini et al. (2012) point out, in Virginia, their traditional contracting method had been used for many years by many different road authorities. Virginia's PBMC program was relatively new at the time of their study. As such, it is likely that factors associated with finding the correct way to implement a PBM program played a role. Factors could include contractors' quality capacity, the acquisition/award process, managing cultural changes in the organization, risk management processes, etc. (Fallah-Fini et al. 2012). In Florida, the AMC program had already been well-established by the time the analysis conducted here was completed. As such, many of these issues that may have been present in Virginia may have been solved in Florida by 2009. It would be interesting to examine the early years of the Florida AMC program to see how it performed then, but unfortunately, the data for this analysis were not readily available as of the date of this report.

The other major factor that caused a difference between this analysis and the Virginia analysis is the models' output choices. As Fallah-Fini et al. (2012) state, "…Our finding may suggest that VDOT should not rely solely on LOS specifications for performance-based contracting, instead VDOT may want to use some hybrid approaches by bringing some of the features of traditional highway maintenance contracting into performance-based maintenance…" The implication here is that in a PBM framework, the actual output may be more than simply "road improvement." In Florida, this can be taken into account by tracking the number of bridges, rest stops, ancillary structures, etc. where work is conducted. Thus, the output from the actual contract is much more than just "lane miles of roadway." Likewise, rating in Florida is much more sophisticated than a LOS approach in that the MRP score takes elements from several aspects of the roadway/roadside into account. It would be interesting to see the Fallah-Fini et al. (2012) analysis completed using a different set of outputs that maybe more-accurately describe some more products of the Virginia contracts.

The obvious area where this study can be improved would be to further break-down outputs into smaller distance scales. The advantage that the Fallah-Fini et al. (2012) study had over this one was that because they used county-wide distance scales, they were able to relate MTR ratios to uncontrollable factors such as weather, traffic load, and terrain. Some of these correlations were significant.

During this study, an analysis of weather in Florida was conducted in that rainfall and low temperature were examined throughout the state. Results were relatively uniform in terms of rainfall, but in North Florida, much colder temperatures are seen in the winter than in South Florida. This would tend to encourage freeze-thaw action and may lead to more maintenance in the northern part of the state. Similarly, in South Florida and around the northern cities (Tampa, Orlando, Jacksonville, etc.), traffic load is much higher than in other places in the state. This could also lead to a need for more maintenance. Both cases could decrease efficiency in terms of MRP scores. These factors should be taken into account, but as stated, on a district-wide scale, a quantity like “traffic load” is or even “low temperature” in an area such as District 5 which spans almost 150 miles in latitude and may have a large difference in low temperature between St. Johns and Brevard Counties is relatively meaningless. Additionally, it is difficult to properly break-down multi-county contracts at present. In the future, it might be useful for the Department to ask contractors to estimate effort level location on AMCs.

The other factor that has not yet been discussed is economic risk. The value of the AMC program as currently constructed is doubly beneficial because not only does it perform more efficiently than more-traditional contracts, but it also shifts risk burden from FDOT toward contractors. Like the administrative costs, it would be interesting to analyze this factor, although like the administrative costs, its actual tangible benefit on MTR scores will most-likely be small.

The last factor that should be discussed is future analysis after natural disasters. The years analyzed in this report did not contain any large hurricanes or tropical storms. In the future, as the AMC program is continued to be analyzed, it will be important to remove hurricane effects from consideration because these events will almost certainly skew results.

5 SUMMARY AND CONCLUSIONS

5.1 SUMMARY

To summarize:

A comprehensive literature review was conducted. Topics studied included:

1. Use of PBMCs internationally

2. Use of PBMCs domestically

3. FDOT's AMC program

4. Meta-frontier analysis

5. CA

Meta-frontier analysis was conducted using a series of input-oriented VRS DEA models with varying configurations. Results showed:

1. AMCs tend to lead to statistically significant better MRP scores than non-AMCs. These results are statistically significant within the 95% confidence level.

2. In almost all cases, AMCs led to higher MTRs than non-AMCs. These results are statistically significant within the 95% confidence level.

3. Percent difference between average AMC MTRs and non-AMC MTRs was 21.7%. This indicates that the AMC program was 21.7% more efficient than the non-AMC program from 2009-2015.

4. Subtle costs such as administration associated with more-traditional contracts appear to play a minor role in AMC performance. Instead, the reason AMCs perform so well is that the number of outputs relative to the cost is very high relative to non-AMCs.

5. While MRP score was significantly different between AMCs and non-AMCs, its inclusion in DEA/meta-frontier analysis did not affect overall results in that removing MRP score as an output still led to significantly higher MTR scores for AMCs than for non-AMCs.

6. As FDOT is continuing to transition toward more AMCs, their performance remains strong. However, the performance of non-AMCs is becoming increasingly weak. This is

due to the fact that non-AMC costs have remained the same while output from non-AMCs has decreased.

In addition, a survey was conducted and CA was used to analyze results. While similar work has been completed by others in the past, this survey was unique in that private contractors were questioned. Results mostly validated results found during previous studies. However, some themes of note should be mentioned. Specifically:

1. Contractors appear to be more confident in the success of the AMC program than DOT personnel.

2. Administrative costs should be better-quantified.

3. Partnering is encouraged to ensure the success of long-term AM agreements.

4. The scope of any performance-based agreement needs to be clear, measurable, and unambiguous.

5.2 OVERALL CONCLUSIONS AND FUTURE RECOMMENDATIONS

The main conclusion from this study is that the AMC program works as designed in that AMC contracts are more efficient than non-AMCs. However, the poor performance of non-AMCs is troubling. In the future, it may benefit FDOT to try to reduce the non-AMC cost/increase non-AMC output for the same cost in order to save additional funds. Alternatively, converting more contracts to AMCs would appear to be beneficial from an efficiency standpoint. But, if this occurs, non-AMC cost needs to decrease.

Note that the 21.7% "more efficient" result does not necessarily mean that the AMC program is 21.7% less expensive than non-AMCs. Rather, this result means that from 2009-2015, the AMC program was more efficient relative to a boundary that is based upon output as well as input. If more data were to be included in the future, this result would change because the meta-frontier would adjust to accommodate more/less efficient data.

The reason that the AMC program works as designed in Florida is more or less borne out by the survey. Mainly, the survey found that people believe a PBMC program can work if implemented properly. Florida has had fifteen years to learn "how" to implement such a program. The most common themes from the survey were that scopes should be clear and measurable and risks should be shared. Results would appear to show that these criteria were met from 2009-2015.

Moving forward, it is critical that FDOT continues to track outputs from its AMC and non-AMC contracts. A follow-up study is recommended in five years to determine if the results from this report continue to hold true. This report should not be interpreted as a blanket statement that says that the AMC program always will function as designed. On the contrary, results shown here only indicate that the AMC program was more efficient than non-AMCs from 2009 through 2015. This snapshot in time needs to be verified continuously so that FDOT can continue to make correct budgetary decisions. Between now and the recommended follow-up study, FDOT should continue to make their annual Bar Charts to make the next round of analysis less time consuming/more efficient. Additionally, subtle costs need to be tracked. For example, when cost centers close or administrative positions are eliminated, these occurrences need to be documented and taken into account monetarily on the annual Pie Charts. While this report showed that these effects are small, they may become larger in the future if non-AMC costs decrease as they should.

LIST OF REFERENCES

Aigner, D.J. and Chu, S. F. (1968). "On estimating the industry production function." *American Economic Review* 58, 826-839.

Alvarez, I.C., Barbero, J., and Zofio, J.L. (2016). A data envelopment analysis toolbox for MATLAB. *Working Papers in Economic Theory* 2016/2, Department of Economics, Universidad Autonoma de Madrid, Spain.

Bowlin, W.F., Charnes, A., Cooper W.W. and Sherman, H.D. (1985). "Data envelopment analysis and regression approaches to efficiency estimation and evaluation." *Ann. Opns Res*. 2, 113-138.

Brown, C., Hansen-Brown, L., and Conte, R. (2011). "Engaging Millennial College-Age Science and Engineering Students Through Experiential Learning Communities." *Journal of Applied Global Research*, 4(10), 41-58.

Bucyk, N. and Lali, M. (2005). "Transportation Research Circular E-C098: Evolution of Highway Maintenance Outsourcing in Alberta, Canada, Maintenance Management 2006, Part I, Outsourcing Maintenance Activities, Evolution of Highway Maintenance Outsourcing in Alberta, Canada." *11th AASHTO–TRB Maintenance Management Conference*, Charleston, S.C., July 16–20, 2005.

Cabana, G., G. Liautaud, and Faiz, A. (1999). "Areawide Performance-Based Rehabilitation and Maintenance Contractors for Low-Volume Roads," Transportation Research Record 1652, *Transportation Research Board, National Research Council*, Washington, D.C., 1999.

Campbell, Mara. (2009). *Routine Maintenance Contracts Results.* Missouri DOT. Jefferson City, MO.

Cook, W.C., Kazakov, A., and Roll, Y. (1990). "A DEA Model for Measuring the Efficiency of Decision Making Units." *European Journal of Operational Research*, 2, 429-444.

Cook, W.D., Kazakov, A., Roll, Y., (1994) "On the measurement and monitoring of relative efficiency of highway maintenance patrols." In: Charnes, A., Cooper, W., Lewin, A.Y., Seiford, L.M. (Eds.), Data Envelopment Analysis: Theory, Methodology and Applications. Kluwer Academic Publishers, Boston, pp. 195–210.

Cooper, W.W., Seiford, L.M., and Tone, K. (2007). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References, and DEA-Solver Software*. Springer Science + Business Media, LLC, New York, NY.

Charnes, A., Cooper, W.W., and Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2 (1978), 429-444.

de la Garza, J.M., Fallah-Fini, S., and Triantis, K. (2009). “Efficiency Measurement of Highway Maintenance Strategies using Dave Envelopment Analysis.” *Proc. 2009 NSF Engineering Research and Innovation Conference*, Hawaii, USA.

Fallah-Fini, S., Triantis, K., and de la Garza, J.M. (2009). “Performance Measurement of Highway Maintenance Operation using Data Envelopment Analysis: Environmental Considerations. *Proc. IIE Annual Conference*, Miami, FL, USA.

Fallah-Fini, S., Triantis, K., de la Garza, J.M., and Seaver, W. (2012). Measuring the efficiency of highway maintenance contracting strategies; a bootstrapped non-parametric meta-frontier approach. *European Journal of Operational Research,* 291(1), 134-145.

Färe R, Primont D (1995). “Multi-output production and duality: theory and applications.” Kluwer, Boston.

Farrell, M.J. (1957). 'The measurement of productive efficiency." *Journal of the Royal Statistical Society A* 120, 253-281.

FDOT (2014). Contractor Field Performance Rating on Maintenance Contracts, Procedure No. 850-070-002. Florida Department of Transportation, Tallahassee, FL.

FDOT (2015). Contract Maintenance Work Document, Form No. 375-020-05. Florida Department of Transportation, Tallahassee, FL.

FDOT (2015). Daily Report of Maintenance Project, Form No. 375-020-01. Florida Department of Transportation, Tallahassee, FL.

FDOT (2011). Experience Forms, Form No. 850-070-01 through 09. Florida Department of Transportation, Tallahassee, FL.

FDOT (2012). Maintenance contract administration, inspection, and reporting, Procedure No. 375-020-002. Florida Department of Transportation, Tallahassee, FL.

FDOT (2015). Maintenance Project Weekly Summary, Form No. 375-020-02. Florida Department of Transportation, Tallahassee, FL.

FDOT (2013). Performance based maintenance contracting, Procedure No. 375-000-005. Florida Department of Transportation, Tallahassee, FL.

FDOT (2014). Road and Bridge Contract Procurement, Procedure No. 375-000-001. Florida Department of Transportation, Tallahassee, FL.

Frost, M. (2001). "Imperatives in Future Road System Management, Improved Road Maintenance Productivity, the Australian Case," presented at 14th IRF Road World Congress, Paris, France, June 11–15.

Greene, W.H. (1980). "Maximum Likelihood Estimation of Econometric Frontier." *Journal of Econometrics 13*, pp. 27-56.

Martin, H.H. (1997),"Contracting out maintenance and a plan for future research", *Journal of Quality in Maintenance Engineering*, Vol. 3 Iss 2 pp. 81 – 90.

Hall, P. (1986). "On the Number of Bootstrap Simulations Required to Construct a Confidence Interval." *Ann. Statistics*, 14, 1456-1462.

Hoffman, G. L., Bhajandas, A., Mallela, J. (2010). Issues and Practices in Performance-Based Maintenance and Operations Contracting. Federal Highway Administration, Transportation Research Board, National Cooperative Highway Research Program, Washington, D.C., prepared by Applied Research Associates, Champaign, IL.

Hyman, W. A. (2009). Synthesis 389: Performance-Based Contracting for Maintenance. Federal Highway Administration, Transportation Research Board, National Cooperative Highway Research Program, Washington, D.C., prepared by Applied Research Associates/ERES Division, Elkridge, MD.

Jones, D. B. (1950). "Quantitative Analysis of Motion Picture Content." *Public Opinion Quarterly Fall50, Vol. 14 Issue 3, p554-558.*

Kazakov, A., Cook, W.D., Roll, Y., (1989) "Measurement of Highway Maintenance Patrol Efficiency: Model and Factors." Transportation Research Record 1216, 39–45.

Krippendorff, K. (1980). *Content Analysis: An Introduction to Its Methodology,* Sage Publications, London

O'Donnell, C.J., Prasada Rao, D.S., Battese, G.E., (2008). Metafrontier Frameworks for the Study of Firm-level Efficiencies and Technology Ratios. *Empirical Economics* 34, 231–255.

Pakkala, P.(2002). "Innovative Project Delivery Methods for Infrastructure, An International Perspective." *Finnish Road Enterprise, Helsinki*, 2002 [Online]. Available: http://alk.tiehallinto.fi/julkaisut/pdf/pakkalae5.pdf (accessed May 27, 2015).

Qualtrics (2016). Qualtrics Labs, Inc., Provo, UT, USA, available from http://www.qualtrics.com.

Ozbek, E.M., de la Garza, J.M., Triantis, K. (2010a). "Data and Modeling Issues Faced during the Efficiency Measurement of Road Maintenance using Data Envelopment Analysis." *Journal of Infrastructure Systems*, 16, 21-30.

Ozbek, E.M., de la Garza, J.M., and Triantis, K. (2010b). "Efficiency Measurement of bride Maintenance using Data Envelopment Analysis." *Journal of Infrastructure Systems*, 16, 31-39.

Ozbek, E.M. (2007). "Development of Comprehensive Framework for the Efficiency Measurement of Road Maintenance Strategies using Data Envelopment Analysis." Virginia Polytechnic Institute and State University, Blacksburg, VA.

Pakkala, Pekka (2006). "World Survey of Contract Maintenance, International Road Federation (IRF)" Executive Workshop on Contract Maintenance, October 15-20, 2006, Orlando, Florida, USA

Pakkala, P.A., W.M. de Jong, and J. Aijo,(2007) "International Overview of Innovative Contracting Practices for Roads," *Finnish Road Administration, Helsinki* [Online]. Available: http://alk.tiehallinto.fi/julkaisut/pdf/internoverview.pdf (accessed April 14, 20015).

Radović, N., Mirković, K., Šešlija, M., and Peško, I. (2014). "Output and Performance based road maintenance contracting – case study Serbia." *Technical Gazette* 21, 3(2014), 681-688.

Ribreau, N.(2004) "Highway Maintenance Outsourcing Experience, Synopsis of Washington State Department of Transportation's Review," In Transportation Research Record Journal of the Transportation Research Board, No. 1877, Transportation Research Board of the National Academies, Washington, D.C., 2004

Robinson, M. and E. Raynault (2005). "PBC in Road Management," *World Bank*, Washington, D.C.

Rouse, P., and Chiu, T. (2008). "Towards Optimal Life Cycle Management in a Road Maintenance Setting using DEA." *European Journal of Operational Research*, 196, 672-681.

Rouse, P., Putterill, M., and Ryan, D. (1997). "Towards a General Managerial Framework for Performance Measurement: A Comprehensive Highway Maintenance Application. *Journal of Productivity Analysis*, 8, 127-149.

Schaar, D. and Sherry, L. (2008). Comparison of data envelopment analysis methods used in airport benchmarking. Fairfax, VA, USA.

Segal, G.F., A. Moore, and S. McCarthy (2003). Contracting for Road and Highway Maintenance, *Reason Public Policy Institute*, Los Angeles, Calif.

Skinner, S. (2007). "Highway Contracting Experiences in Ontario Canada," presented at the 86th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 21–25, 2007.

Simar, L. (1992). "Estimation and inference in two-stage, semiparametric models of production processes"." *The Journal of Productivity Analysis.*,3, 171-203.

Simar, L., and Wilson, P.W. (1998). "Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models." *Management Sciences*, 44 (1), 49-61.

Simar, Léopold ; Wilson, Paul (2003). "Estimation and inference in two-stage, semi-parametric models of production processes*."* STAT Discussion Papers ; 0307.

Sims, T. (2004). "Improving Rest Areas Through Performance-Based Contracts," *Highway Maintenance Contracting 2004*, World State of the Practice, Report of the National Highway Maintenance Contract Seminar, Orlando, Fla., April.

Singer, H. A. (1950). "An Analysis of the New York Press Treatment of the Peace Conference at the Waldorf-Astoria," *Journal of Educational Sociology*, 23(5), 258-270.

Stankevich, N., N. Qureshi, and C. Querioz. (2005). "Performance-Based Contracting for Preservation and Improvement of Road Assets," Transport Note No. TN-27, World Bank, Washington, D.C.

Stenbeck, T. (2007) [Online]. Available: http://www.cbi.selstenbeck/artiklar/Canada/CanadianProvinces.doc(accessed Mar. 3, 2007).

Thanassoulis, E., (1993). "A Comparison of Regression Analysis and Data Envelopment Analysis as Alternative Methods for Performance Assessments." *Journal of Operational research Society* 44, I 29–1144.

Walden, J.B. "Estimating Vessel Efficiency Using a Bootstrapped Data Envelopment Analysis Model." *Marine Resource Economics*, 21, 181-192.

Wang, Y. and Zhou, S. (2015) "How Do Sports Organizations Use Social Media to Build Relationships? A Content Analysis of NBA Clubs' Twitter Use." *International Journal of Sport Communication jun2015, Vol. 8 Issue 2, p133.*

Word Counter: The Word Count Calculator. Retrieved January 14, 2016, from https://wordcounter.net/

Zietlow, G.(2005a). "Cutting Costs and Improving Quality Through Performance-Based Road Management and Maintenance and Contracts—The Latin American and OECD Experiences," prepared for University of Birmingham (United Kingdom), Senior Road Executives Programme, Restructuring Road Management, Birmingham, April 24–29

Zietlow, G. "Using Micro-Enterprises to Create Local Contracting Capacity—The Latin American Experience in Road Maintenance," presented at University of Birmingham(United Kingdom), Senior Road Executives Programme, Restructuring Road Management, Birmingham, April 24–29[Online]. Available at http://www.zietlow.com.

APPENDIX A – ADDITIONAL BACKGROUND INFORMATION

DATE 22APR05 FLORIDA DEPARTMENT OF TRANSPORTATION

MAINTENANCE RATING PROGRAM

UNIT NAME: ALL COST CENTER NO.: ALL
FACILITY TYPE: ALL FACILITY TYPES
GEOGRAPHIC AREA: STATEWIDE MILEAGE EVALUATED: 10002.616
EVALUATION PERIOD : 2ND PERIOD - NOV THRU FEB FY 2004-05

ROADWAY	#	YES	*
FLEX POTHOLE	2330	2280	98
FLEX EDGE RVL	341	340	100
FLEX SHOVING	2330	2303	99
FLEX DEP/BUMP	2329	2180	94
FLX PVD SH/TO	1955	1835	94
RIGID POTHOLE	77	69	90
RIGID DEP/BMP	77	72	94
RGD JOINT/CRK	77	71	92
RGD PVD SH/TO	366	361	99

TRAFFIC SERVICES	#	YES	*
RAISED MARKER	2387	1646	69
STRIPING	2387	1989	83
PAVT SYMBOL	996	910	91
GUARDRAIL	654	526	80
ATTENUATOR	34	32	94
SIGNS < 30 SF	1218	927	76
SIGNS > 30 SF	289	217	75
OBJECT MARKER	1279	981	77
LIGHTING	413	348	84

ROADSIDE	#	YES	*
SHLDR UNPAVED	1909	1298	68
FRONT SLOPE	1946	1539	79
SLOPE PAVEMNT	69	69	100
SIDEWALK	586	564	96
FENCE	833	765	92

DRAINAGE	#	YES	*
SIDE/CRS DRA	958	816	85
RS/MED DITCH	1800	1658	92
OUTFALL DITCH	41	40	98
INLETS	1165	996	85
MISC DRAINAGE	504	398	79
SWEEPING	1022	924	90

VEGETATION - AESTHETICS	#	YES	*
ROADSIDE MOW	2317	2174	94
SLOPE MOWING	290	266	92
LANDSCAPING	43	42	98
TREE TRIMMING	2384	1894	79
CURB/SW EDGE	739	450	61
LITTER REMOVE	2386	1947	82
TURF CONDITION	2327	1967	85

LEVEL OF MAINTENANCE BY ELEMENT :

ROADWAY	96
ROADSIDE	78
TRAFFIC SERVICES	78
DRAINAGE	87
VEGETATION - AESTHETICS	84

LEVEL OF MAINTENANCE:

ALL FACILITY TYPES 84

** MILEAGE EXCLUDES RAMPS AND BRIDGES **

Figure A-1. Sample MRP Sheet (for Mainframe MRP Scores)

	Owners		Industry		Combined	
	%	Rank	%	Rank	%	Rank
Risk transfer to contractor	75	1	89	1	81	1
Encourages "outcome" thinking	75	2	78	2	76	2
Promotes innovation	67	3	78	3	71	3
Defines LOS	67	4	44	10	57	4
More efficient contract administration	67	5	44	11	57	5
Defines performance expectations	58	7	44	12	52	6
Shifts night work to contractor	67	6	33	18	52	7
Transfers resource/people issues to contractor	58	8	44	13	52	8
Planned expenditures	50	9	44	14	48	9
Reduces governmental restrictions/constraints	42	15	56	6	48	10
Lower administrative/oversight costs	33	20	56	7	43	
Provides contractor flexibility	42	14	44	15	43	
Additional resources to toolbox	42	13	33	19	38	
Reduces owner costs	25	25	56	8	38	
Increases transparency/accountability & confidence	17	30	67	5	38	
Develops a sub-contracting industry	42	18	33	20	38	
Improves collection of third party claims	42	19	33	21	38	
Ability to focus on specific assets	42	12	22	26	33	
Improves response time	0	35	78	4	33	
Long-term security for contractors	33	22	33	22	33	
Fosters life cycle approach	33	23	33	23	33	
Promotes proactive management	50	10	22	25	33	
Realigns resources to match needs	50	11	11	32	33	
Forces owner to identify costs	42	16	22	27	33	
Improves ability to allocate resources	42	17	22	28	33	
Establishes alignment between owner & contractor	33	21	22	29	29	
Improves quality, timeliness & performance	8	32	33	24	25	
Provides long-term consistent outputs	0	38	56	9	24	
Targets improvement in DBE program	25	26	22	30	24	
Improves NBIS reactions to bridge deficiencies	0	46	44	17	20	
Encourages coordination/integration of activities	25	27	11	34	20	
Better understanding of risk	0	37	44	16	19	
Improves LOS	25	24	11	33	19	
Creates or enhances industry	17	28	0	40	10	
Positions the agency more strategically	17	29	0	41	10	
Allows different pricing mechanisms	17	31	0	42	10	
Provides innovation transfer to owner	0	45	22	31	10	

Note: Shaded cells indicate differences between owners and industry of more than 30% in voting results.

Figure A-2. Strengths of PBMC (adapted from Hoffman 2010)

	Owner		Industry		Combined	
	%	Rank	%	Rank	%	Rank
Lack of accepted agency guidelines or standards	83	3	67	5	76	1
Uncertainty of multi-year funding availability	67	8	67	4	67	2
Loss of agency experience & capability	83	2	33	10	62	3
Perception that LOS is driven by "bottom line"	75	5	44	8	62	4
Negative impact to employee morale	92	1	22	14	62	5
Concern for traditional contractor loss of work	67	7	56	6	62	6
Challenges in pricing/funding over multiple years	58	10	55	7	57	7
Legal liability implications	33	15	89	1	57	8
Lack of competition among contractors	75	4	22	12	52	9
Lack of direct control over work activities	25	21	67	2	43	10
Not as responsive to local politics	67	6	11	19	43	10
Lack of organizational framework to deal with PBMC	67	9	11	25	43	10
Contractor limited resources to react to major events	42	12	0	34	42	
Increased cost	58	11	11	20	38	
Lack of awareness/knowledge of PBMC	33	17	44	9	38	
Difficulty to assign/allocate tort liability	0	34	67	3	29	
Loss of familiarity with local customers and issues	33	19	22	17	29	
Insufficient money to budget up front	33	13	11	18	25	
Requires inventory & condition assessment info	25	20	22	13	25	
Impact of "force majeure" on contract	17	31	33	11	25	
Perception that only larger contractors compete	33	18	11	23	25	
Contract complexities	33	16	11	21	24	
Impact on public sector jobs in rural areas	33	14	0	27	20	
Decoupling of payment from work activity	17	27	22	15	20	
Lack of legal framework	17	29	22	16	20	
Potential for larger claims	25	24	11	24	20	
Resistance to political pressure	25	22	0	29	14	
Customers identify with owner, not contractor	25	23	0	31	14	
Loss of historical cost data by activity	17	30	11	22	14	
Perception that maintenance work is "free"	25	25	0	35	14	
Decreases opportunity for DBEs	17	26	0	26	10	
Lack of "fine tune" mechanism/adjustments	17	28	0	30	10	
Increased project oversight requirements	17	32	0	32	10	
Newness of process	0	33	0	28	0	
Challenges in siting maintenance flexibility	0	35	0	33	0	

Note: Shaded cells indicate differences between owners and industry of more than 30% in voting results.

Figure A-3. Weaknesses of PBMC (adapted from Hoffman 2010)

	Owners		Industry		Combined	
	%	Rank	%	Rank	%	Rank
Establish PBMC as a long-term, sustainable approach	92	1	100	1	95	1
Impact to employee morale/culture change	83	2	67	2	76	2
Lack of agency guidelines for PBMC	67	4	67	3	67	3
Determine costs & performance levels	75	3	56	5	67	4
Achieving executive level support	50	5	44	7	48	5
Funding uncertainty over multiple years	33	6	56	4	42	6
Legal liability implications	25	8	44	6	33	
Perception/customer desire driven by bottom line	17	10	22	8	19	
Lack of contractor competition	17	9	11	9	14	
Loss of agency experience & capability	25	7	0	12	14	
Pricing for multi-year contract	8	11	11	10	10	

Figure A-4. Challenges of PBMC (adapted from Hoffman 2010)

APPENDIX B – SURVEY QUESTIONS AND RAW DATA

FDOT project survey_v2

I1 Please list the applicable credentials of the principle contact for Performance Based Contracting(PBMC) of your agency/company.

(Company or Agency)/Department (1)____________

Title (2)_____________

Email (3)_____________

I2 Please indicate your position on whether or not the following types of maintenance contracts typically have successful outcomes.

	Completely Disagree (1)	Somewhat Disagree (2)	Neutral (3)	Somewhat Agree (4)	Completely Agree (5)
PBMC (1)	❍	❍	❍	❍	❍
Unit-price (2)	❍	❍	❍	❍	❍
Lump sum (3)	❍	❍	❍	❍	❍
Work-order oriented (4)	❍	❍	❍	❍	❍

Figure B-1. Survey Page 1

I3 Please indicate your position on the following statements.

	Completely Disagree (1)	Somewhat Disagree (2)	Neutral (3)	Somewhat Agree (4)	Completely Agree (5)
PBMC results in cost savings (1)	❍	❍	❍	❍	❍
PBMC requires less administration (2)	❍	❍	❍	❍	❍
PBMC increases innovation potential (3)	❍	❍	❍	❍	❍
PBMC results in improved LOS (4)	❍	❍	❍	❍	❍
PBMC allows for more stable budget forecasting (5)	❍	❍	❍	❍	❍
PBMC requires less in-house staff (6)	❍	❍	❍	❍	❍
For PBMC, cost savings are not realized until at least one year into the contract. (7)	❍	❍	❍	❍	❍
For PBMC, Level of Service(LOS) increase is not realized until at least one year into the contract. (8)	❍	❍	❍	❍	❍

Figure B-2. Survey Page 2

I4 Please indicate whether or not you believe the following PBMC contract structures are effective.

	Completely Disagree (1)	Somewhat Disagree (2)	Neutral (3)	Somewhat Agree (4)	Completely Agree (5)
Area wide PBMC covering a subunit of the state for one activity or related group of activities (1)	❍	❍	❍	❍	❍
Area wide PBMC for more than one activity or related group of activities (2)	❍	❍	❍	❍	❍
Area wide PBMC covering all or most activities within a subunit state (3)	❍	❍	❍	❍	❍
PBMC for selected activities within a corridor (4)	❍	❍	❍	❍	❍
PBMC for fence-to-fence maintenance covering all activities in corridor (5)	❍	❍	❍	❍	❍

I5 In your opinion, what is the approximate percentage of work that must be done by the principle contractor, as opposed to awarding sub-contracts, for PBMC to be successful.
______ % of work to be done by principle contractor (1)

Figure B-3. Survey Page 3

I6 Please indicate the percentage of the contract amount you believe should be subject to incentives(bonuses for exceeding performance expectations) and disincentives(penalties for failing to meet performance standards) using the scales below to ensure performance standards are met without making the contract too risky for the contractor.

______ Possible incentive amount (1)

______ Possible disincentive amount (2)

I7 Please briefly list ways PBMCs can be made most cost effective.

I10 Which of the following are you responding for?

- ❍ FDOT (1)
- ❍ Other State DOT (2)
- ❍ Contractor (3)

If Contractor Is Selected, Then Skip To Has your company been awarded any typ...If FDOT Is Selected, Then Skip To Please provide your applicable creden...

D1 Please indicate your position on the following topics as valid reasons to not use PBMC.

	No Importance (1)	Little Importantance (2)	Neither Important Nor Unimportant (3)	Somewhat Important (4)	Very Important (5)
Employee Concerns (1)	❍	❍	❍	❍	❍
Union issues (2)	❍	❍	❍	❍	❍
Lack of experience (3)	❍	❍	❍	❍	❍
Attempted without success (4)	❍	❍	❍	❍	❍
Legal issues/Legislation (5)	❍	❍	❍	❍	❍
Lack of cost savings (6)	❍	❍	❍	❍	❍
Poor contractor selection process (7)	❍	❍	❍	❍	❍
Level of Service either the same or worse (8)	❍	❍	❍	❍	❍

Figure B-4. Survey Page 3

D2 Has your agency used PBMC for maintenance and/or operations for highways?
- ❍ Yes (1)
- ❍ No (2)

D3 Please list the factors which motivated your organization to or not to pursue PBMC in descending order of importance.

If Please list the factor... Is Displayed, Then Skip To Please choose ALL of the followi...

C1 Has your company been awarded any type of PBMC for highway maintenance?
- ❍ Yes (1)
- ❍ No (2)

C2 Please indicate the minimum and maximum contract lengths(in years) for PBMCs to remain feasible and cost effective.

______ Minimum Term (1)
______ Maximum Term (2)

C3 Please indicate the minimum annual contract value ($/year) for PBMCs to remain feasible and cost effective for the following categories.

Roadway (1)
Structure (2)
Facility (3)

C4 What, if any, are the minimum training requirements and/or experience contractors should complete to facilitate a PBMC successfully.

If What, if any, are the minim... Is Displayed, Then Skip To Please choose ALL of the following ty...

F1 Please provide your applicable credentials.

Name (1)
Title (2)
District (3)
Phone (4)
Email (5)

Figure B-5. Survey Page 5

F2 Please indicate your position on the following statements.

	Completely Disagree (1)	Somewhat Disagree (2)	Neutral (3)	Somewhat Agree (4)	Completely Agree (5)
PBMC should result in more day to day management on the part of the district personnel. (1)	❍	❍	❍	❍	❍
PBMC should result in less day to day management on the part of district personnel. (2)	❍	❍	❍	❍	❍
PBMC typically means the contractor has the freedom to set performance standards. (3)	❍	❍	❍	❍	❍
The only responsibility of district personnel in regard to PBMC is to monitor the condition of the asset in relation to performance standards. (4)	❍	❍	❍	❍	❍
For PBMC, the contractor is solely responsible for monitoring asset performance. (5)	❍	❍	❍	❍	❍
For PBMC, the district is	❍	❍	❍	❍	❍

Figure B-6. Survey Page 4

solely responsible for monitoring asset performance. (6)					

I12 Please choose ALL of the following types of contracts your agency, company, or district has experience with.

- ❑ Area wide PBMC covering a subunit of the state for one activity or related group of activities (1)
- ❑ Area wide PBMC for more than one activity or related group of activities (2)
- ❑ Area wide PBMC covering all or most activities within a state (3)
- ❑ PBMC for selected activities within a corridor (4)
- ❑ PBMC for fence-to-fence maintenance covering all activities in corridor (5)
- ❑ Other (6)
- ❑ None (7)

I13 Please use this question to elaborate on any responses or provide additional information on PBMC in general or pertaining to your agency/company.

I14 If you would be willing to do a phone interview discussing your response and additional pertinent information regarding highway maintenance contracting please fill out the fields below.

Name (1)
Department (2)
Email (3)
Phone (4)

Figure B-7. Survey Page 7

Table B-1. FDOT Survey 1 (Contract Type Success)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	PBMC	2	3	14	17	7	43	3.56
2	Unit-price	0	2	7	19	16	44	4.11
3	Lump sum	0	2	6	24	13	45	4.07
4	Work-order oriented	0	0	3	14	27	44	4.55

Table B-2. FDOT Survey 1 (Contract Type Success) stats

Statistic	PBMC	Unit-price	Lump sum	Work-order oriented
Min Value	1	2	2	3
Max Value	5	5	5	5
Mean	3.56	4.11	4.07	4.55
Variance	1.01	0.71	0.61	0.39
Standard Deviation	1.01	0.84	0.78	0.63
Total Responses	43	44	45	44

Table B-3. Contractor Survey 1 (Contract Type Success)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	PBMC	1	0	3	10	9	23	4.13
2	Unit-price	0	5	8	8	3	24	3.38
3	Lump sum	0	3	8	8	6	25	3.68
4	Work-order oriented	0	5	8	8	3	24	3.38

Table B-4. Contractor Survey 1 (Contract Type Success) stats

Statistic	PBMC	Unit-price	Lump sum	Work-order oriented
Min Value	1	2	2	2
Max Value	5	5	5	5
Mean	4.13	3.38	3.68	3.38
Variance	0.94	0.94	0.98	0.94
Standard Deviation	0.97	0.97	0.99	0.97
Total Responses	23	24	25	24

Table B-5. Other DOT Survey 1 (Contract Type Success)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	PBMC	0	1	2	1	1	5	3.40
2	Unit-price	0	0	0	3	2	5	4.40
3	Lump sum	0	1	1	2	1	5	3.60
4	Work-order oriented	0	0	1	3	1	5	4.00

Table B-6. Other DOT Survey 1 (Contract Type Success) stats

Statistic	PBMC	Unit-price	Lump sum	Work-order oriented
Min Value	2	4	2	3
Max Value	5	5	5	5
Mean	3.40	4.40	3.60	4.00
Variance	1.30	0.30	1.30	0.50
Standard Deviation	1.14	0.55	1.14	0.71
Total Responses	5	5	5	5

Table B-7. FDOT Survey 2

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	PBMC results in cost savings	1	8	16	15	10	50	3.50
2	PBMC requires less administration	2	9	11	18	10	50	3.50
3	PBMC increases innovation potential	3	9	10	20	8	50	3.42
4	PBMC results in improved LOS	7	12	18	12	1	50	2.76
5	PBMC allows for more stable budget forecasting	2	3	12	21	12	50	3.76
6	PBMC requires less in-house staff	3	2	8	21	16	50	3.90
7	For PBMC, cost savings are not realized until at least one year into the contract.	3	11	23	11	2	50	2.96
8	For PBMC, Level of Service(LOS) increase is not realized until at least one year into the contract.	4	17	20	7	2	50	2.72

Table B-8. FDOT Survey 2 stats

Statistic	PBMC results in cost savings	PBMC requires less administration	PBMC increases innovation potential	PBMC results in improved LOS	PBMC allows for more stable budget forecasting	PBMC requires less in-house staff	For PBMC, cost savings are not realized until at least one year into the contract.	For PBMC, Level of Service(LOS) increase is not realized until at least one year into the contract.
Min Value	1	1	1	1	1	1	1	1
Max Value	5	5	5	5	5	5	5	5
Mean	3.50	3.50	3.42	2.76	3.76	3.90	2.96	2.72
Variance	1.11	1.28	1.31	1.08	1.04	1.19	0.86	0.90
Standard Deviation	1.05	1.13	1.14	1.04	1.02	1.09	0.92	0.95
Total Responses	50	50	50	50	50	50	50	50

Table B-9. Contractor Survey 2

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	PBMC results in cost savings	0	0	2	9	16	27	4.52
2	PBMC requires less administration	0	3	3	10	11	27	4.07
3	PBMC increases innovation potential	0	2	2	7	16	27	4.37
4	PBMC results in improved LOS	0	1	6	9	11	27	4.11
5	PBMC allows for more stable budget forecasting	1	0	2	7	17	27	4.44
6	PBMC requires less in-house staff	1	2	0	10	14	27	4.26
7	For PBMC, cost savings are not realized until at least one year into the contract.	2	7	5	8	5	27	3.26
8	For PBMC, Level of Service(LOS) increase is not realized until at least one year into the contract.	3	4	7	10	3	27	3.22

Table B-10. Contractor Survey 2 stats

Statistic	PBMC results in cost savings	PBMC requires less administration	PBMC increases innovation potential	PBMC results in improved LOS	PBMC allows for more stable budget forecasting	PBMC requires less in-house staff	For PBMC, cost savings are not realized until at least one year into the contract.	For PBMC, Level of Service(LOS) increase is not realized until at least one year into the contract.
Min Value	3	2	2	2	1	1	1	1
Max Value	5	5	5	5	5	5	5	5
Mean	4.52	4.07	4.37	4.11	4.44	4.26	3.26	3.22
Variance	0.41	0.99	0.86	0.79	0.87	1.12	1.58	1.41
Standard Deviation	0.64	1.00	0.93	0.89	0.93	1.06	1.26	1.19
Total Responses	27	27	27	27	27	27	27	27

Table B-11. Other DOT Survey 2

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	PBMC results in cost savings	0	1	2	2	0	5	3.20
2	PBMC requires less administration	0	1	2	1	1	5	3.40
3	PBMC increases innovation potential	0	1	0	2	2	5	4.00
4	PBMC results in improved LOS	1	0	2	2	0	5	3.00
5	PBMC allows for more stable budget forecasting	0	0	1	2	2	5	4.20
6	PBMC requires less in-house staff	0	1	0	3	1	5	3.80
7	For PBMC, cost savings are not realized until at least one year into the contract.	1	1	2	0	1	5	2.80
8	For PBMC, Level of Service(LOS) increase is not realized until at least one year into the contract.	1	1	1	1	1	5	3.00

Table B-12. Other DOT Survey 2 stats

Statistic	PBMC results in cost savings	PBMC requires less administration	PBMC increases innovation potential	PBMC results in improved LOS	PBMC allows for more stable budget forecasting	PBMC requires less in-house staff	For PBMC, cost savings are not realized until at least one year into the contract.	For PBMC, Level of Service(LOS) increase is not realized until at least one year into the contract.
Min Value	2	2	2	1	3	2	1	1
Max Value	4	5	5	4	5	5	5	5
Mean	3.20	3.40	4.00	3.00	4.20	3.80	2.80	3.00
Variance	0.70	1.30	1.50	1.50	0.70	1.20	2.20	2.50
Standard Deviation	0.84	1.14	1.22	1.22	0.84	1.10	1.48	1.58
Total Responses	5	5	5	5	5	5	5	5

Table B-13. FDOT Survey 3 (PBMC Type Success)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	Area wide PBMC covering a subunit of the state for one activity or related group of activities	5	4	10	26	5	50	3.44
2	Area wide PBMC for more than one activity or related group of activities	2	6	7	27	8	50	3.66
3	Area wide PBMC covering all or most activities within a subunit state	2	4	8	21	15	50	3.86
4	PBMC for selected activities within a corridor	3	4	13	21	9	50	3.58
5	PBMC for fence-to-fence maintenance covering all activities in corridor	2	2	8	19	19	50	4.02

Table B-14. FDOT Survey 3 (PBMC Type Success) stats

Statistic	Area wide PBMC covering a subunit of the state for one activity or related group of activities	Area wide PBMC for more than one activity or related group of activities	Area wide PBMC covering all or most activities within a subunit state	PBMC for selected activities within a corridor	PBMC for fence-to-fence maintenance covering all activities in corridor
Min Value	1	1	1	1	1
Max Value	5	5	5	5	5
Mean	3.44	3.66	3.86	3.58	4.02
Variance	1.23	1.05	1.14	1.15	1.08
Standard Deviation	1.11	1.02	1.07	1.07	1.04
Total Responses	50	50	50	50	50

Table B-15. Contractor Survey 3 (PBMC Type Success)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	Area wide PBMC covering a subunit of the state for one activity or related group of activities	3	6	6	4	8	27	3.30
2	Area wide PBMC for more than one activity or related group of activities	0	4	4	6	13	27	4.04
3	Area wide PBMC covering all or most activities within a subunit state	0	1	1	6	19	27	4.59
4	PBMC for selected activities within a corridor	0	4	5	8	10	27	3.89
5	PBMC for fence-to-fence maintenance covering all activities in corridor	0	2	0	2	23	27	4.70

Table B-16. Contractor Survey 3 (PBMC Type Success) stats

Statistic	Area wide PBMC covering a subunit of the state for one activity or related group of activities	Area wide PBMC for more than one activity or related group of activities	Area wide PBMC covering all or most activities within a subunit state	PBMC for selected activities within a corridor	PBMC for fence-to-fence maintenance covering all activities in corridor
Min Value	1	2	2	2	2
Max Value	5	5	5	5	5
Mean	3.30	4.04	4.59	3.89	4.70
Variance	1.99	1.27	0.56	1.18	0.68
Standard Deviation	1.41	1.13	0.75	1.09	0.82
Total Responses	27	27	27	27	27

Table B-17. Other DOT Survey 3 (PBMC Type Success)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	Area wide PBMC covering a subunit of the state for one activity or related group of activities	0	0	3	2	0	5	3.40
2	Area wide PBMC for more than one activity or related group of activities	0	0	2	3	0	5	3.60
3	Area wide PBMC covering all or most activities within a subunit state	1	0	1	2	1	5	3.40
4	PBMC for selected activities within a corridor	1	0	0	4	0	5	3.40
5	PBMC for fence-to-fence maintenance covering all activities in corridor	1	0	1	2	1	5	3.40

Table B-18. Other DOT Survey 3 (PBMC Type Success) stats

Statistic	Area wide PBMC covering a subunit of the state for one activity or related group of activities	Area wide PBMC for more than one activity or related group of activities	Area wide PBMC covering all or most activities within a subunit state	PBMC for selected activities within a corridor	PBMC for fence-to-fence maintenance covering all activities in corridor
Min Value	3	3	1	1	1
Max Value	4	4	5	4	5
Mean	3.40	3.60	3.40	3.40	3.40
Variance	0.30	0.30	2.30	1.80	2.30
Standard Deviation	0.55	0.55	1.52	1.34	1.52
Total Responses	5	5	5	5	5

Table B-0-19. FDOT Survey 4

#	Answer	Min Value	Max Value	Average Value	Standard Deviation	Responses
1	% of work to be done by principle contractor	10.00	90.00	58.65	19.13	49

Table B-0-20. FDOT Survey 5

#	Answer	Min Value	Max Value	Average Value	Standard Deviation	Responses
1	Possible incentive amount	0.00	100.00	23.86	24.05	50
2	Possible disincentive amount	0.00	100.00	45.80	31.40	50

Table B-21. Contractor Survey 4 & 5

#	Answer	Min Value	Max Value	Average Value	Standard Deviation	Responses
1	% of work to be done by principle contractor	15.00	91.00	52.74	23.15	27
#	Answer	Min Value	Max Value	Average Value	Standard Deviation	Responses
1	Possible incentive amount	7.00	80.00	24.44	19.88	27
2	Possible disincentive amount	5.00	70.00	24.52	17.84	27

Table B-0-22. Other DOT Survey 4

#	Answer	Min Value	Max Value	Average Value	Standard Deviation	Responses
1	% of work to be done by principle contractor	20.00	90.00	54.40	27.33	5

Table B-0-23. Other DOT Survey 5

#	Answer	Min Value	Max Value	Average Value	Standard Deviation	Responses
1	Possible incentive amount	10.00	100.00	33.00	38.34	5
2	Possible disincentive amount	10.00	100.00	44.40	37.24	5

Table B-24. FDOT Survey 6 (Contract Type Experience)

#	Answer		Response	%
1	Area wide PBMC covering a subunit of the state for one activity or related group of activities		28	60%
2	Area wide PBMC for more than one activity or related group of activities		30	64%
3	Area wide PBMC covering all or most activities within a state		16	34%
4	PBMC for selected activities within a corridor		32	68%
5	PBMC for fence-to-fence maintenance covering all activities in corridor		36	77%
6	Other		6	13%
7	None		0	0%

Table B-25. Contractor Survey 6 (Contract Type Experience)

#	Answer		Response	%
1	Area wide PBMC covering a subunit of the state for one activity or related group of activities		15	56%
2	Area wide PBMC for more than one activity or related group of activities		19	70%
3	Area wide PBMC covering all or most activities within a state		17	63%
4	PBMC for selected activities within a corridor		18	67%
5	PBMC for fence-to-fence maintenance covering all activities in corridor		22	81%
6	Other		12	44%
7	None		0	0%

Table B-26. Other DOT Survey 6 (Contract Type Experience)

#	Answer		Response	%
1	Area wide PBMC covering a subunit of the state for one activity or related group of activities		1	25%
2	Area wide PBMC for more than one activity or related group of activities		1	25%
3	Area wide PBMC covering all or most activities within a state		1	25%
4	PBMC for selected activities within a corridor		2	50%
5	PBMC for fence-to-fence maintenance covering all activities in corridor		2	50%
6	Other		0	0%
7	None		0	0%

Table B-27. FDOT Survey 7 (FDOT Personnel PBMC Understanding Question)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
1	PBMC should result in more day to day management on the part of the district personnel.	22	11	8	6	0	47	1.96
2	PBMC should result in less day to day management on the part of district personnel.	0	3	6	17	21	47	4.19
3	PBMC typically means the contractor has the freedom to set performance standards.	26	10	4	6	1	47	1.85

Table B-28. FDOT Survey 7 (FDOT Personnel PBMC Understanding Question)

#	Question	Completely Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Completely Agree	Total Responses	Mean
4	The only responsibility of district personnel in regard to PBMC is to monitor the condition of the asset in relation to performance standards.	6	8	5	22	6	47	3.30
5	For PBMC, the contractor is solely responsible for monitoring asset performance.	13	19	7	5	3	47	2.28
6	For PBMC, the district is solely responsible for monitoring asset performance.	8	19	6	12	2	47	2.60

Table B-29. FDOT Survey 7 (FDOT Personnel PBMC Understanding Question) stats

Statistic	PBMC should result in more day to day management on the part of the district personnel.	PBMC should result in less day to day management on the part of district personnel.	PBMC typically means the contractor has the freedom to set performance standards.	The only responsibility of district personnel in regard to PBMC is to monitor the condition of the asset in relation to performance standards.	For PBMC, the contractor is solely responsible for monitoring asset performance.	For PBMC, the district is solely responsible for monitoring asset performance.
Min Value	1	2	1	1	1	1
Max Value	4	5	5	5	5	5
Mean	1.96	4.19	1.85	3.30	2.28	2.60
Variance	1.17	0.81	1.35	1.60	1.38	1.38
Standard Deviation	1.08	0.90	1.16	1.27	1.17	1.17
Total Responses	47	47	47	47	47	47

Table B-30. Contractor Survey 7 (Term Length)

#	Answer	Min Value	Max Value	Average Value	Standard Deviation	Responses
1	Minimum Term	4.00	10.00	6.00	1.55	27
2	Maximum Term	5.00	20.00	13.59	5.34	27

Table B-31. Contractor Survey 8 (Minimum Annual Contract Value in $/year for PBMCs to Remain Feasible and Cost Effective by Type)

Respondent #	Roadway	Structure	Facility
1	250,000	500,000	200,000
2	25,000,000	25,000,000	25,000,000
3	5,000,000	5,000,000	5,000,000
4	6,000,000.00	2,000,000.00	1,500,000.00
5	3,000,000	5,000,000	5,000,000
6	$?	$?	$?
7	2,000,000	1,000,000	500,000
8	$2,000,000.00	$2,000,000.00	$1,000,000.00
9	$7,000,000	$5,000,000	$2,000,000
10	$1M/yr	$1M/yr	$1M/yr
11	$2 Million	$2 Million	$2 Million
12	$5M	$5M	$5M
13	$5 mm	$5 mm	$5 mm
14	5 million per year	5 million per year	5 million per year
15	$15 million pa	$15 million pa	$15 million pa
16	?	?	?
17	1,000,000	1,000,000	
18	1,500,000	1,000,000	1,000,000
19	10,000,000	10,000,000	5,000,000
20	15 Mil	8 Mil	2 mil
21	unable to answer with the given data	unable to answer with the given data	unable to answer with the given data
22	30,000,000	10,000,000	5,000,000
23	4000000	3000000	3000000
24	10,000,000	5,000,000	5,000,000
25	10-15 million	n/a	n/a
	$1.5m	$1m	$0.5m (to give an overall $3m per annum to cover overhead.

Table B-32. Other DOT Survey 7 (Reasons For Not Using PBMC)

#	Question	No Importance	Little Importance	Neither Important Nor Unimportant	Somewhat Important	Very Important	Total Responses	Mean
1	Employee Concerns	0	0	3	1	0	4	3.25
2	Union issues	1	0	2	1	0	4	2.75
3	Lack of experience	0	0	2	2	0	4	3.50
4	Attempted without success	0	1	2	1	0	4	3.00
5	Legal issues/ Legislation	1	0	1	2	0	4	3.00
6	Lack of cost savings	0	0	1	3	0	4	3.75
7	Poor contractor selection process	0	0	2	1	1	4	3.75
8	Level of Service either the same or worse	0	0	1	3	0	4	3.75

Table B-33. Other DOT Survey 7 (Reasons For Not Using PBMC) stats

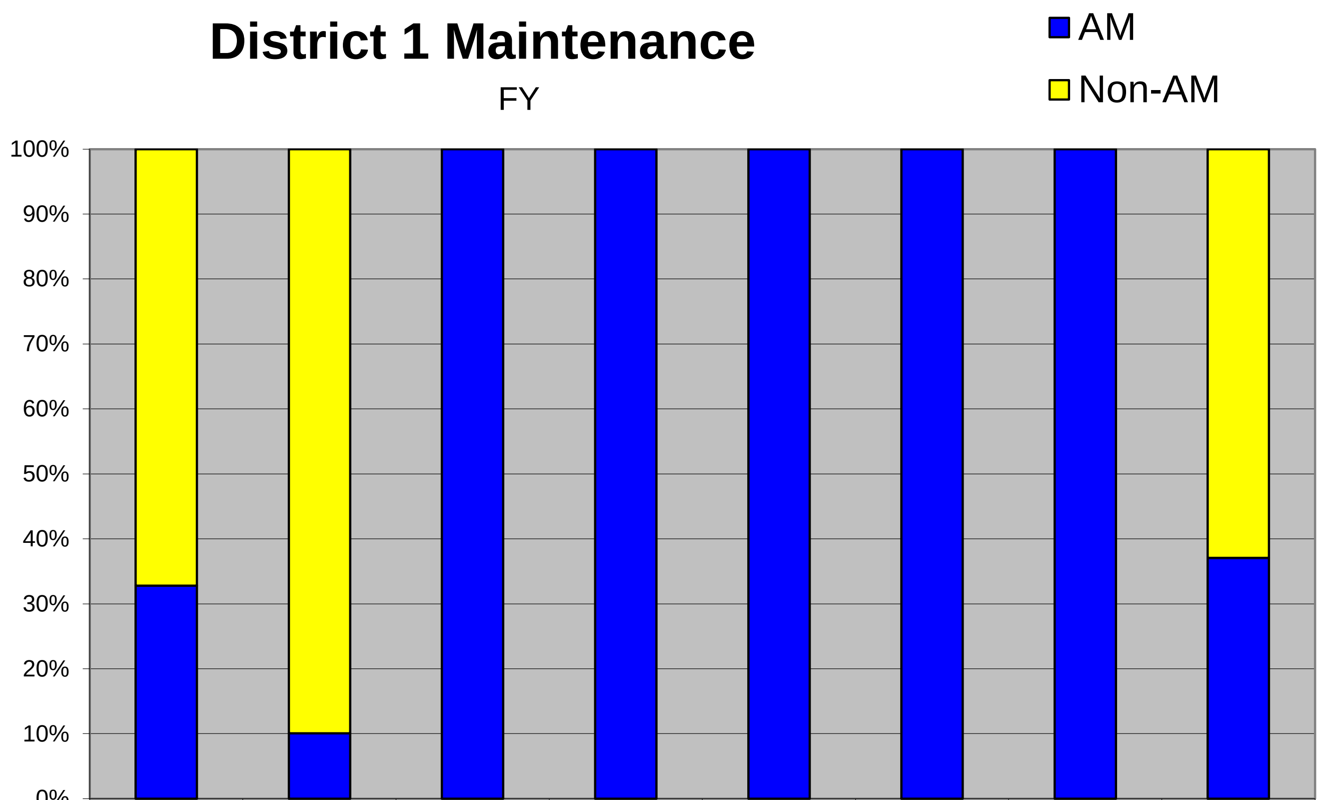
Statistic	Employee Concerns	Union issues	Lack of experience	Attempted without success	Legal issues/Legislation	Lack of cost savings	Poor contract or selection process	Level of Service either the same or worse
Min Value	3	1	3	2	1	3	3	3
Max Value	4	4	4	4	4	4	5	4
Mean	3.25	2.75	3.50	3.00	3.00	3.75	3.75	3.75
Variance	0.25	1.58	0.33	0.67	2.00	0.25	0.92	0.25
Standard Deviation	0.50	1.26	0.58	0.82	1.41	0.50	0.96	0.50
Total Responses	4	4	4	4	4	4	4	4

Table B-34. Combined Coding Sheets

Combined Coding Sheets			Coder 1							Coder 2						
Identified Key Words	Occurances	% of total	Factors affecting cost	Factors affecting LOS	Scoping	Assessment and Performance measures	Procurement and Bidding	Contract management and control	Other	Factors affecting cost	Factors affecting LOS	Scoping	Assessment and Performance measures	Procurement and Bidding	Contract management and control	Other
contractor, contractors	129	1.75	13	18	6	30	13	32	17	6	2	30	29	9	46	7
contract,contracts	144	1.95	19	20	18	22	15	31	19	5	1	61	14	12	40	11
work	76	1.03	9	12	12	10	1	22	10	2	1	17	6	5	40	5
performance	73	0.99	4	10	0	34	1	9	15	1	1	26	24	8	12	1
maintenance	48	0.65	0	5	16	6	0	10	11	2	1	20	4	10	7	4
pbmc	47	0.64	5	7	4	5	0	16	10	5	1	7	4	10	18	2
cost, costs	42	0.57	34	0	1	1	0	1	5	4	1	15	2	8	6	6
risk, risks	31	0.42	9	0	3	1	2	12	4	0	0	18	1	5	5	2
expectations	27	0.37	2	1	0	22	0	2	0	0	0	18	3	1	2	3
good	26	0.35	1	1	3	7	1	7	6	0	0	3	9	4	7	3
scope	24	0.32	1	0	23	0	0	0	0	0	0	24	0	0	0	0
term, terms	31	0.42	7	4	10	3	2	2	3	1	0	25	0	0	5	0
clear	22	0.30	1	0	6	20	2	1	1	0	1	20	1	0	0	0
		Tally Total	105	78	102	161	37	145	101	**26.00**	**9.00**	**284.00**	**97.00**	**72.00**	**188.00**	**44.00**
		Ranks	3	6	4	1	7	2	5	6	7	1	3	4	2	5

The theme "ranks" from the previous table are averaged in Table 4-34 to identify the most predominant themes of the text analysis.

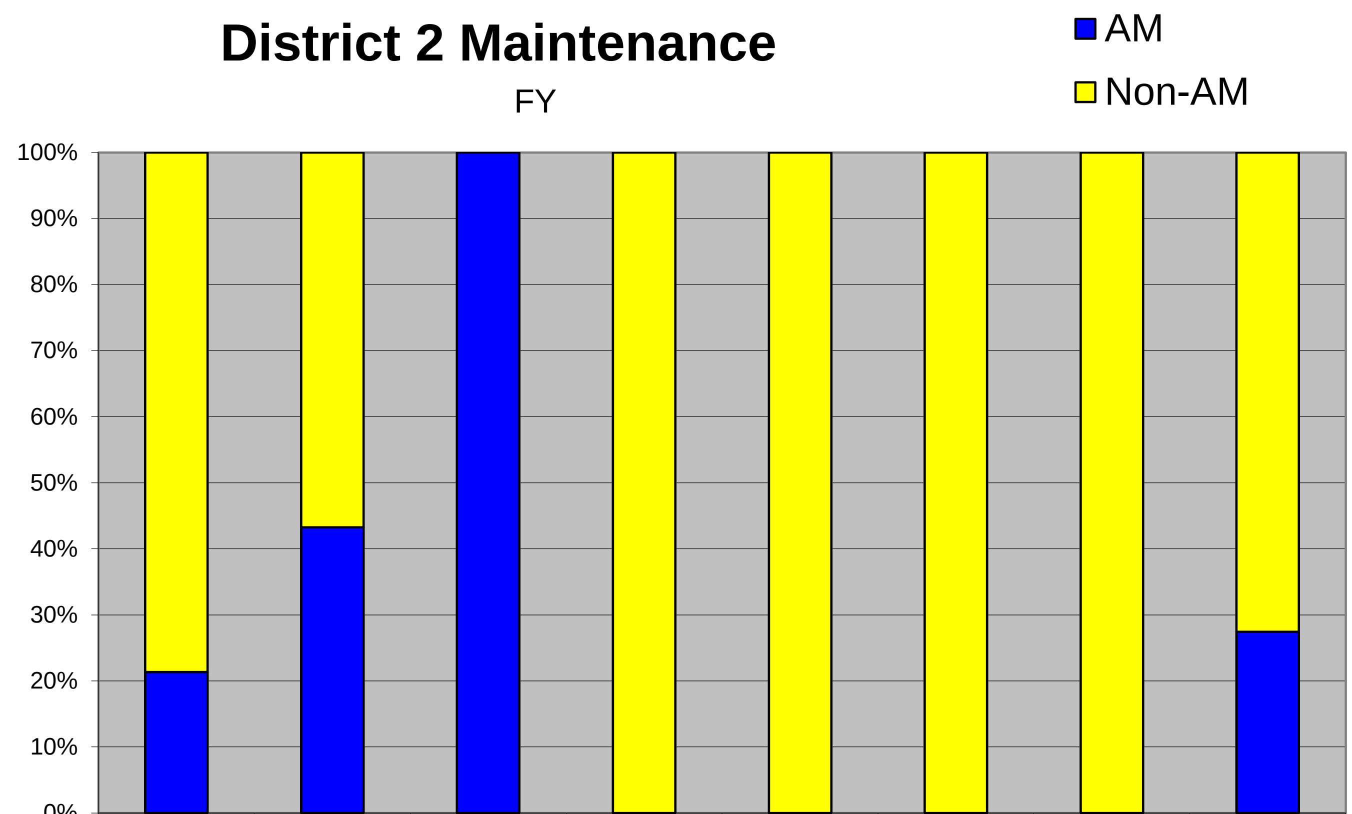
APPENDIX C – FDOT BAR CHARTS



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	674	776	0	0	0	0	0	63%
AM	329	87	6	6	18,477	12,737	1444	37%

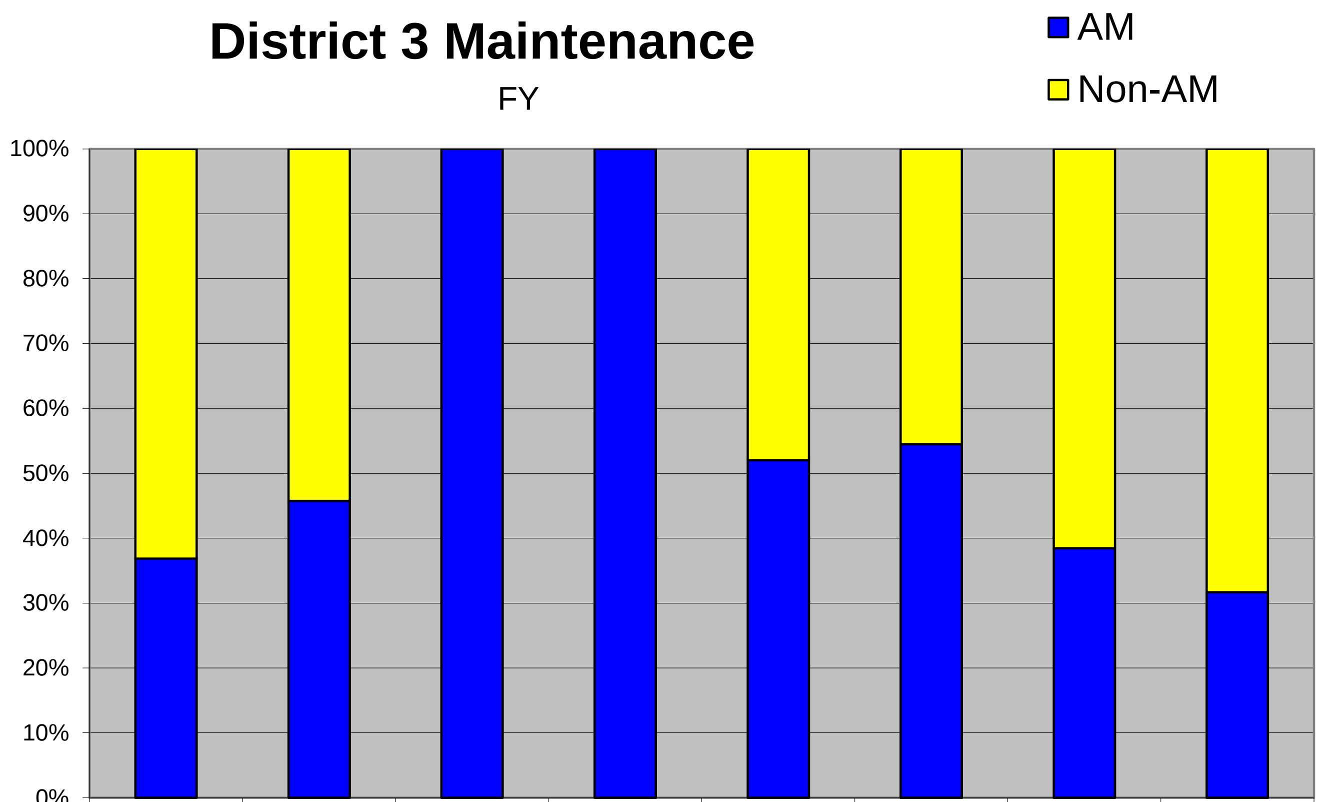
Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

Figure C-1. District 1 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	1366	467	0	17	26,988	24,444	2390	73%
AM	370	355	17	0	0	0	0	27%
	Centerline Miles		**# of Rest Areas**		**Deck Area (1000SF)**		**# of Struct**	

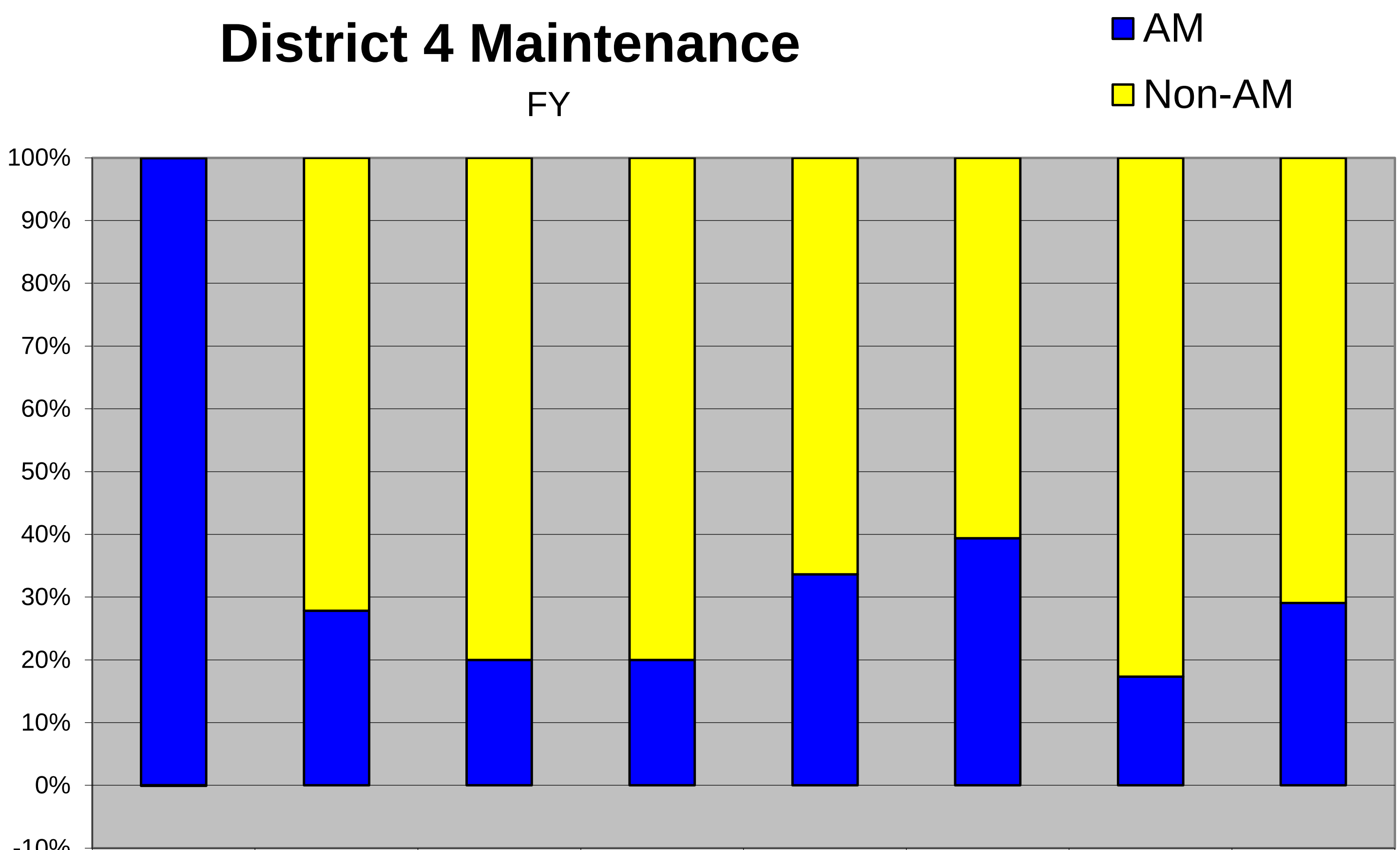
Figure C-2. District 2 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	1079	371	0	0	11,434	8,554	925	68%
AM	629	313	14	14	12,395	10,235	578	32%

Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

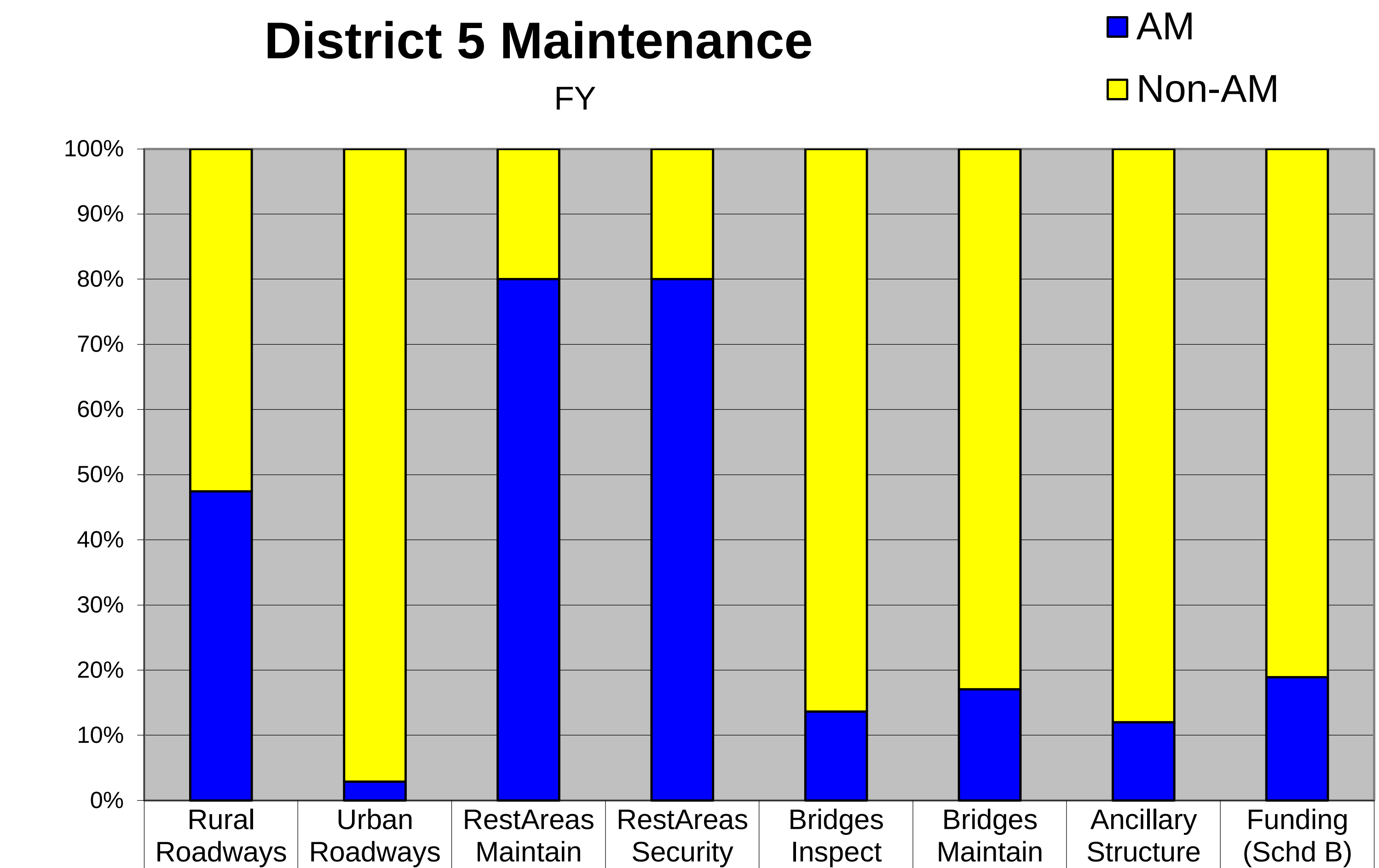
Figure C-3. District 3 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	0	773	4	4	15,698	11,861	1999	71%
AM	307	298	1	1	7,955	7,709	419	29%

Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

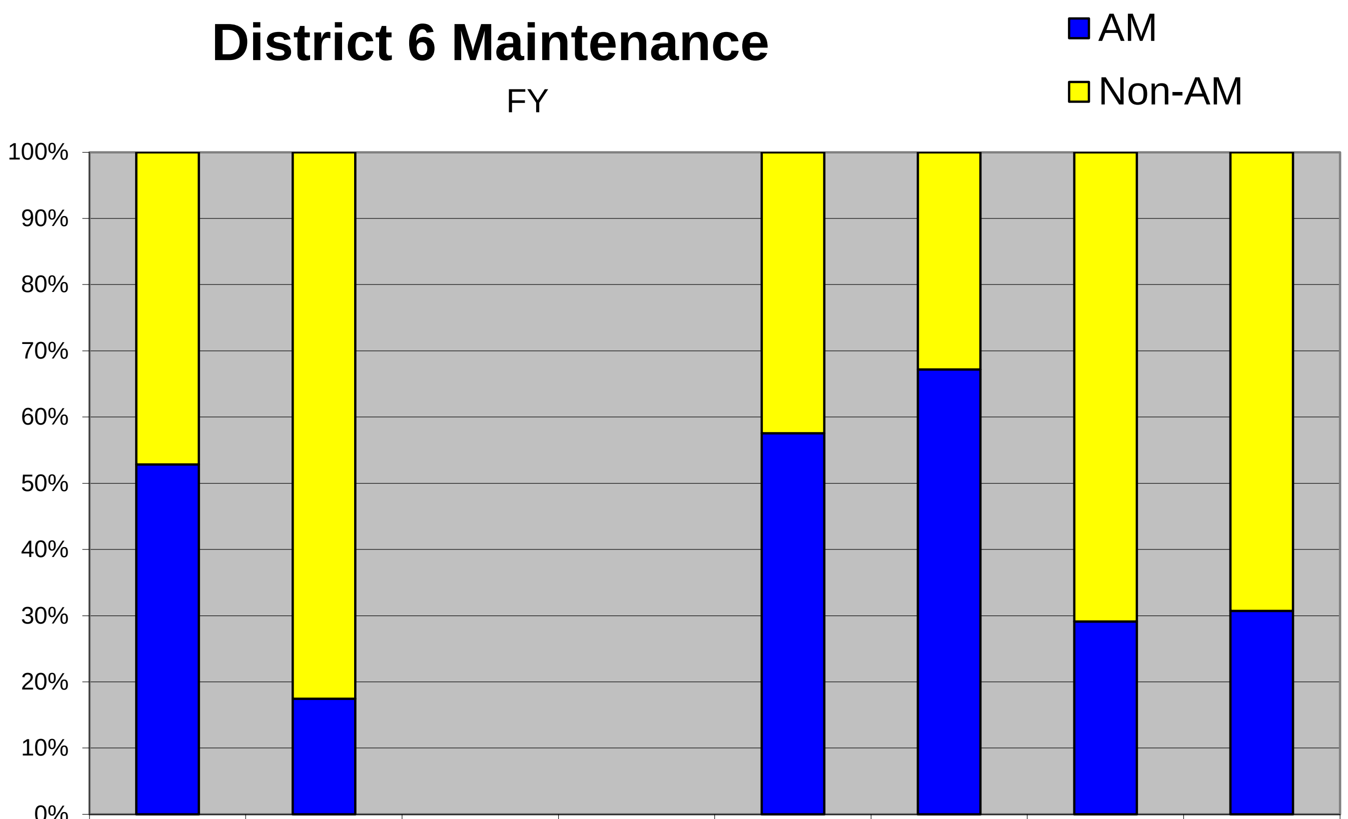
Figure C-4. District 4 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	442	1242	2	2	18,973	14,183	1833	81%
AM	399	37	8	8	3,000	2,917	250	19%

Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

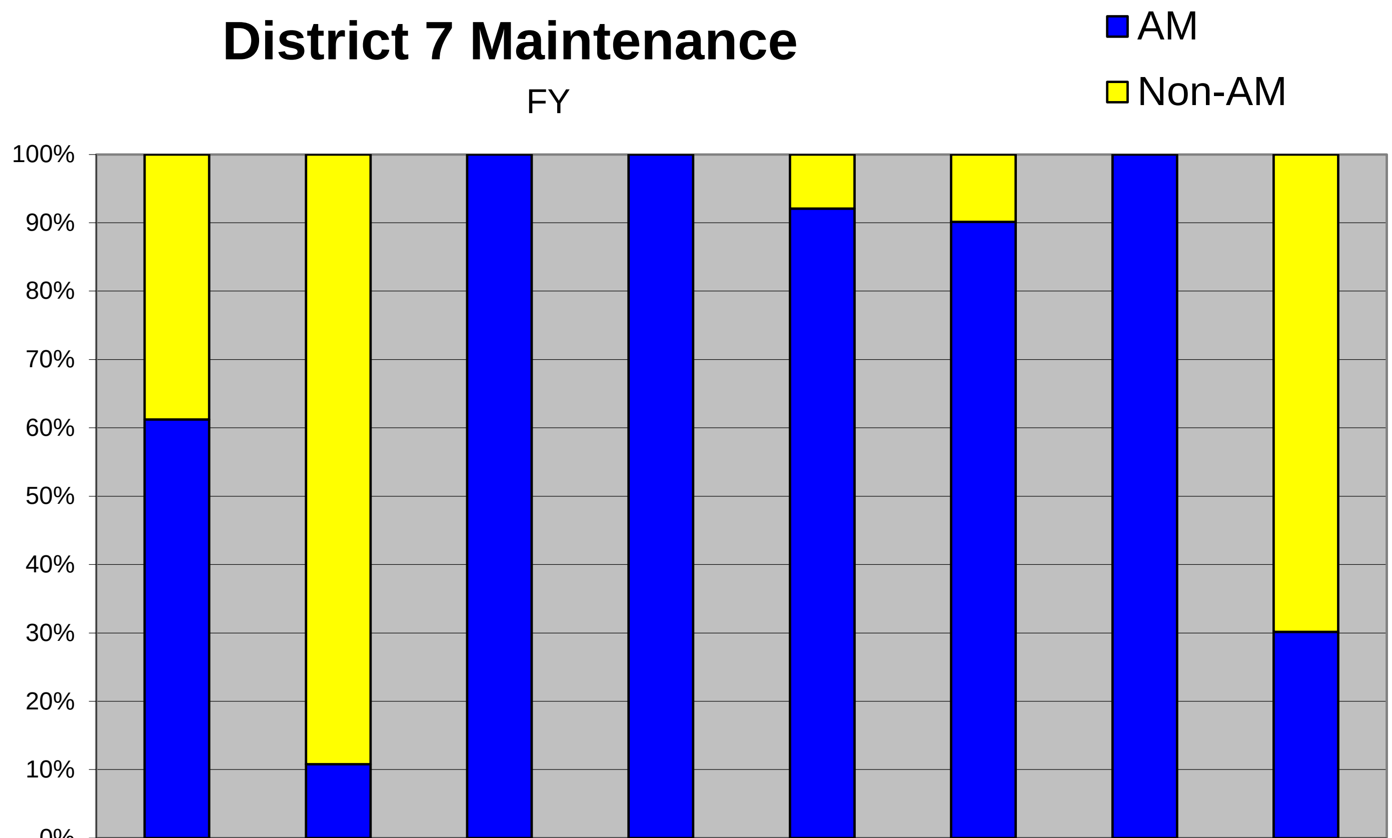
Figure C-5. District 5 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	61	470	0	0	9,760	6,454	1017	69%
AM	69	100	0	0	13,220	13,220	418	31%

Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

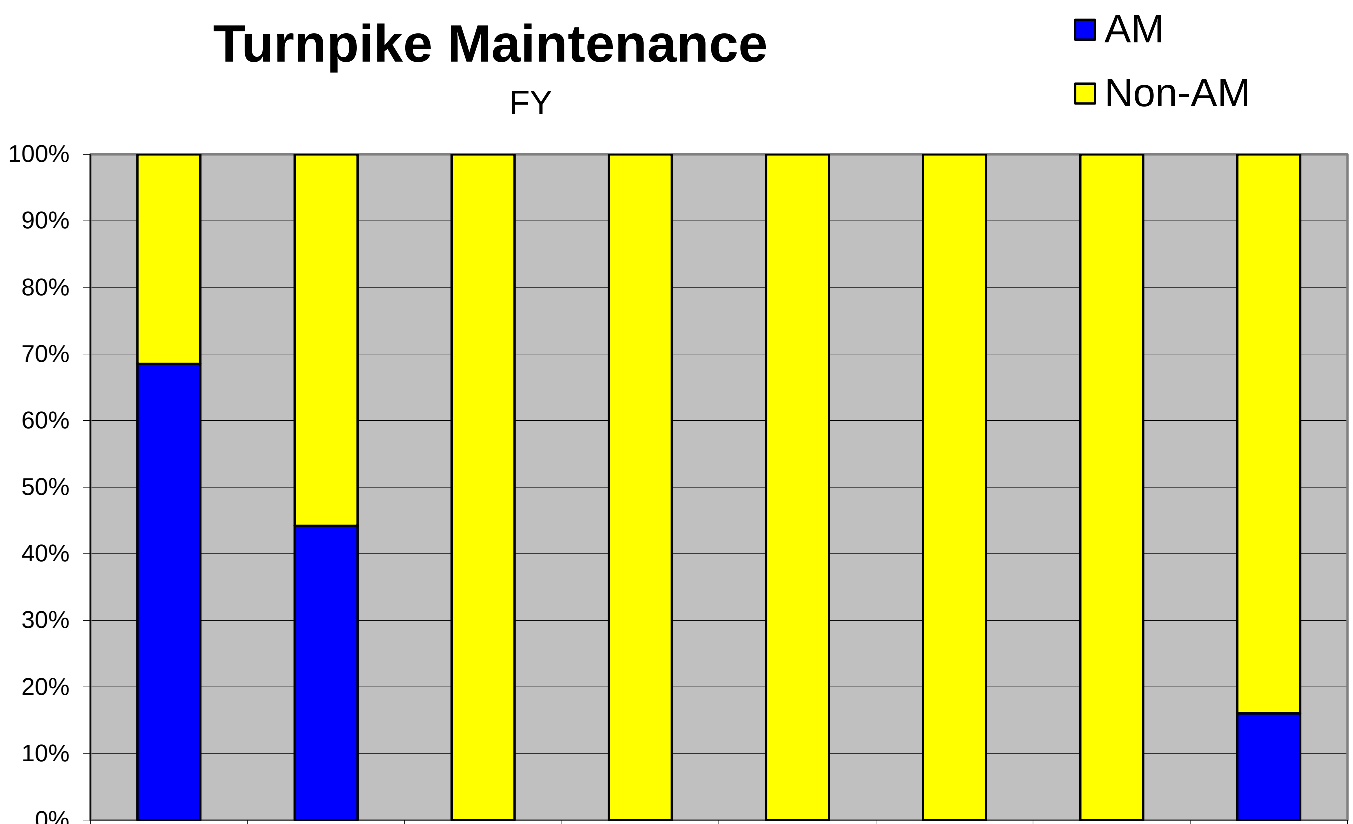
Figure C-6. District 6 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	93	745	0	0	2,084	2,084	0	70%
AM	147	90	5	5	24,182	18,983	1632	30%

Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

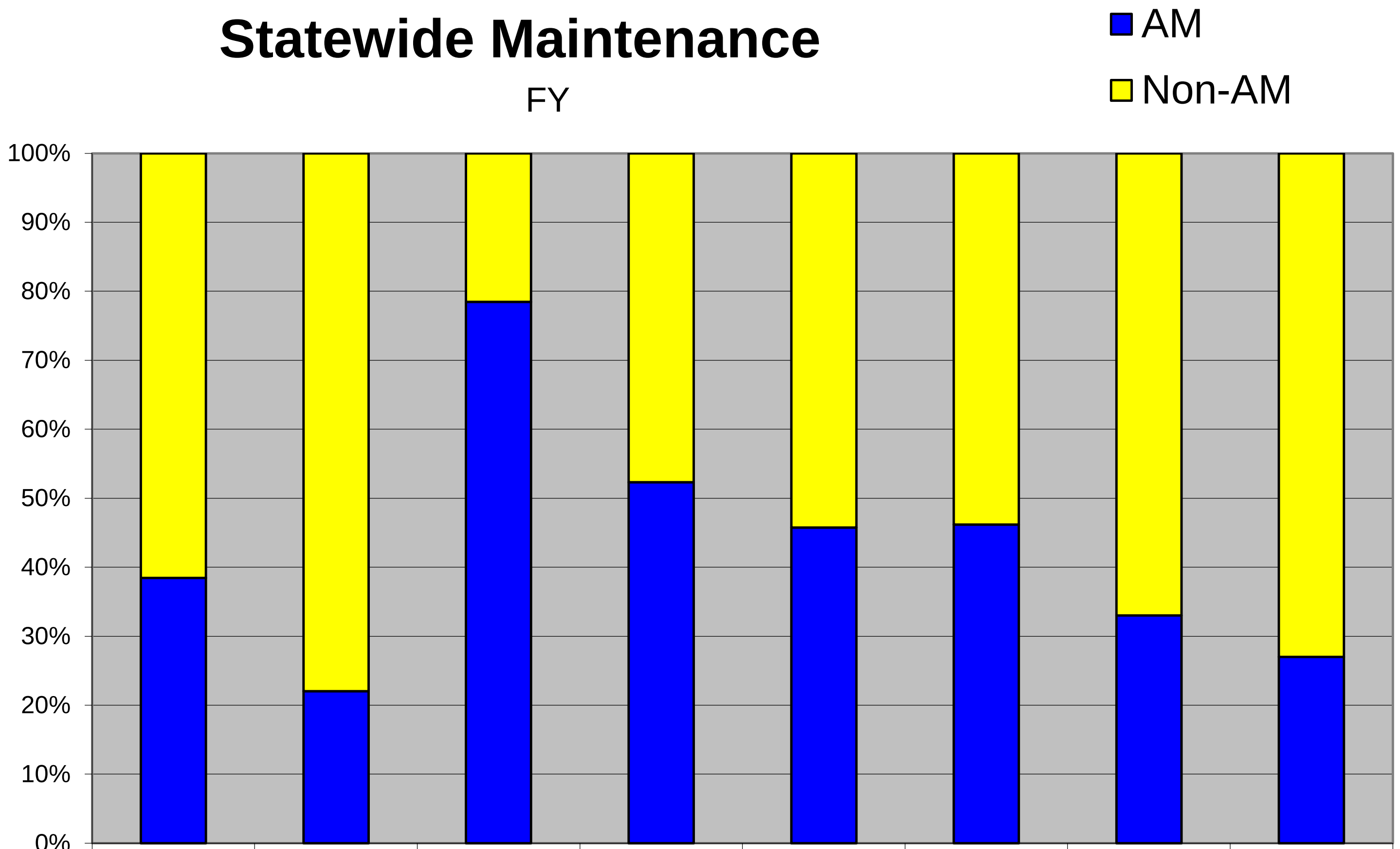
Figure C-7. District 7 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	47	171	8	8	9,074	9,074	1454	84%
AM	103	135	0	0	0	0	0	16%

Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

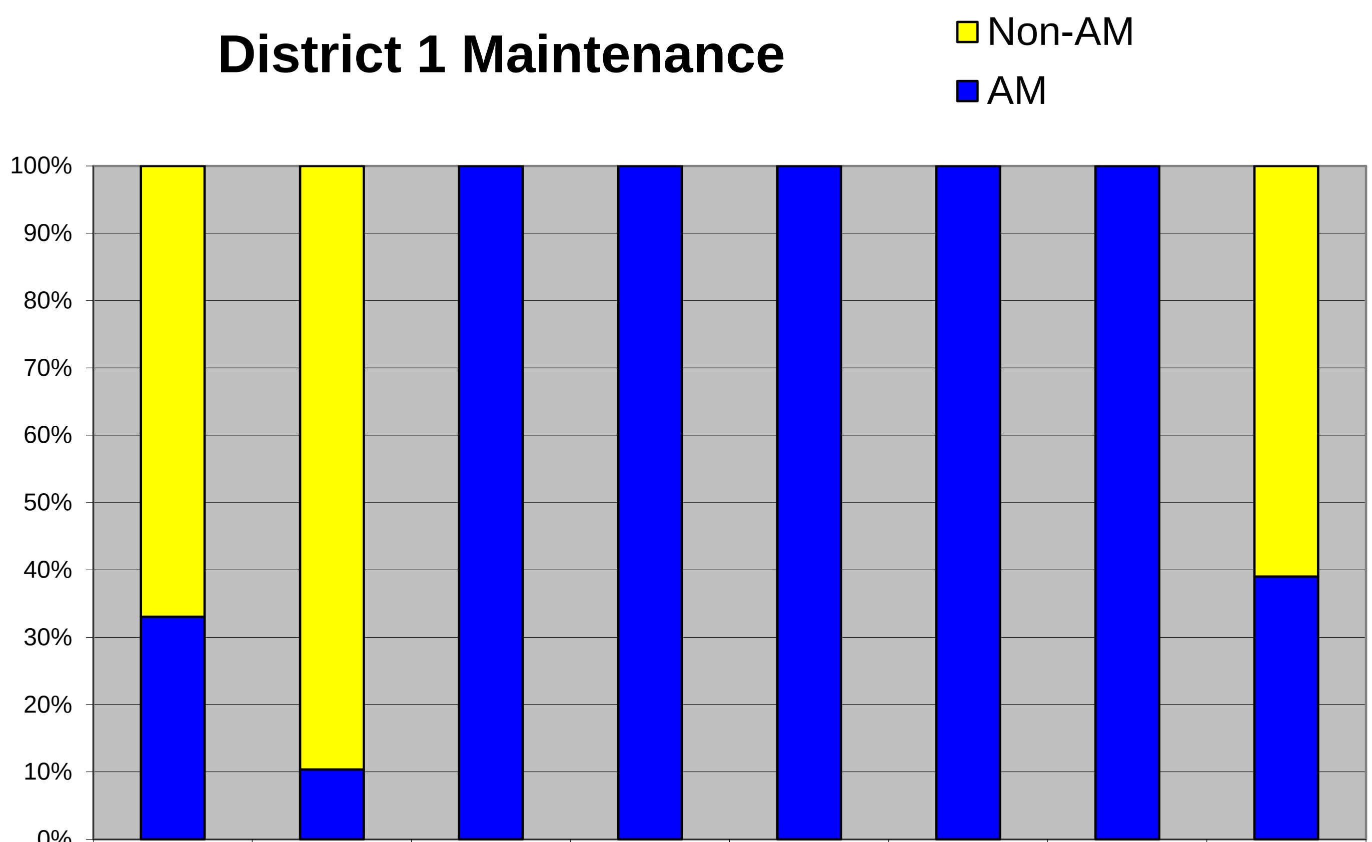
Figure C-8. District 8 2010 Bar Chart



	Rural Roadways	Urban Roadways	RestAreas Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding (Schd B)
Non-AM	3762	5014	14	31	94,011	76,655	9618	73%
AM	2352	1415	51	34	79,230	65,801	4741	27%

Centerline Miles **# of Rest Areas** **Deck Area (1000SF)** **# of Struct**

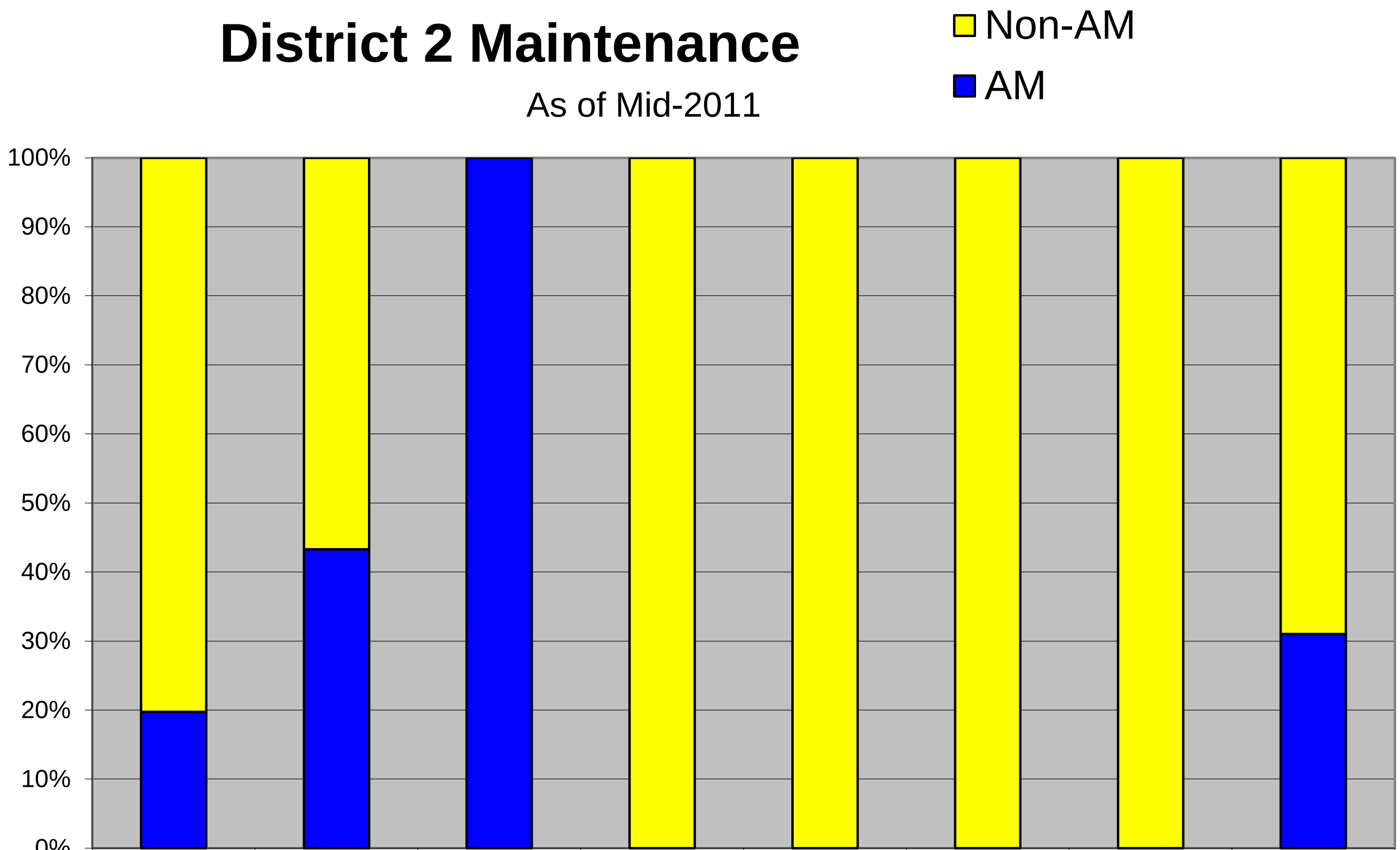
Figure C-9. Statewide Bar Chart for 2010



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	666	753	0	0	0	0	0	61%
AM	329	87	8	6	18,658	12,925	1405	39%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

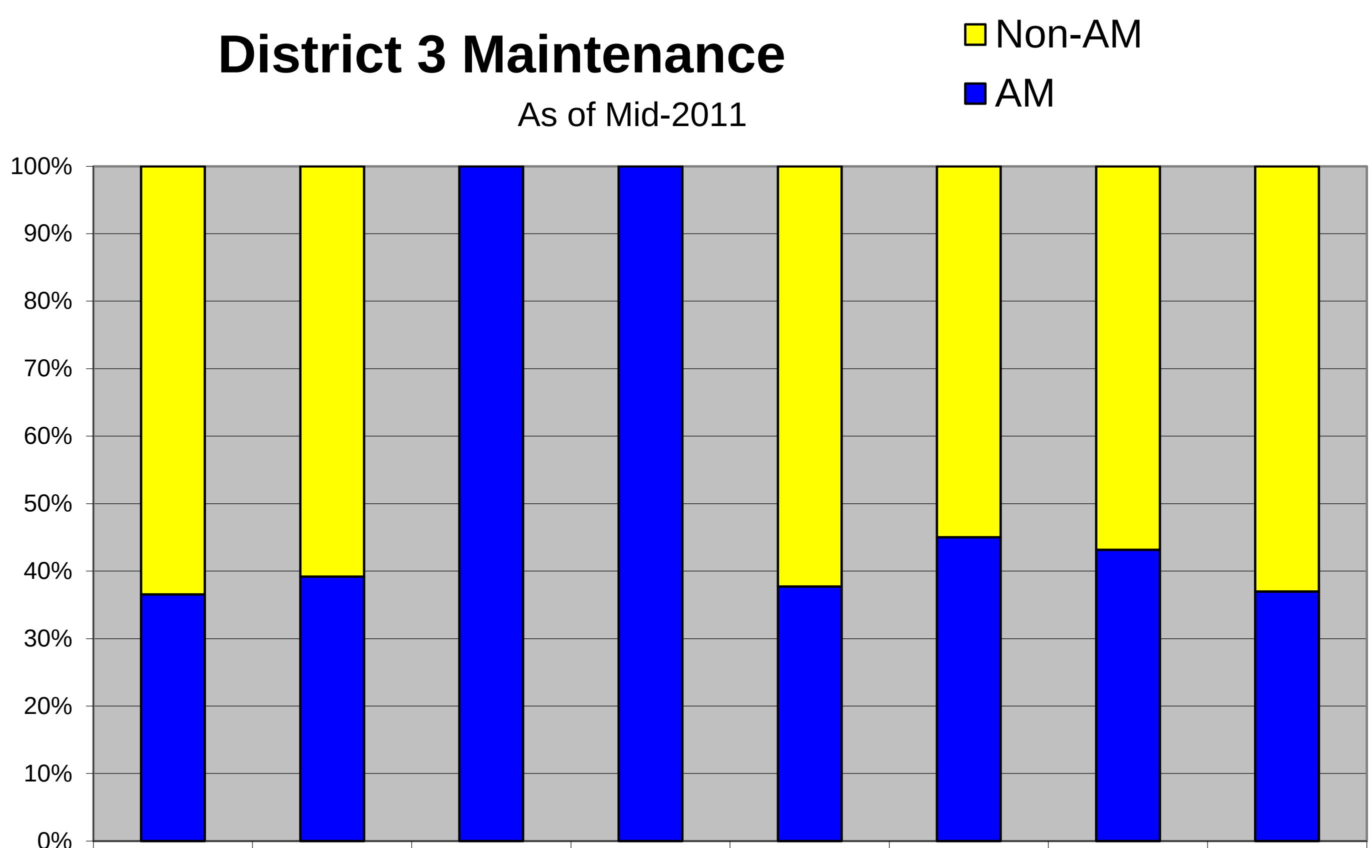
Figure C-10. District 1 2012 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	1394	465	0	17	27,842	25,140	2424	69%
AM	343	355	30	0	0	0	0	31%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

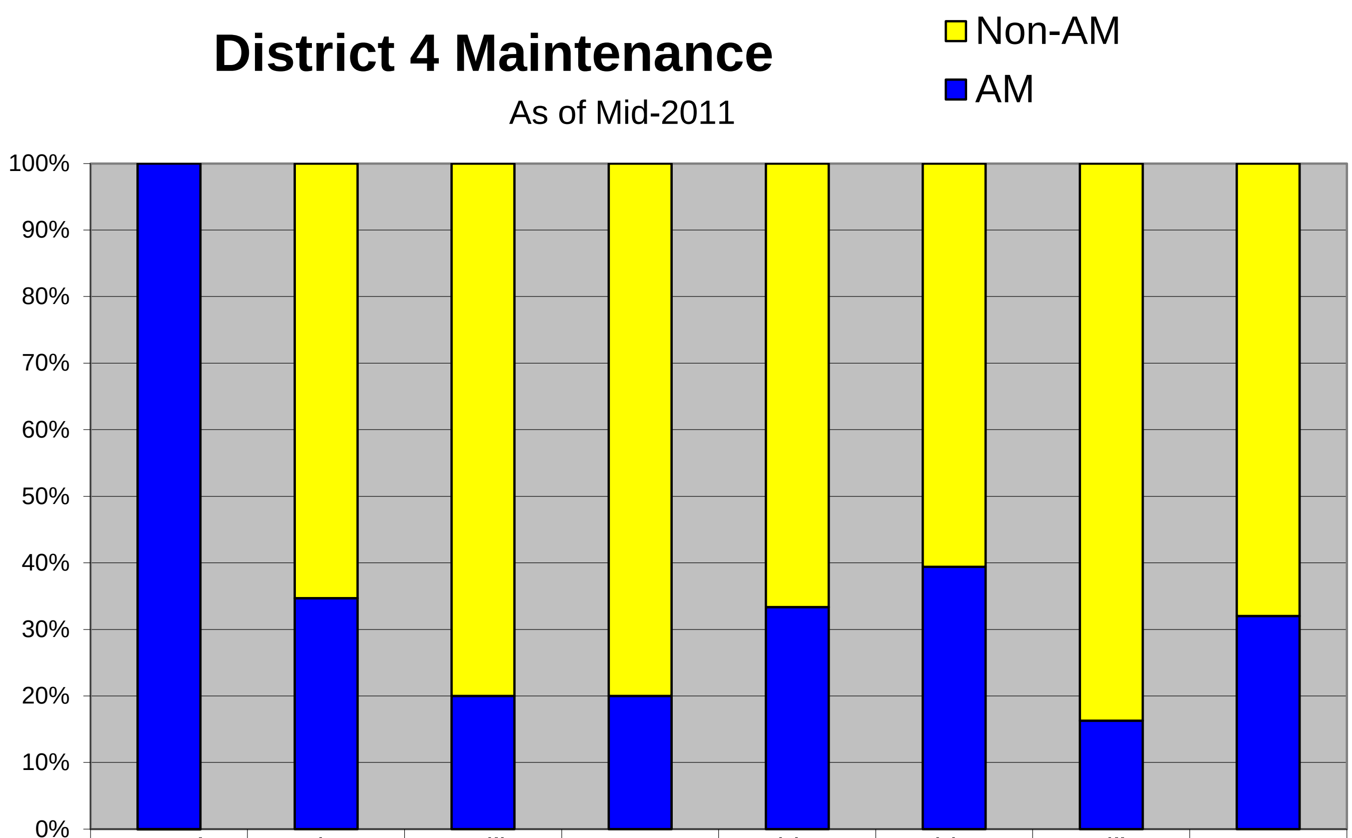
Figure C-11. District 2 2012 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	1084	413	0	0	14,908	10,353	632	63%
AM	624	266	19	14	9,034	8,483	480	37%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

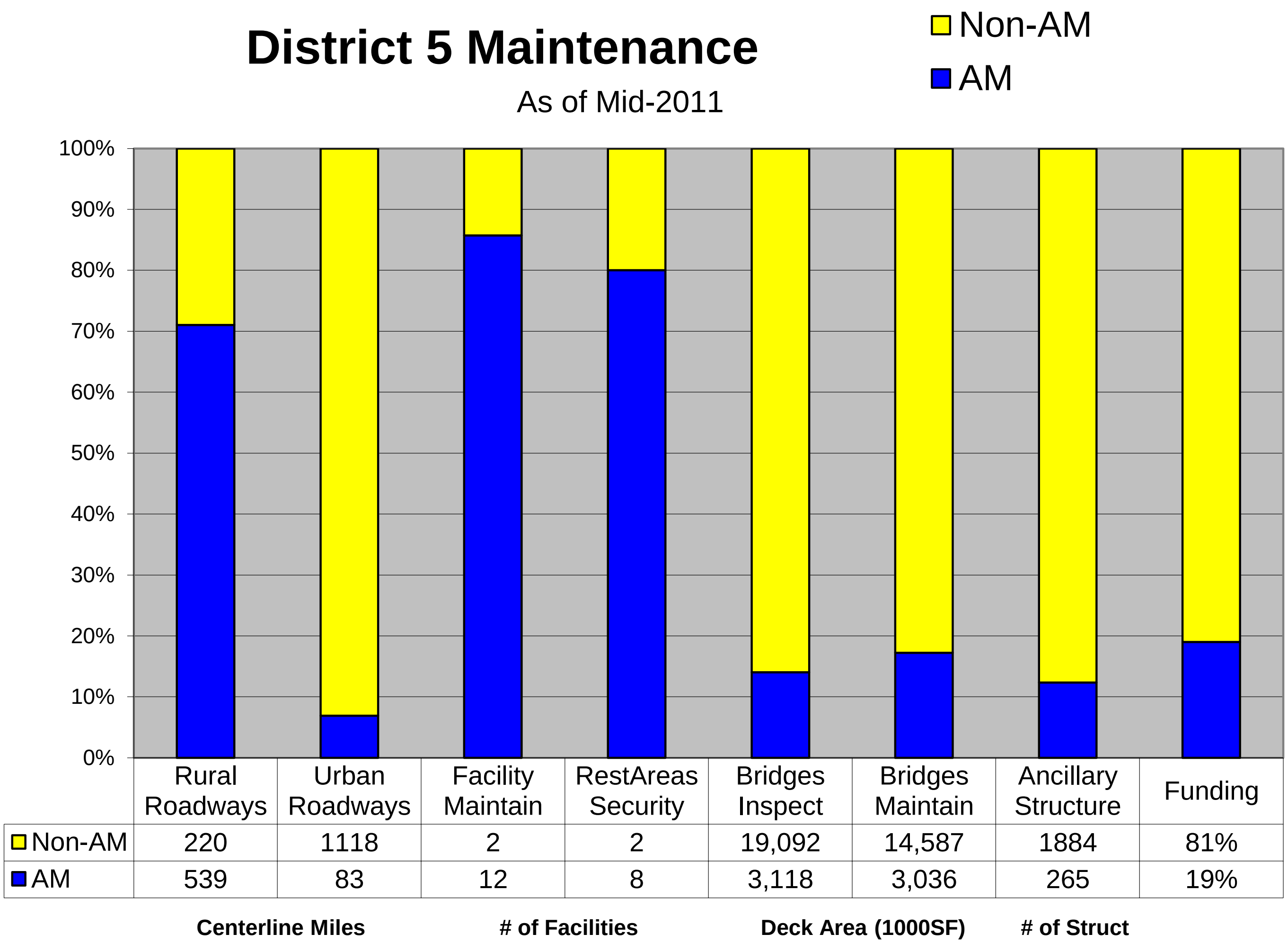
Figure C-12. District 3 2012 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	610	4	4	15,944	11,856	2368	68%
AM	275	324	1	1	7,983	7,713	460	32%

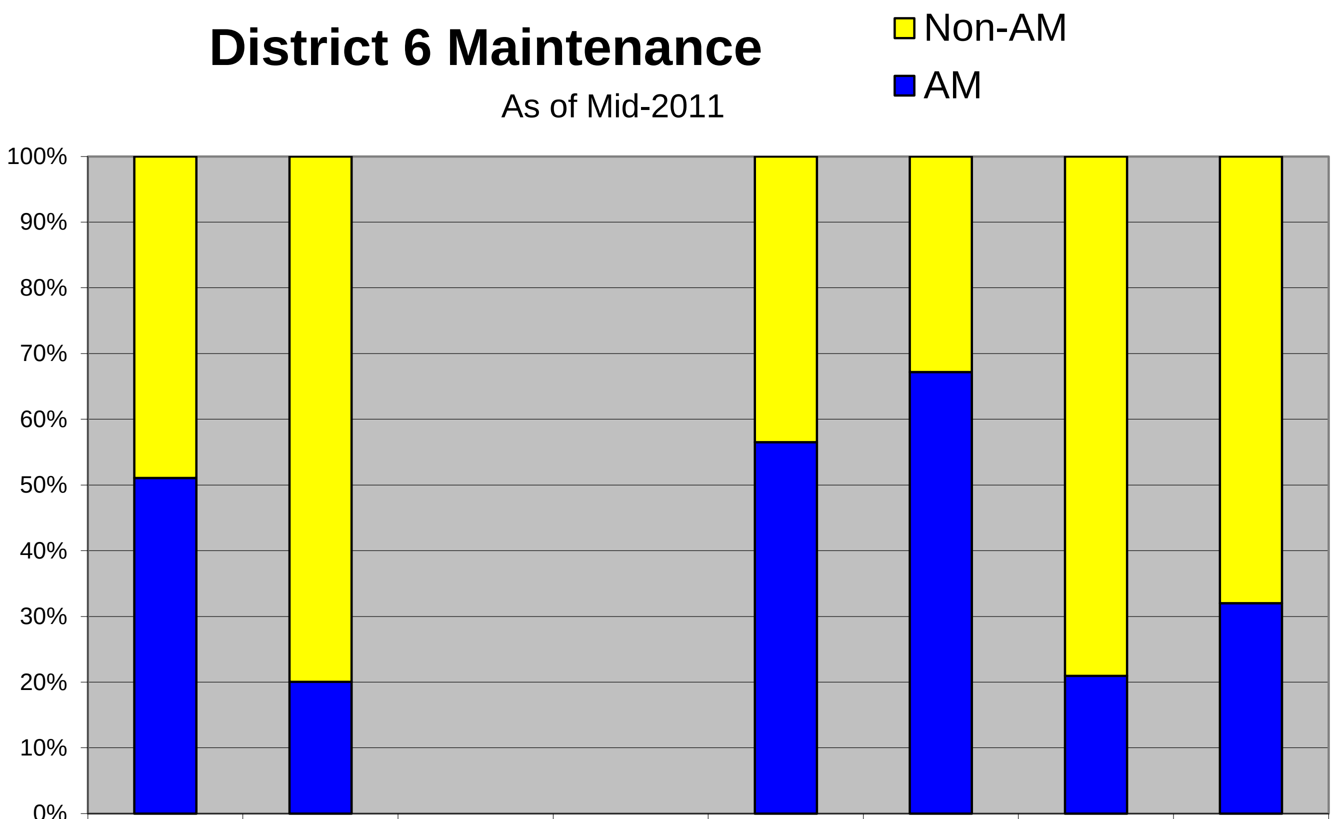
Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

Figure C-13. District 4 2012 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	220	1118	2	2	19,092	14,587	1884	81%
AM	539	83	12	8	3,118	3,036	265	19%

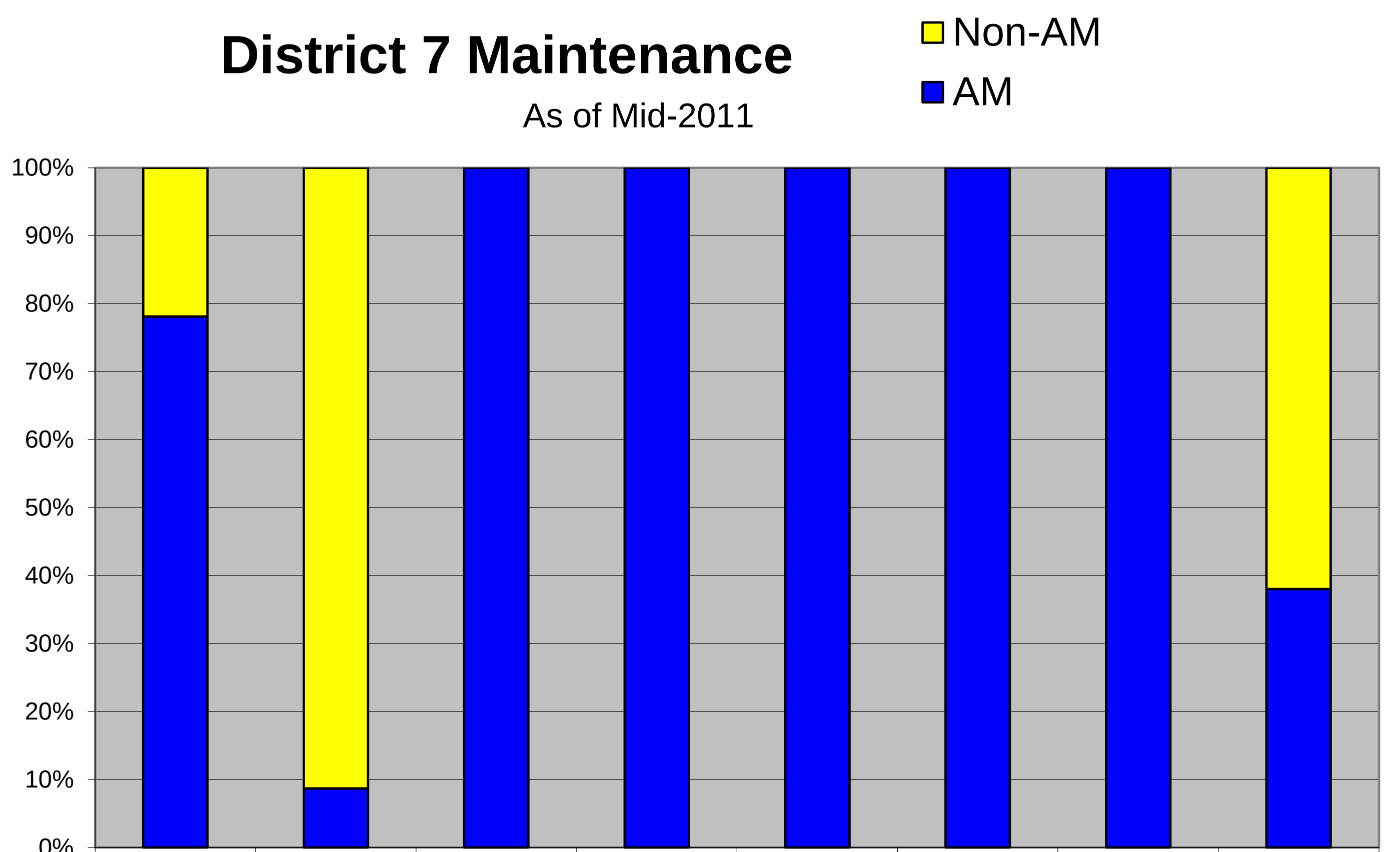
Figure C-14. District 5 2012 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	62	423	0	0	10,225	6,496	1640	68%
AM	65	106	0	0	13,290	13,290	435	32%

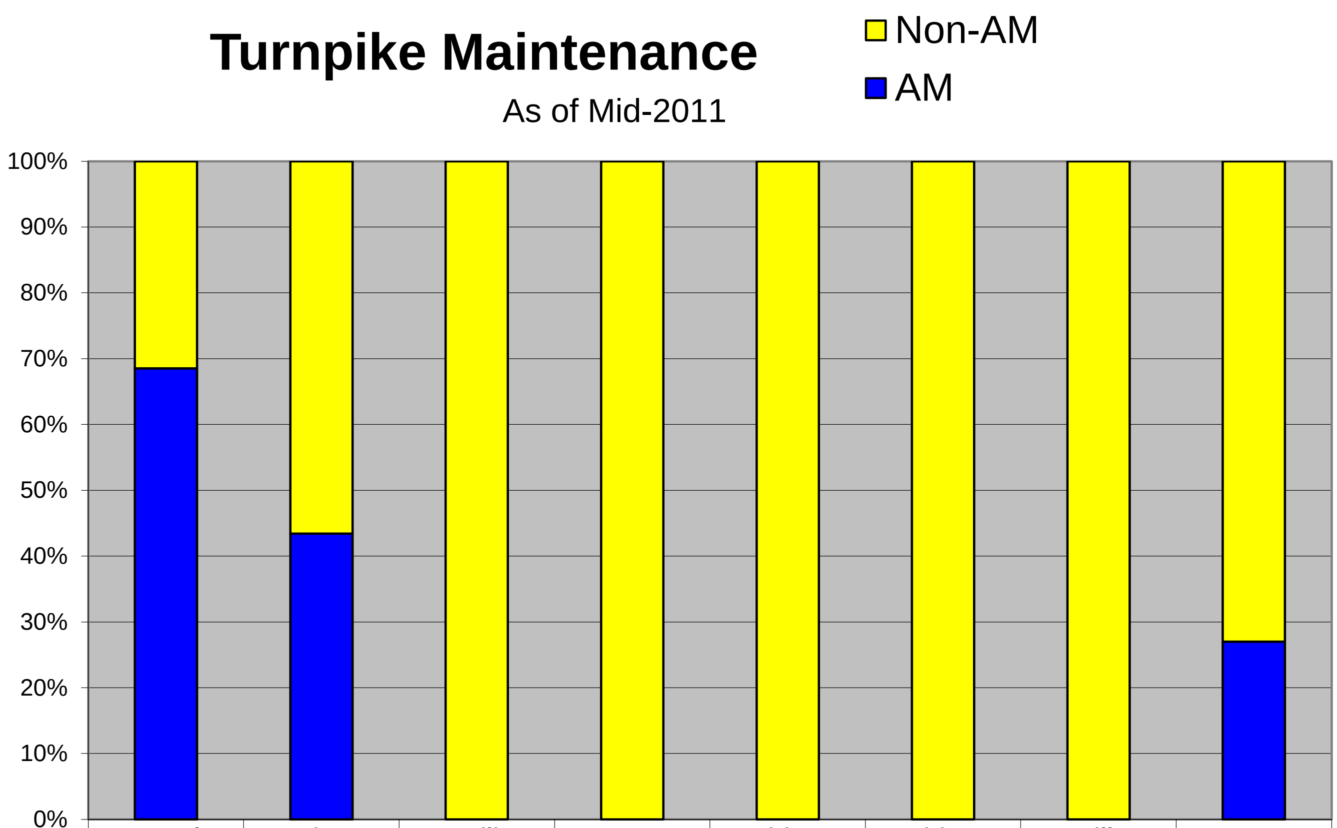
Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

Figure C-15. District 6 2012 Bar Chart



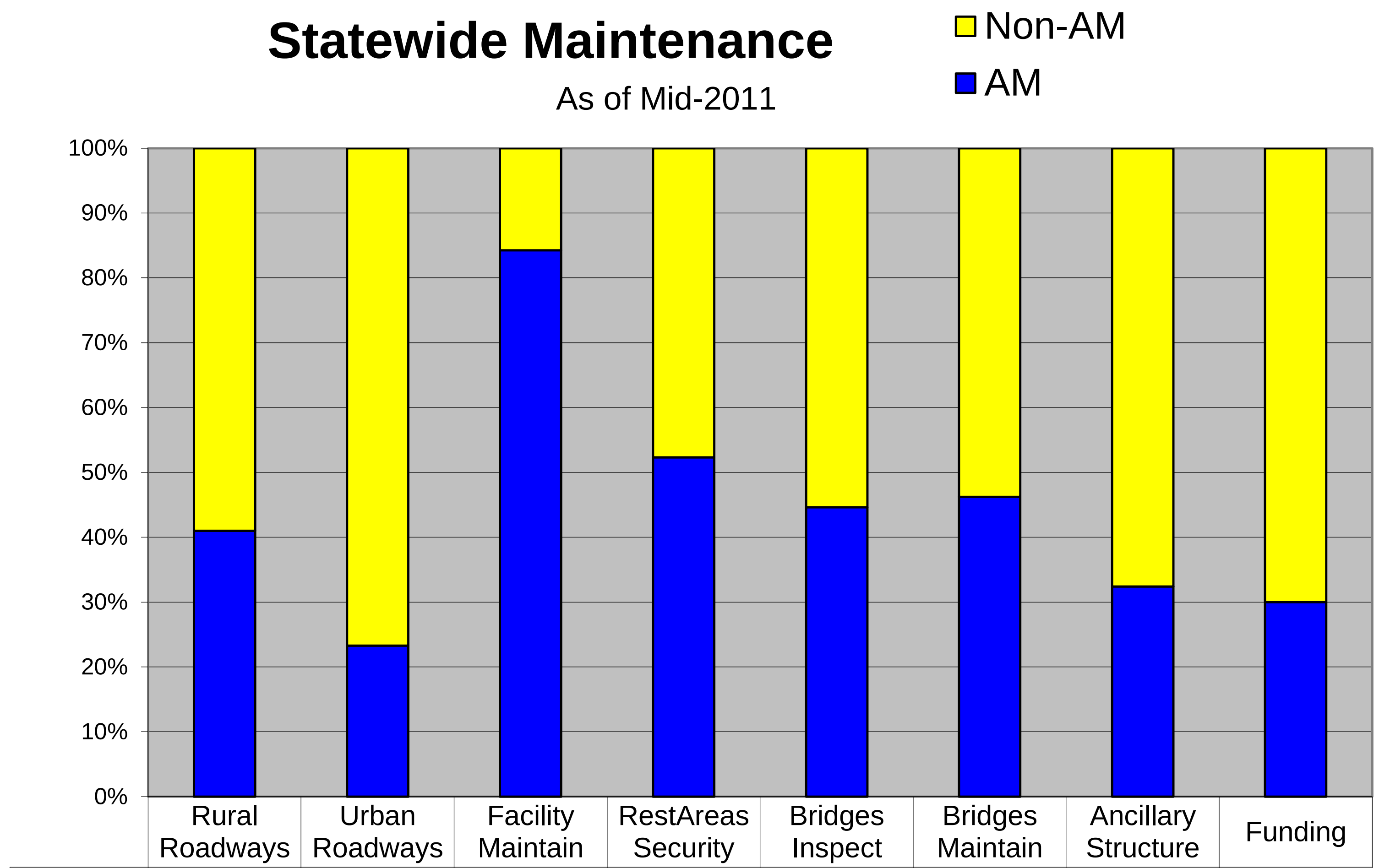
	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	47	734	0	0	0	0	0	62%
AM	167	70	5	5	26,210	21,169	1981	38%
	Centerline Miles		**# of Facilities**		**Deck Area (1000SF)**		**# of Struct**	

Figure C-16. District 7 2012 Bar Chart



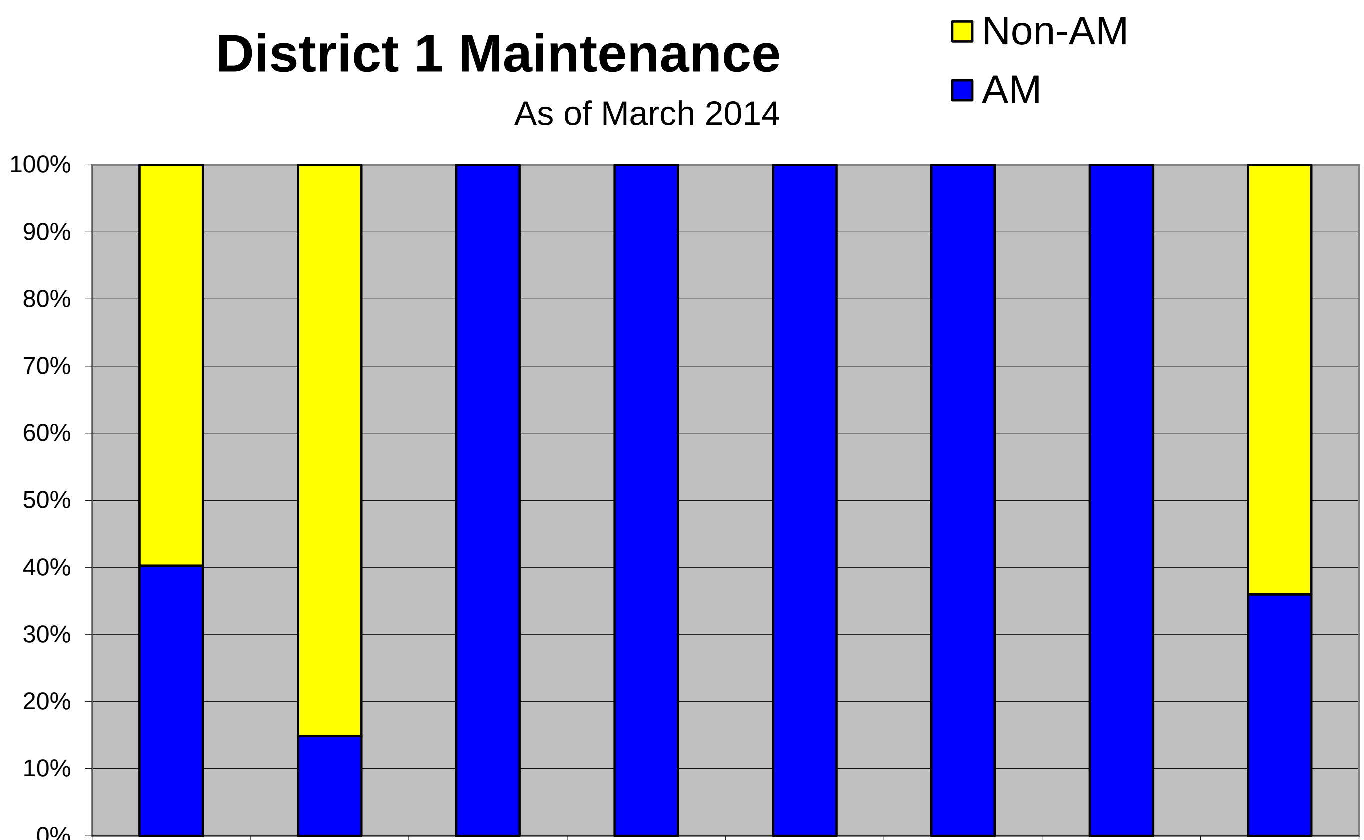
	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	47	173	8	8	9,096	9,096	1536	73%
AM	103	133	0	0	0	0	0	27%
	Centerline Miles		**# of Facilities**		**Deck Area (1000SF)**		**# of Struct**	

Figure C-17. District 8 2012 Bar Chart



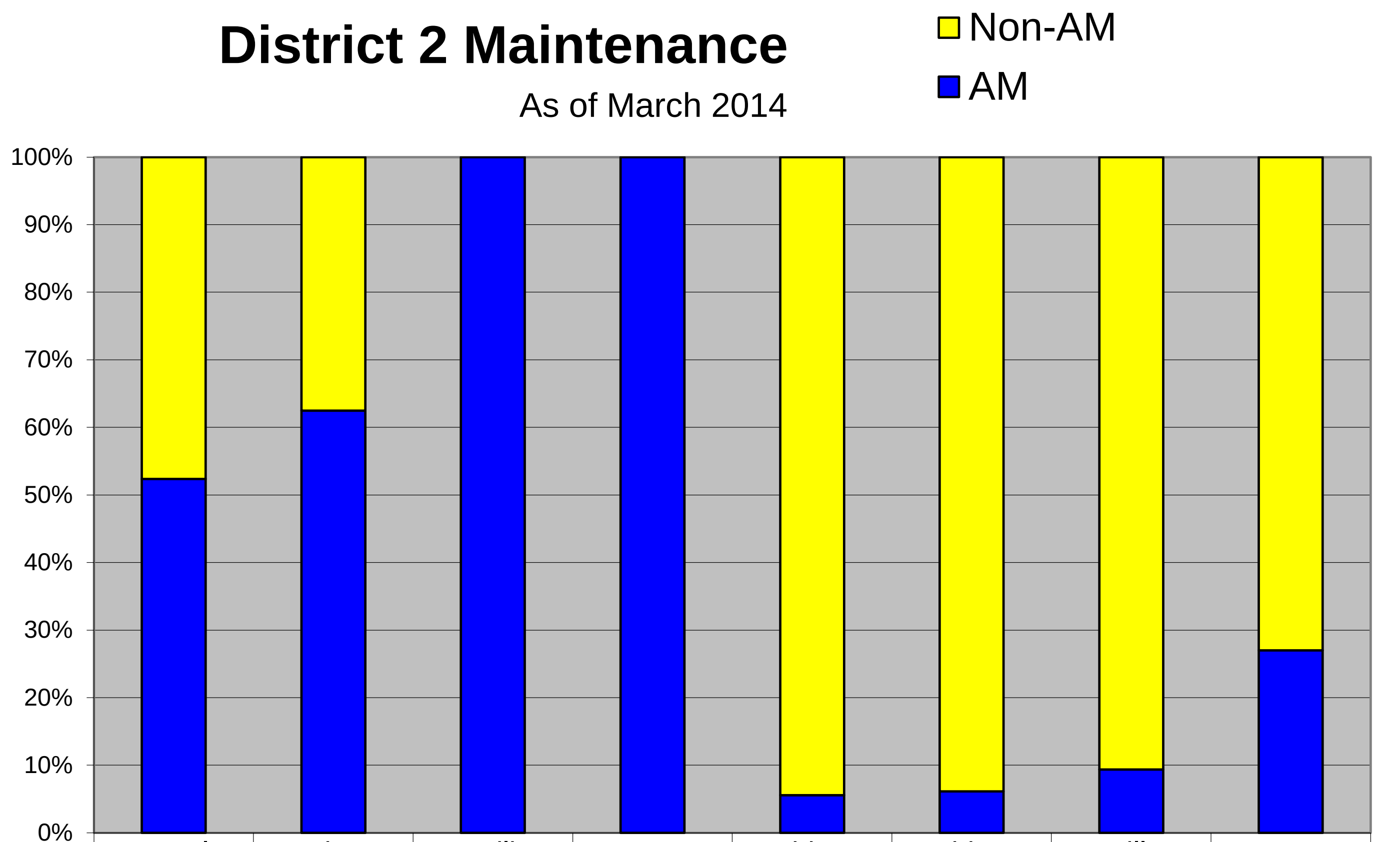
	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	3520	4689	14	31	97,107	77,528	10484	70%
AM	2445	1424	75	34	78,292	66,616	5026	30%
	Centerline Miles		**# of Facilities**		**Deck Area (1000SF)**		**# of Struct**	

Figure C-18. Statewide Bar Chart for 2012



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	594	715	0	0	0	0	0	64%
AM	401	125	8	6	18,690	13,672	1586	36%
	Centerline Miles		# of Facilities		Deck Area (1000SF)		# of Struct	

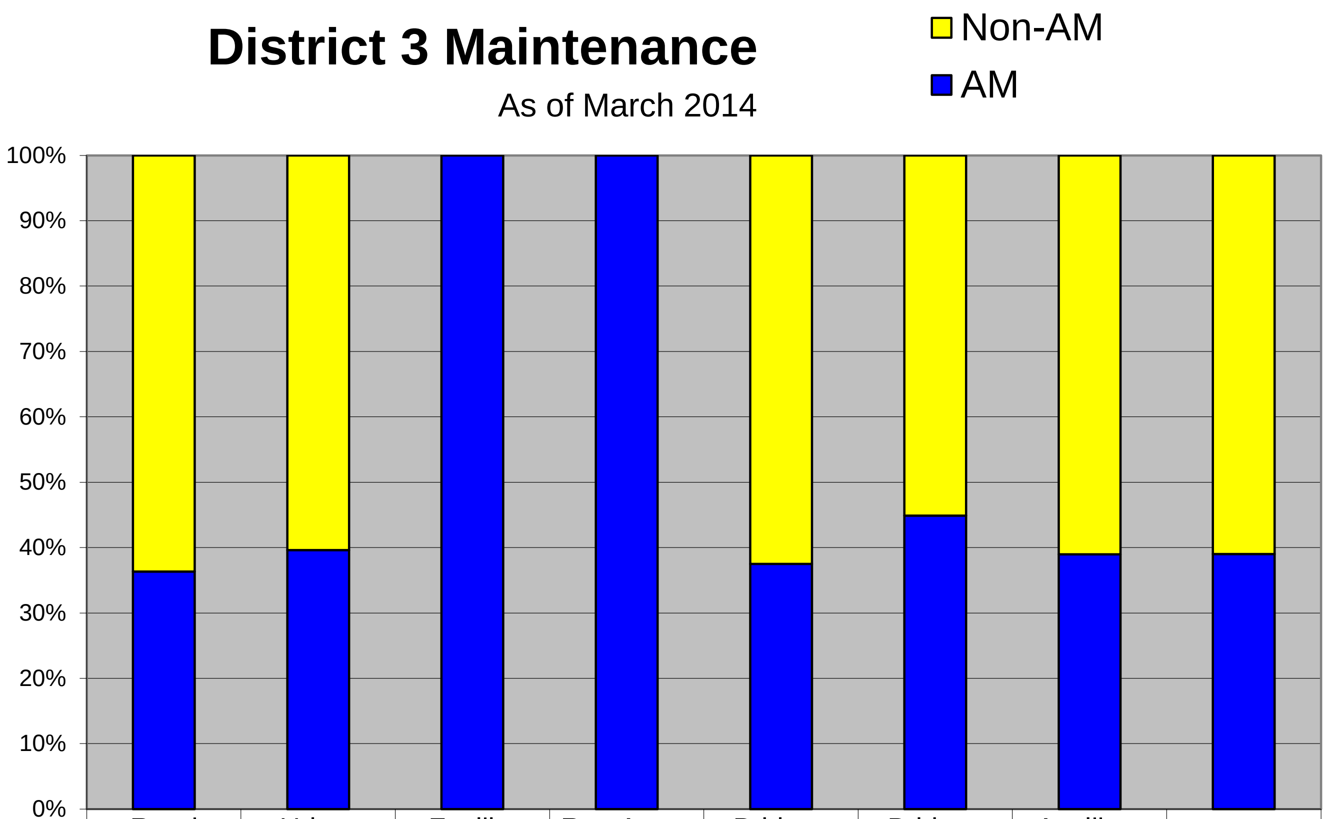
Figure C-19. District 1 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	827	308	0	0	26,296	23,594	2439	73%
AM	909	512	30	17	1,546	1,546	252	27%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

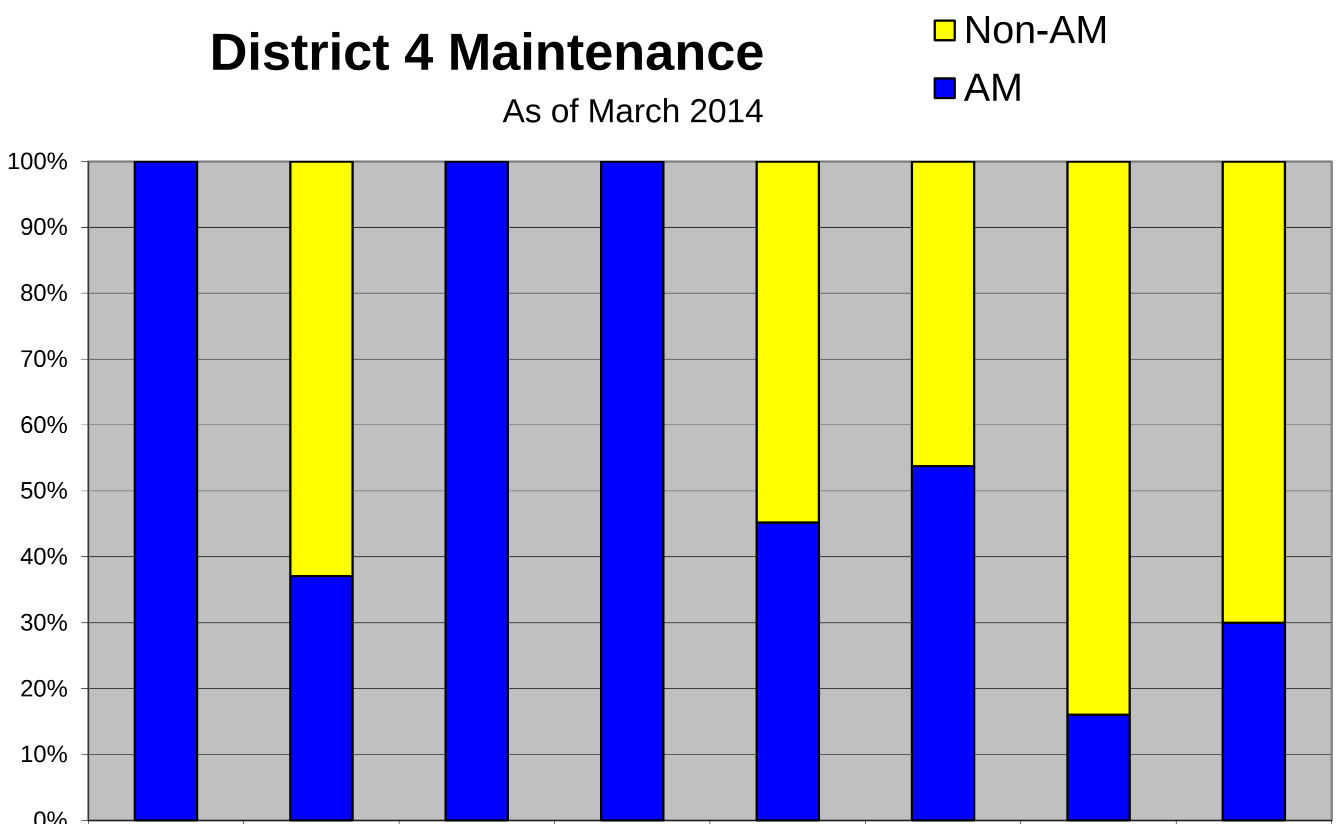
Figure C-20. District 2 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	1096	410	0	0	14,959	10,378	734	61%
AM	625	269	19	14	8,983	8,459	469	39%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

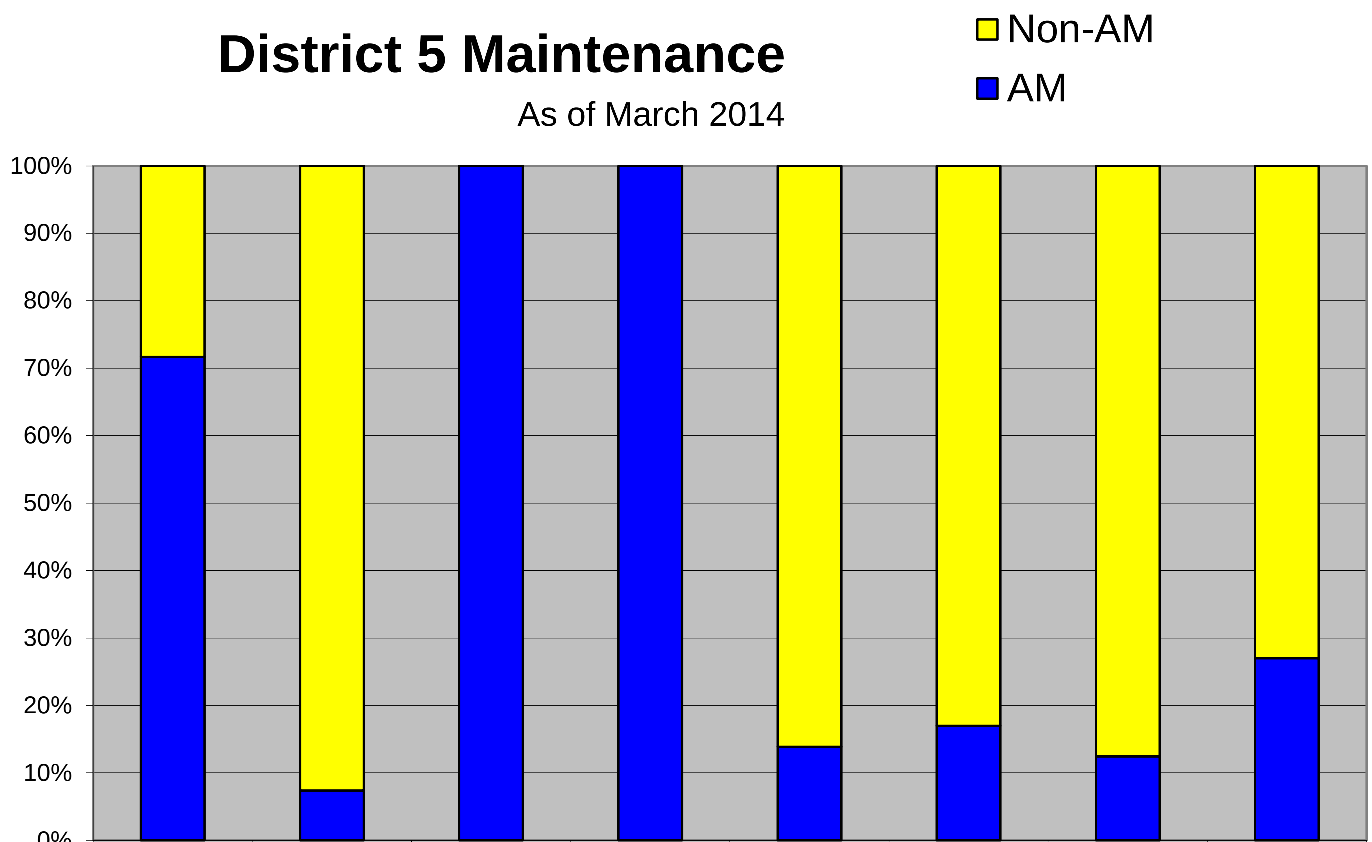
Figure C-21. District 3 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	588	0	0	13,097	9,051	2639	70%
AM	275	346	5	5	10,798	10,518	503	30%

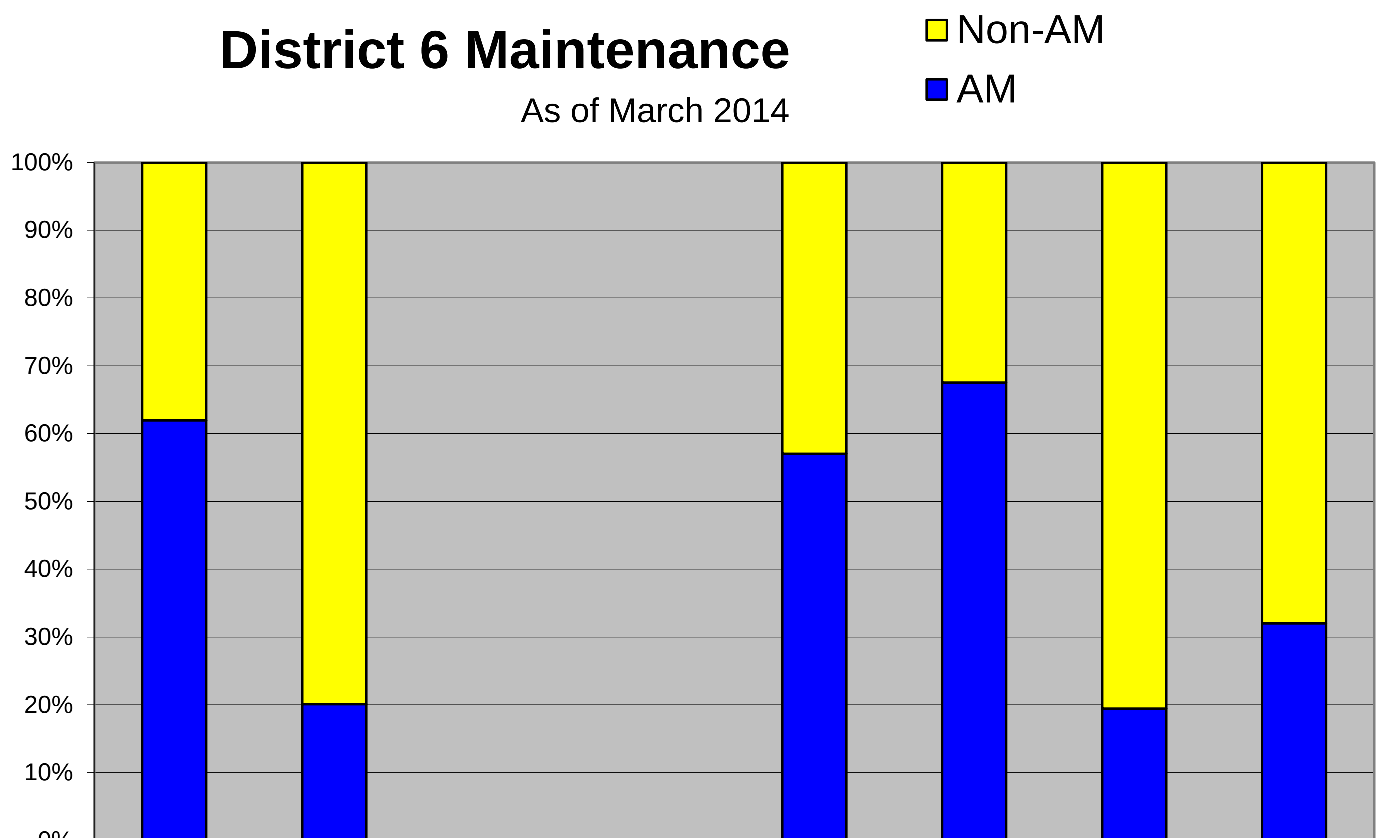
Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

Figure C-22. District 4 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	215	1112	0	0	19,135	14,634	2006	73%
AM	544	89	14	10	3,075	2,989	285	27%
	Centerline Miles		**# of Facilities**		**Deck Area (1000SF)**		**# of Struct**	

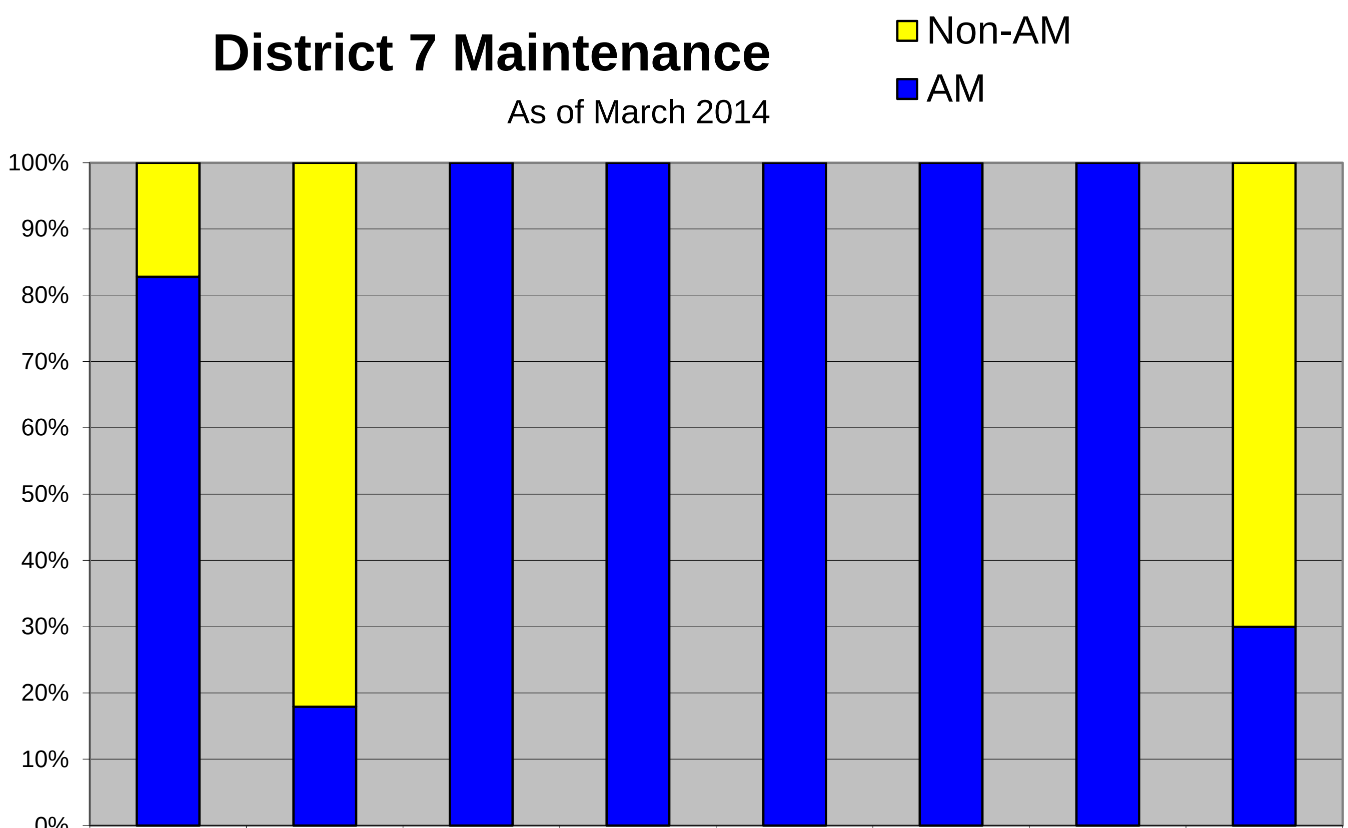
Figure C-23. District 5 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	48	423	0	0	10,069	6,424	1761	68%
AM	79	106	0	0	13,361	13,361	425	32%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

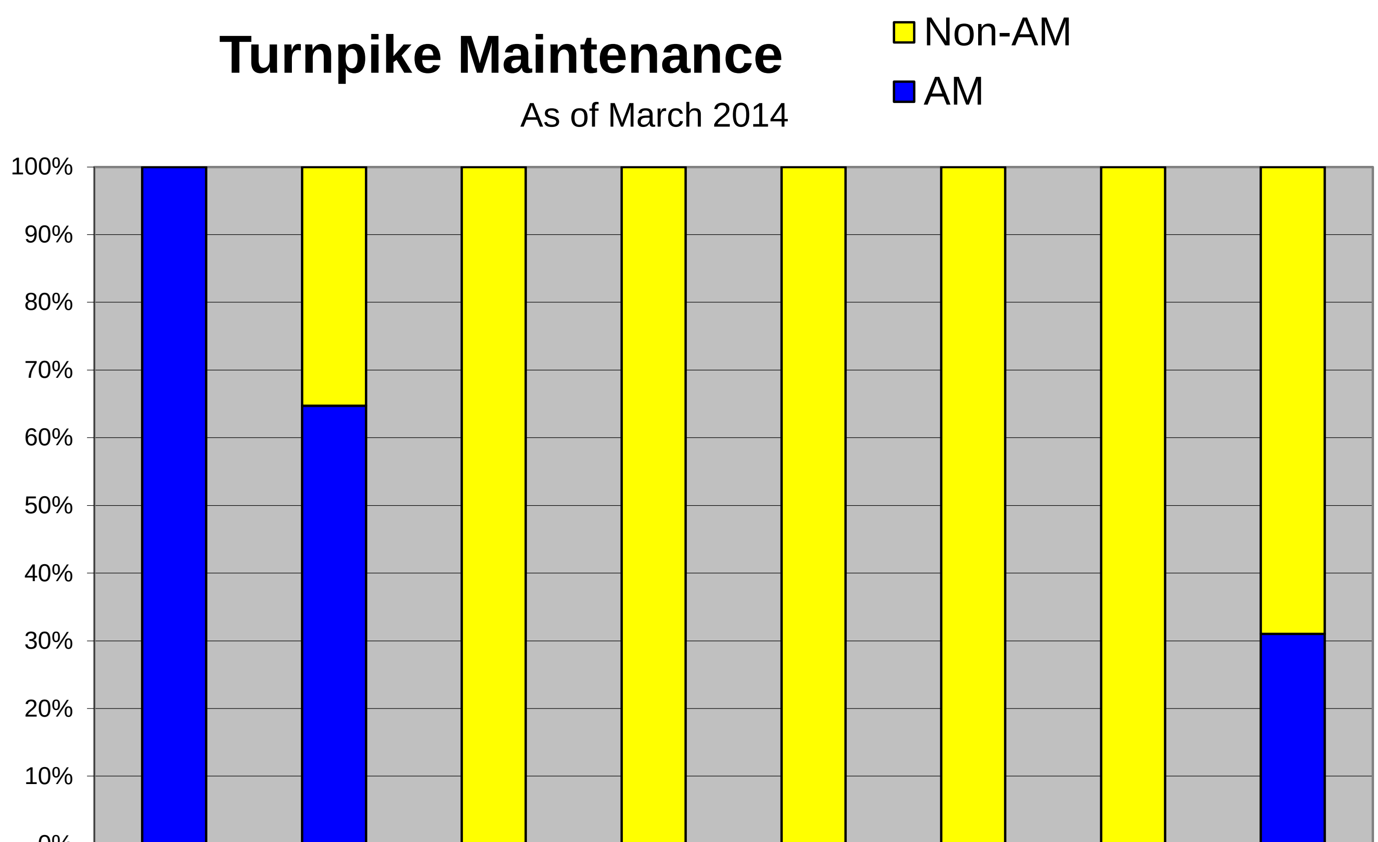
Figure C-24. District 6 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	37	659	0	0	0	0	0	70%
AM	176	144	5	5	27,920	23,027	1973	30%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

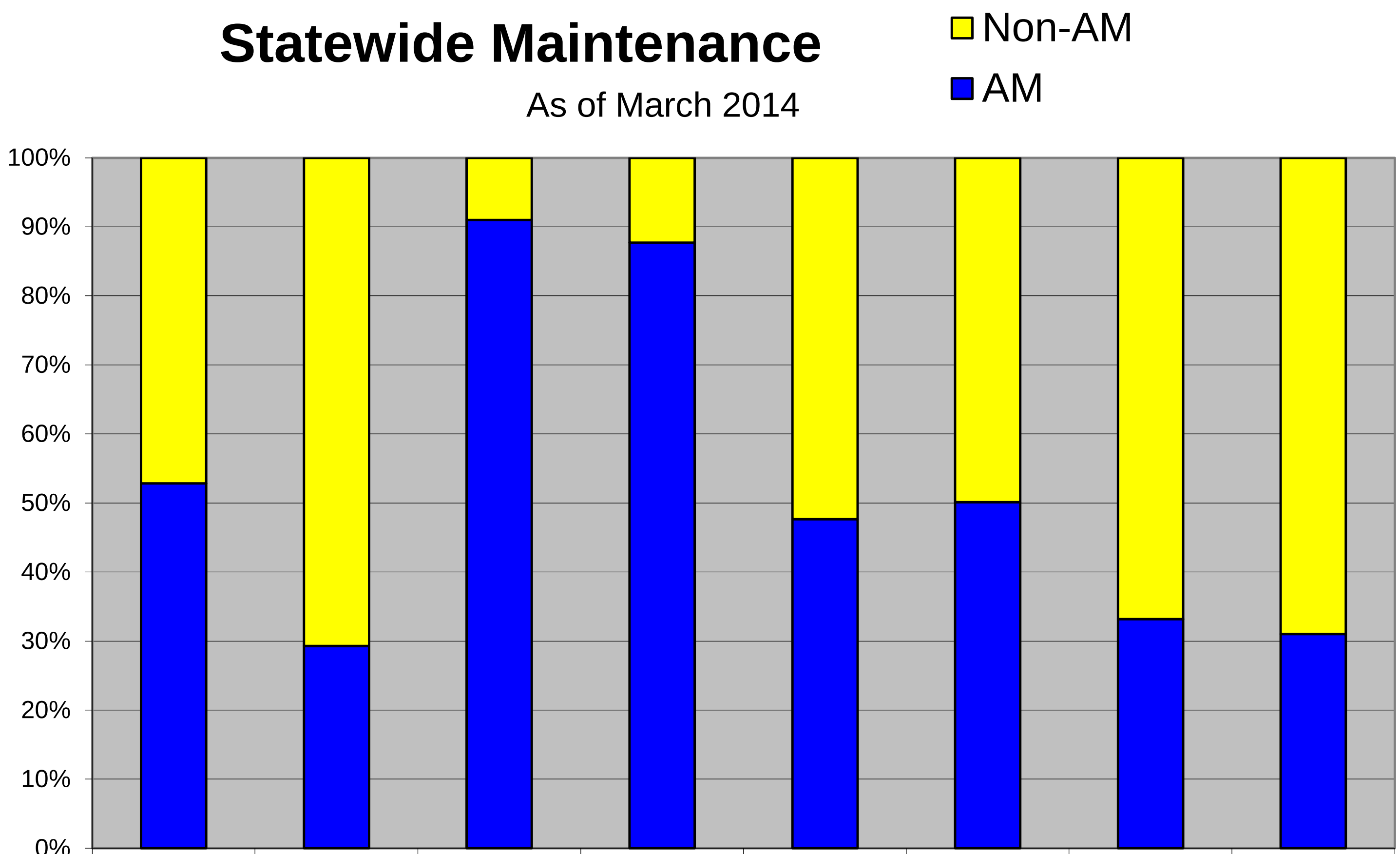
Figure C-25. District 7 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	108	8	8	9,096	9,096	1485	69%
AM	150	198	0	0	0	0	0	31%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

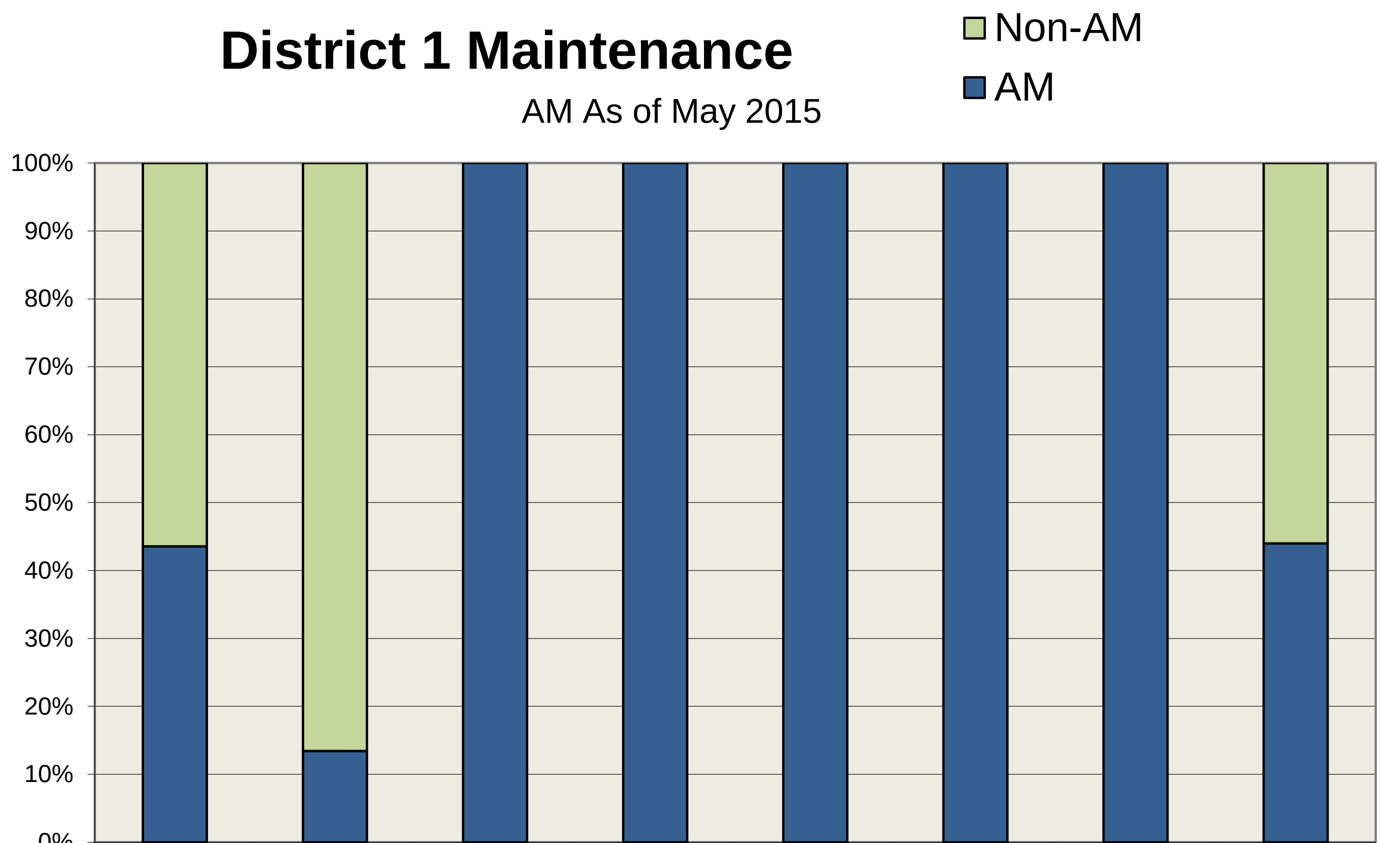
Figure C-26. District 8 2014 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	2817	4323	8	8	92,653	73,177	11064	69%
AM	3159	1789	81	57	84,373	73,573	5493	31%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

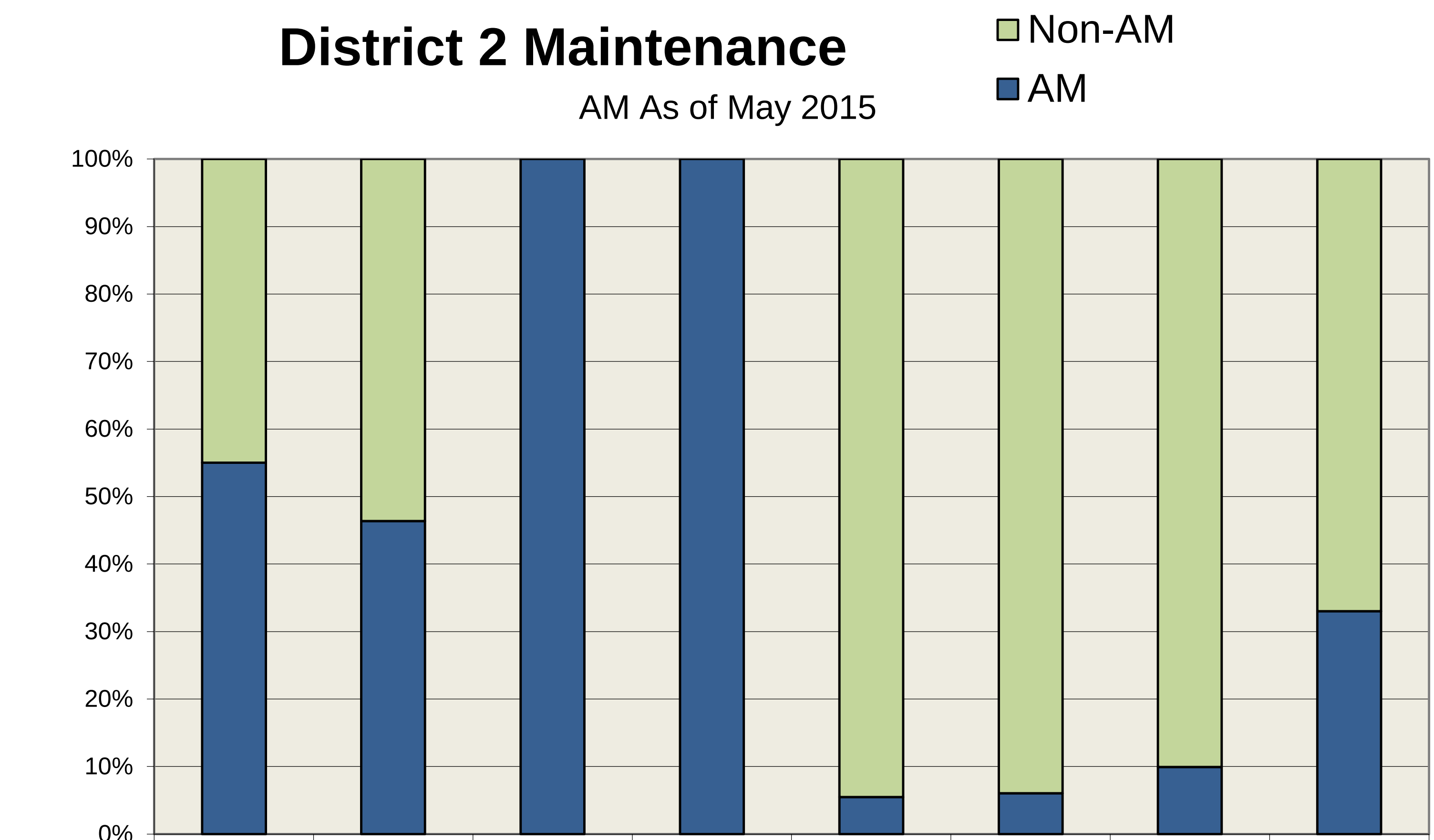
Figure C-27. Statewide Bar Chart for 2014



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	512	806	0	0	0	0	0	56%
AM	395	125	7	6	19,012	13,171	1697	44%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

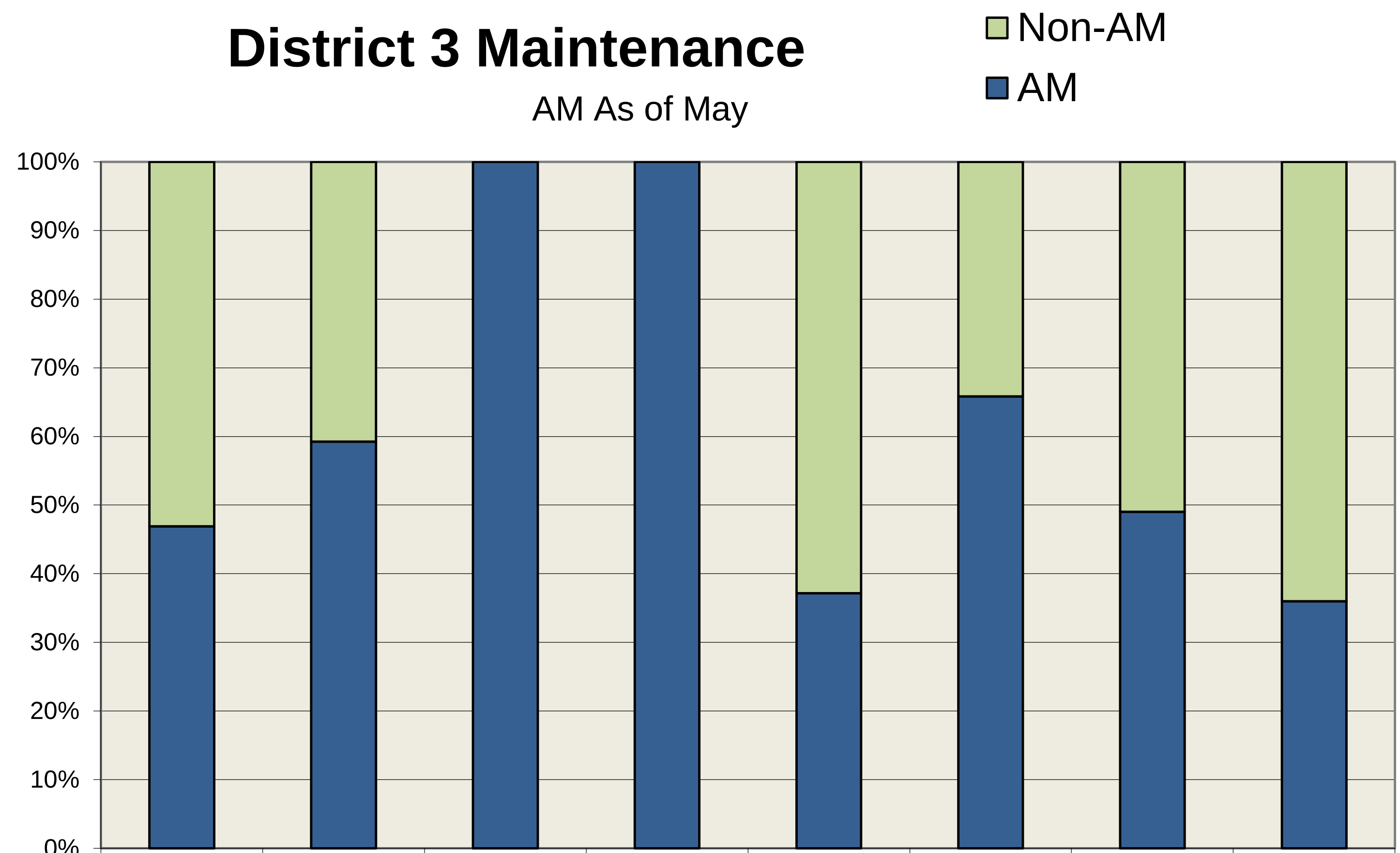
Figure C-28. District 1 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	747	480	0	0	26,669	24,057	2487	67%
AM	913	415	30	17	1,547	1,547	274	33%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

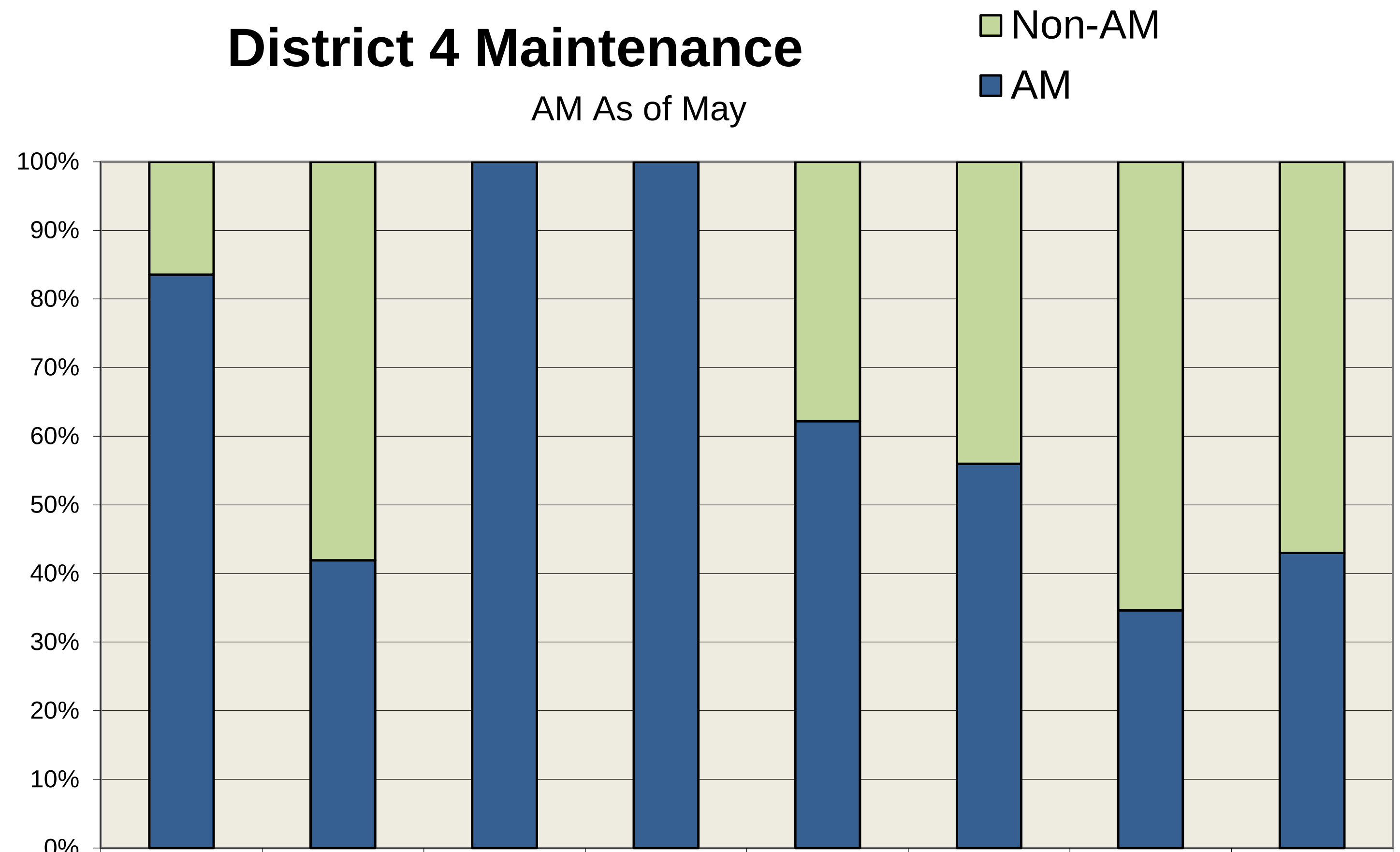
Figure C-29. District 2 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	912	282	0	0	15,290	7,137	675	64%
AM	805	410	19	14	9,034	13,758	649	36%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

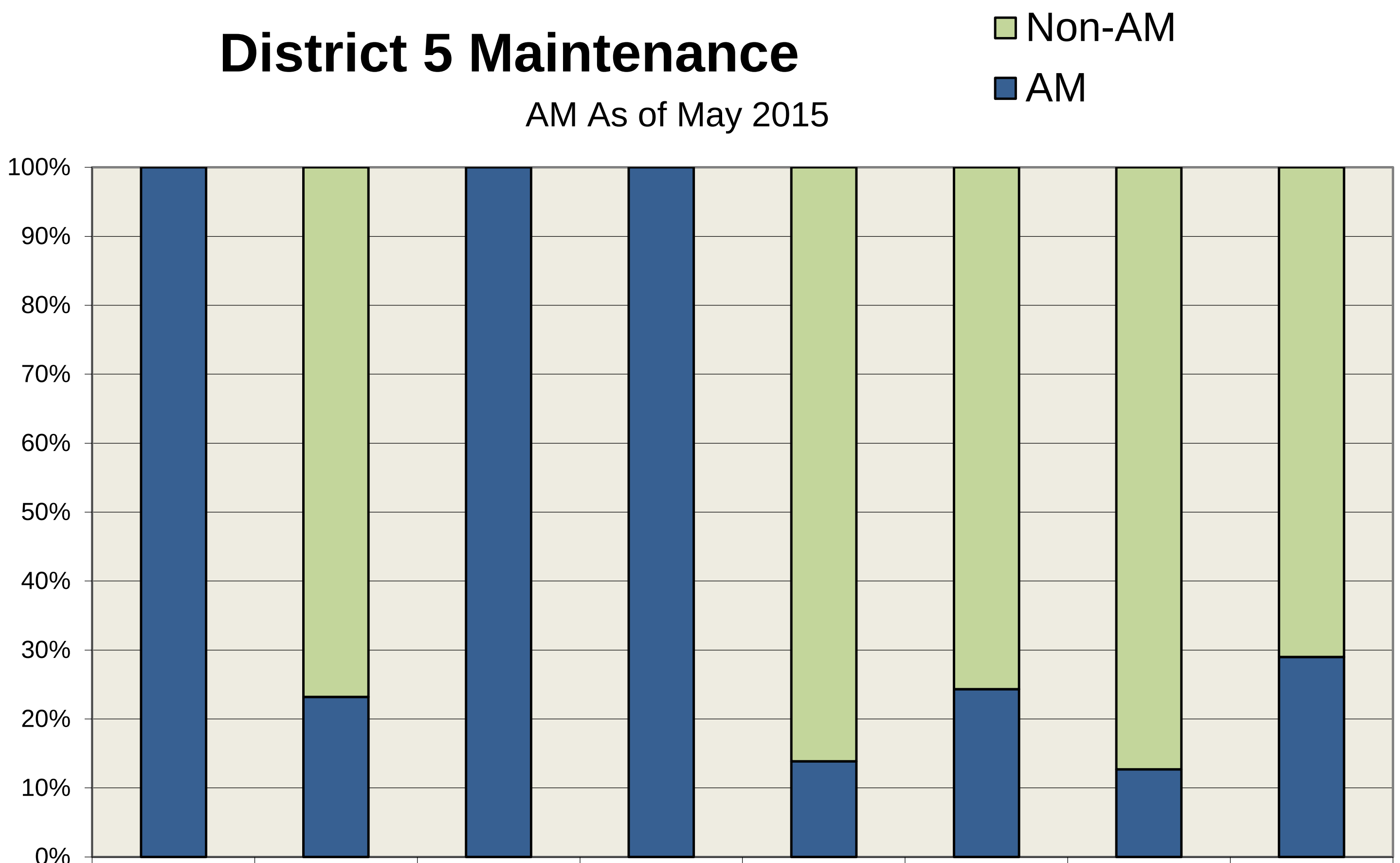
Figure C-30. District 3 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	48	535	0	0	9,584	8,884	2168	57%
AM	244	386	5	5	15,758	11,308	1148	43%

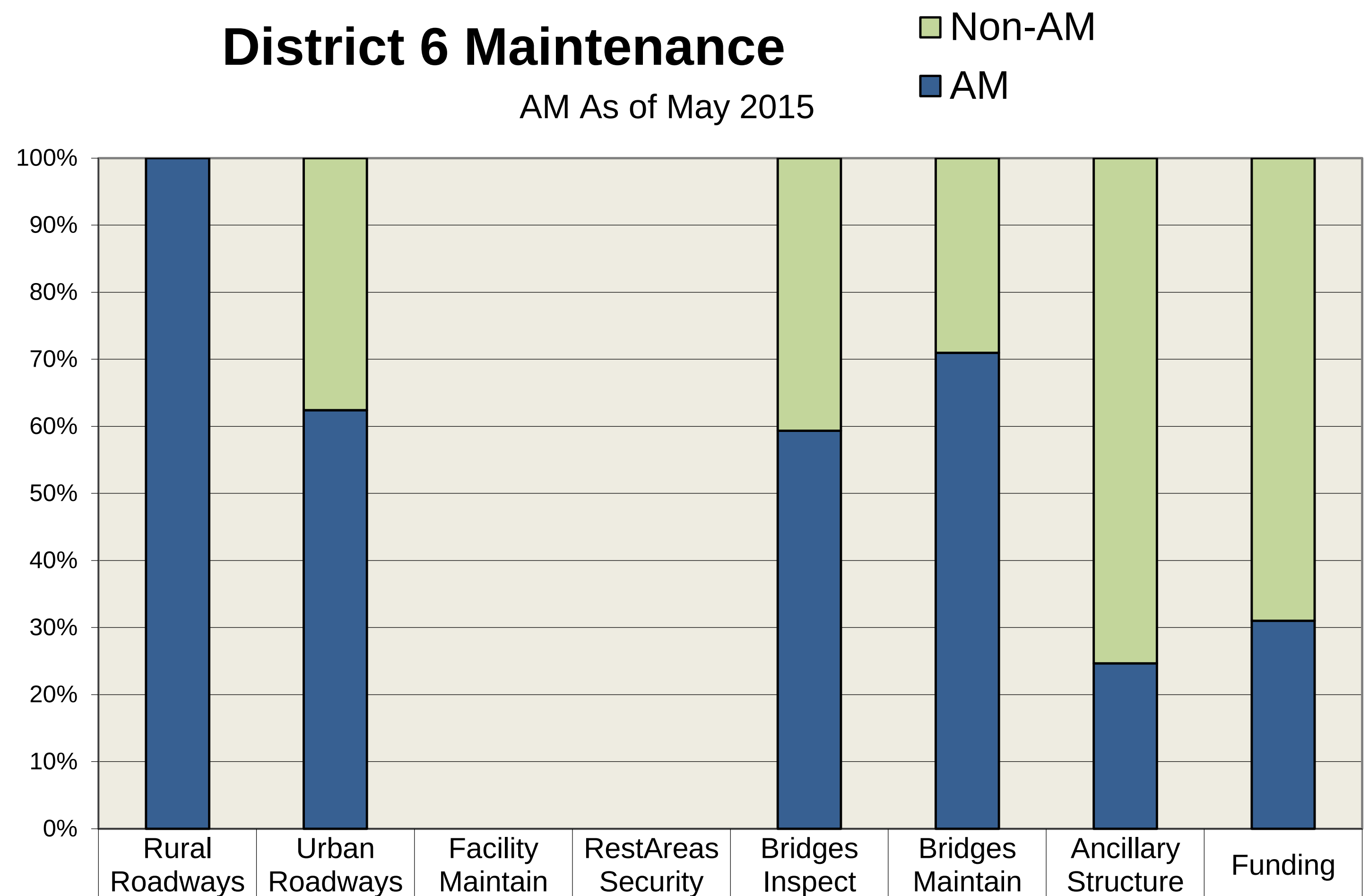
Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

Figure C-31. District 4 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	987	0	0	19,781	13,857	2150	71%
AM	657	298	14	10	3,182	4,451	313	29%
	Centerline Miles		# of Facilities		Deck Area (1000SF)		# of Struct	

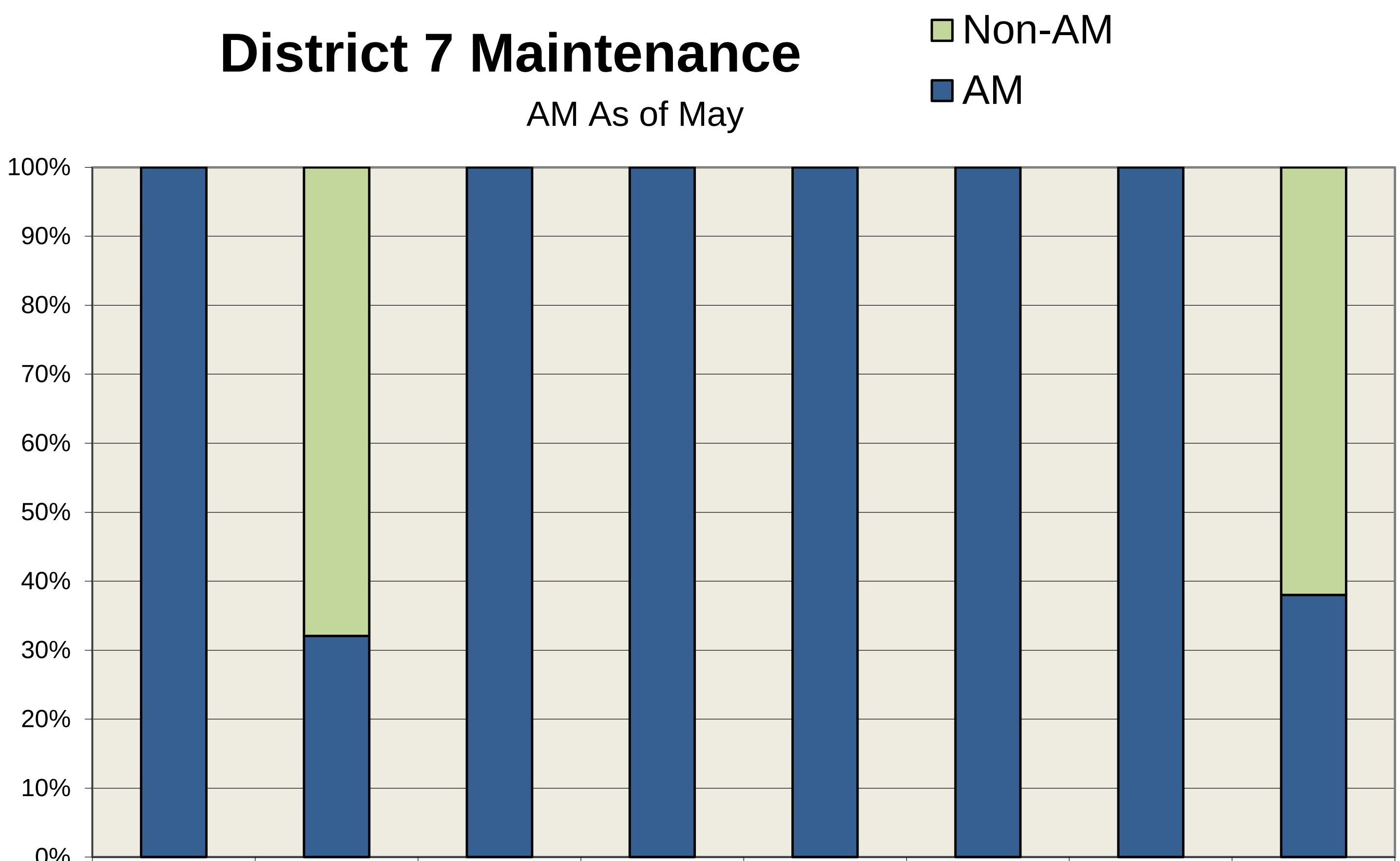
Figure C-32. District 5 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	206	0	0	9,565	5,715	1856	69%
AM	109	342	0	0	13,960	13,960	607	31%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

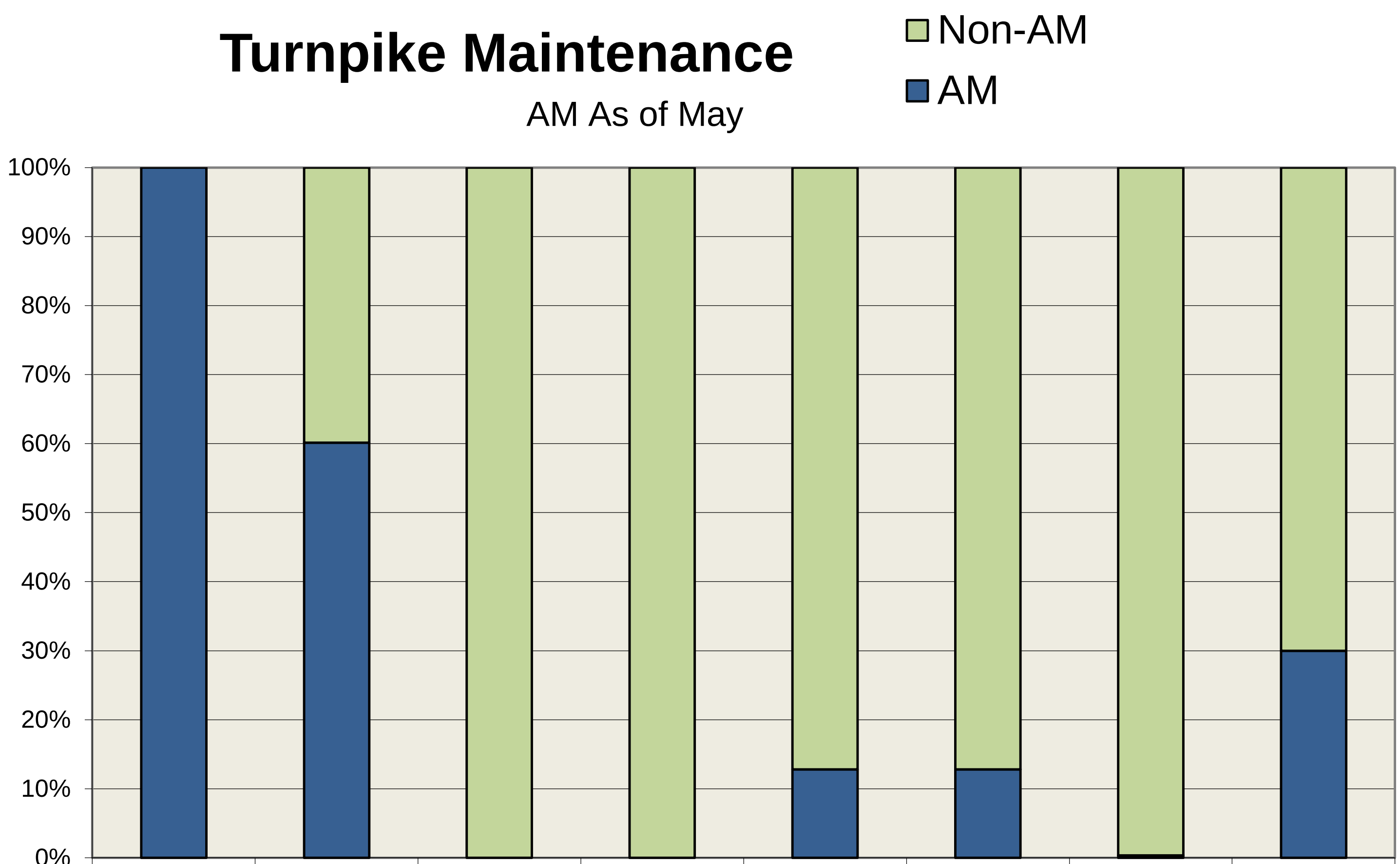
Figure C-33. District 6 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	597	0	0	0	0	0	62%
AM	145	282	5	5	26,824	21,761	1526	38%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

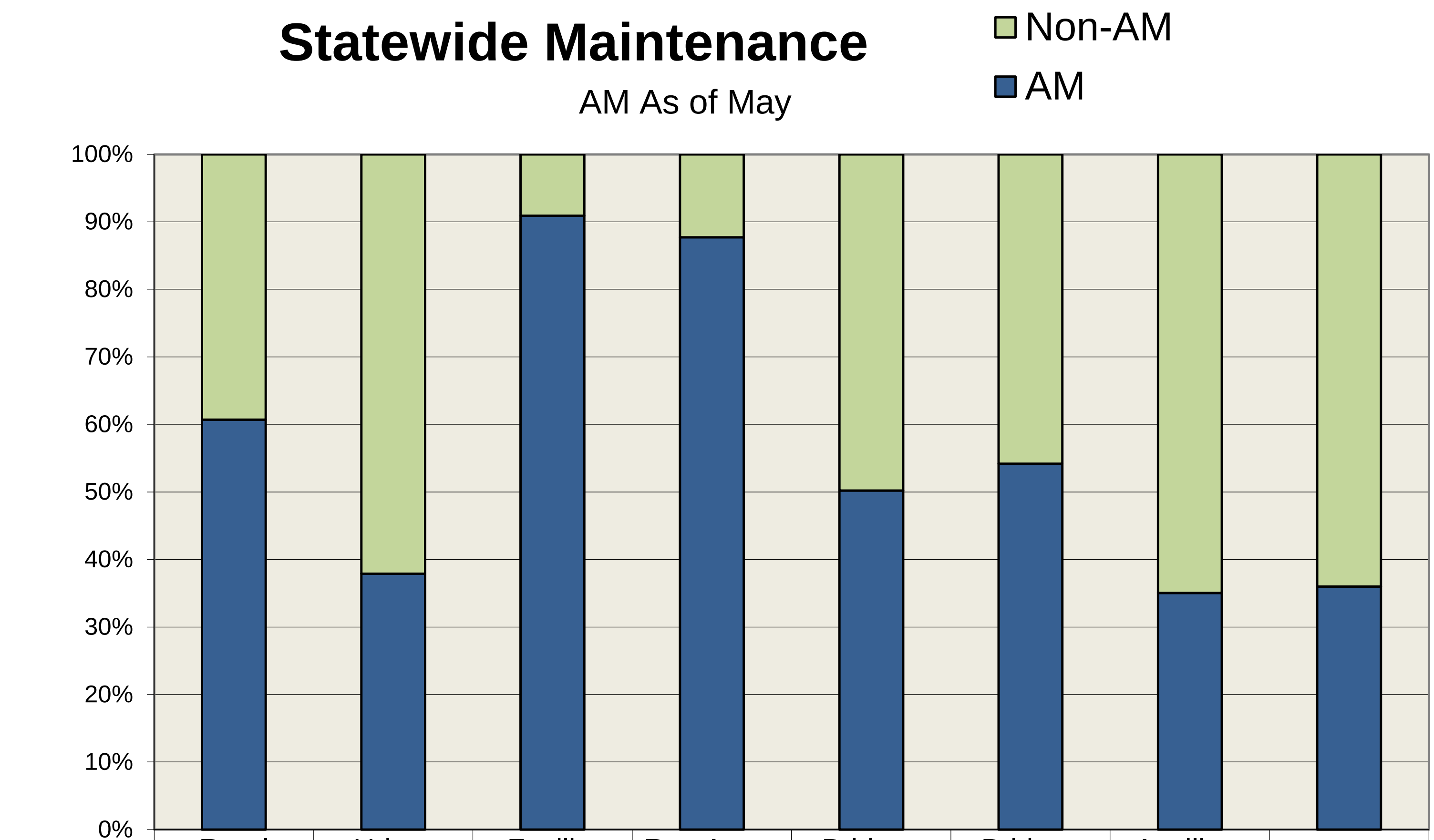
Figure C-34. District 7 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	128	8	8	9,093	9,093	2204	70%
AM	157	193	0	0	1,333	1,333	8	30%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

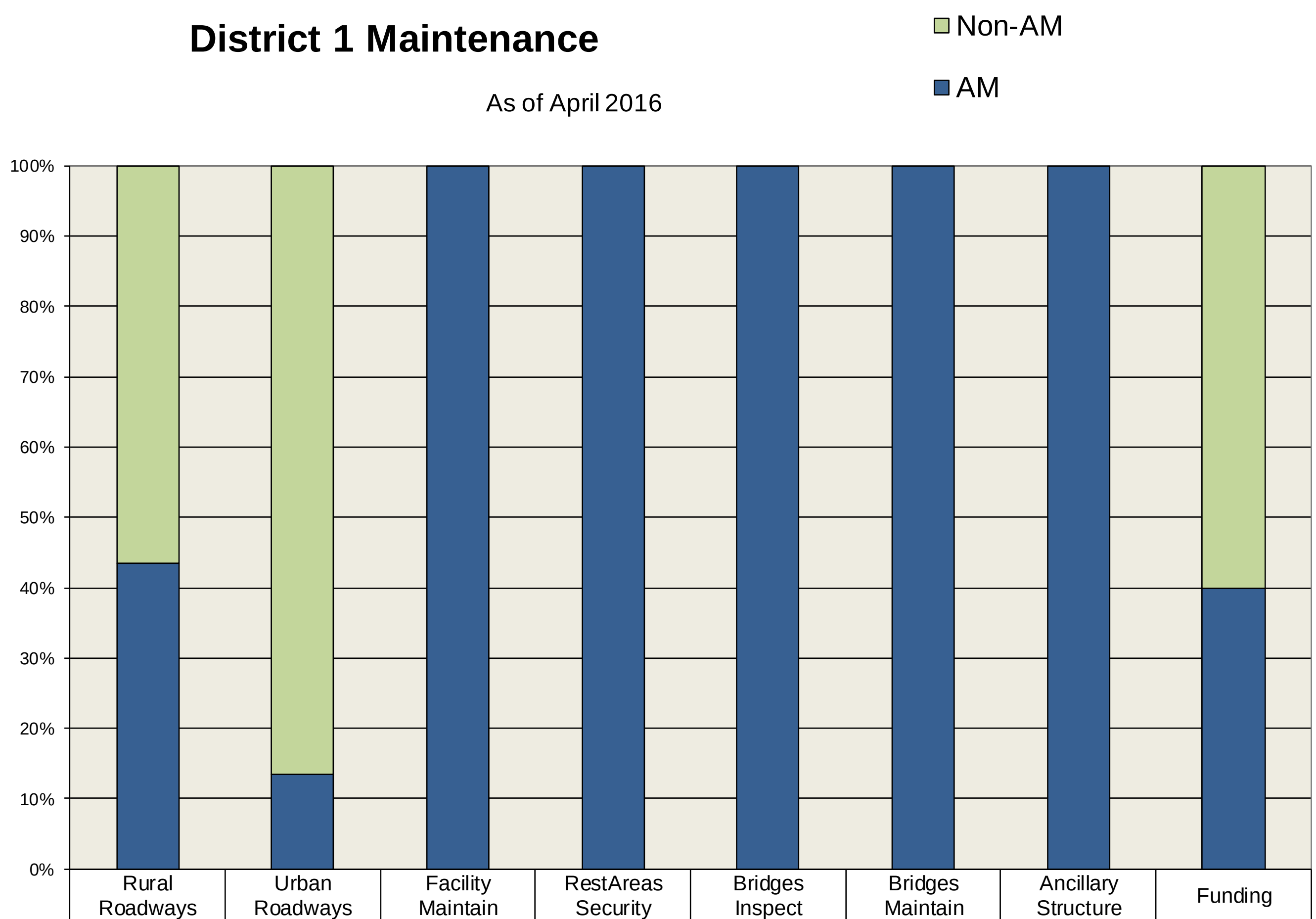
Figure C-35. District 1 2015 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	2219	4021	8	8	89,982	68,743	11540	64%
AM	3425	2451	80	57	90,651	81,290	6222	36%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

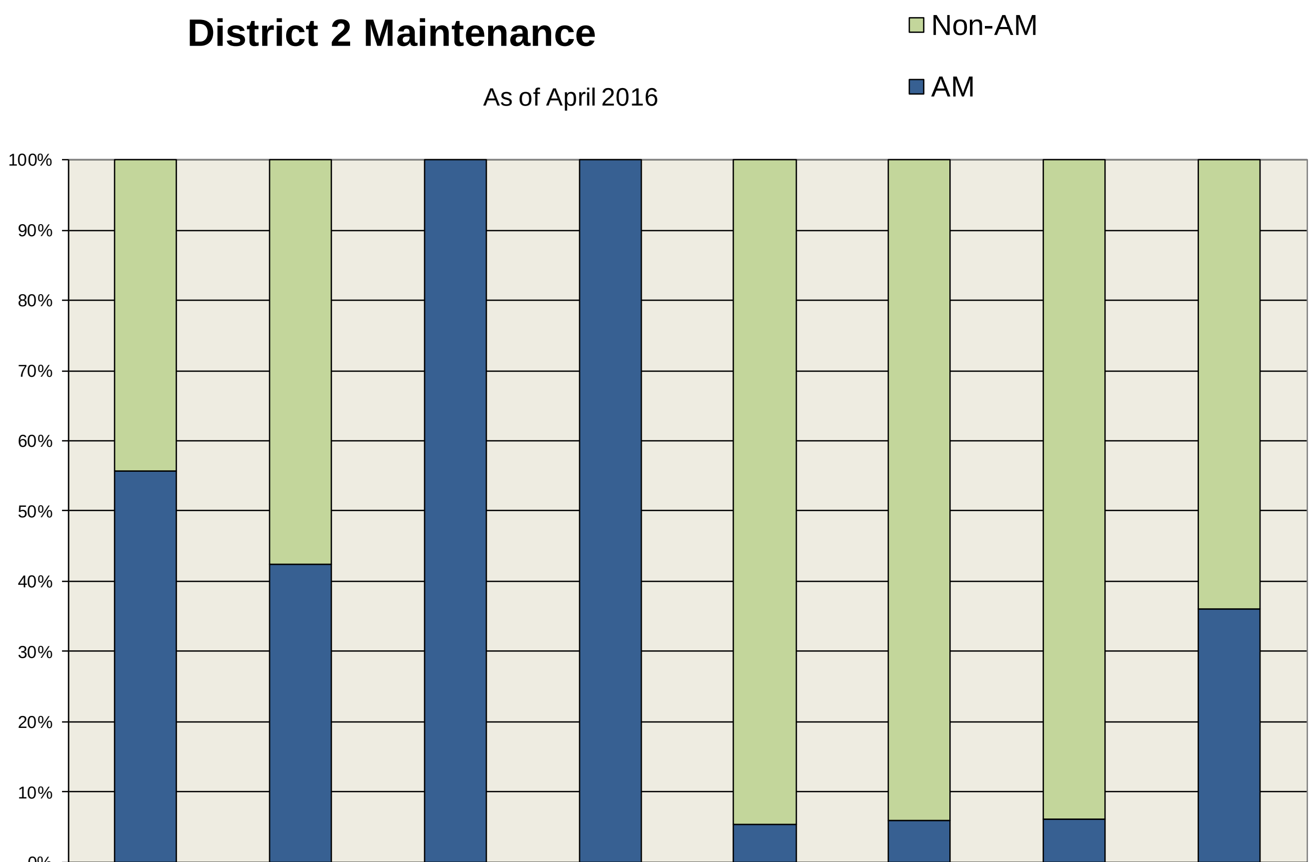
Figure C-36. Statewide Bar Chart for 2015



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	512	806	0	0	0	0	0	60%
AM	395	125	7	5	19,479	13,872	3089	40%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

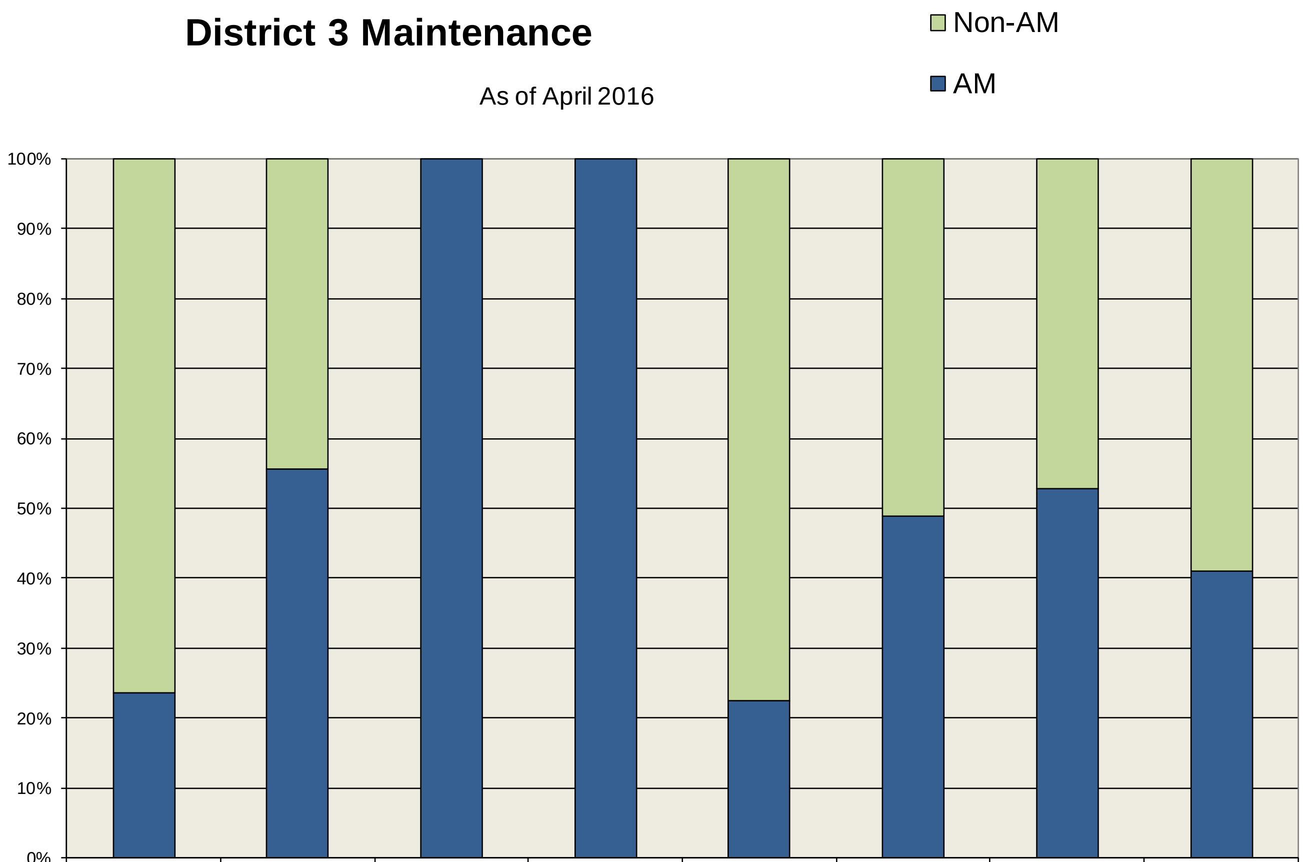
Figure C-37. District 1 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	736	516	0	0	27,046	24,259	4170	64%
AM	924	379	30	17	1,547	1,547	275	36%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

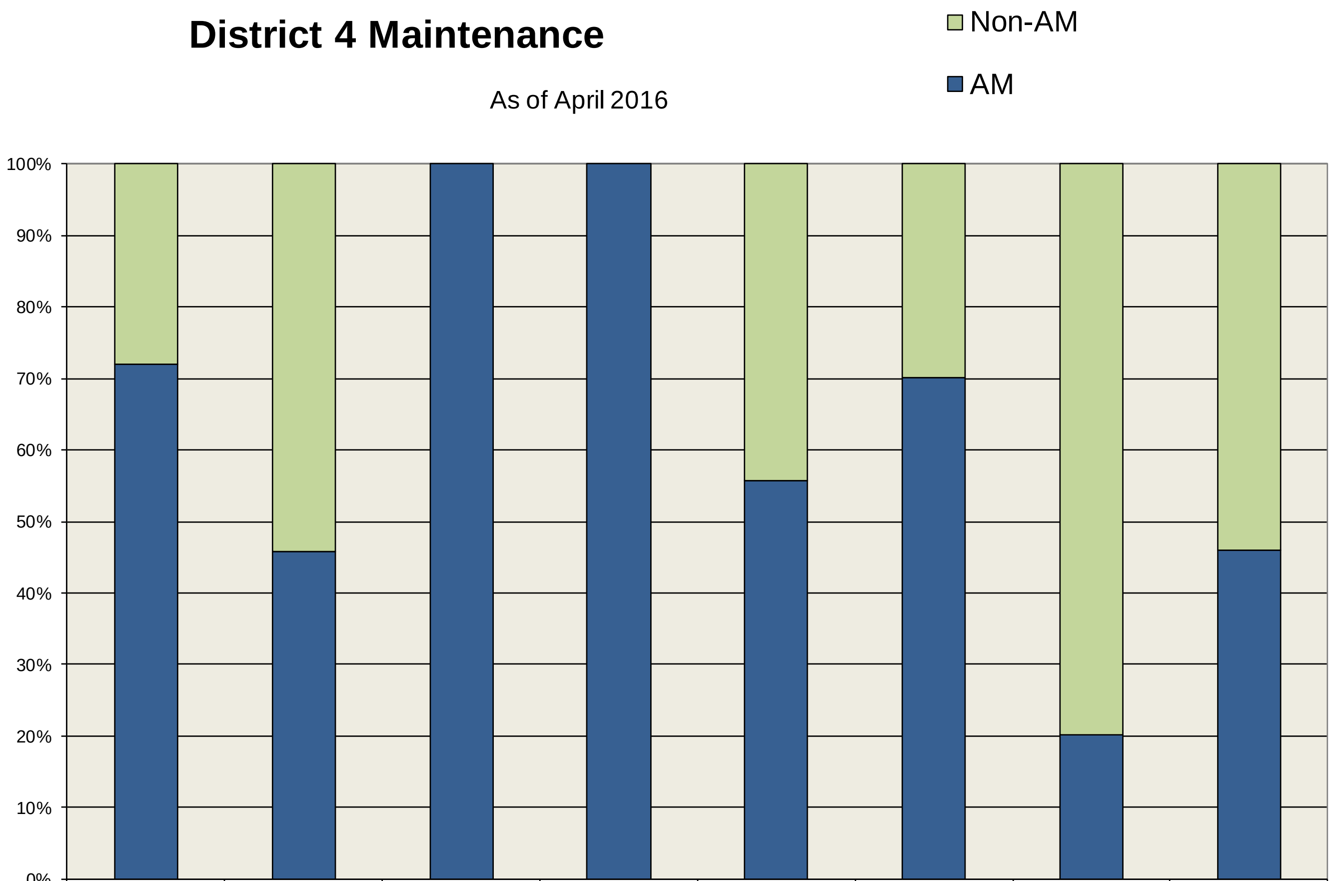
Figure C-38. District 2 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	1303	304	0	0	19,034	9,810	1070	59%
AM	401	381	19	14	5,497	9,407	1200	41%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

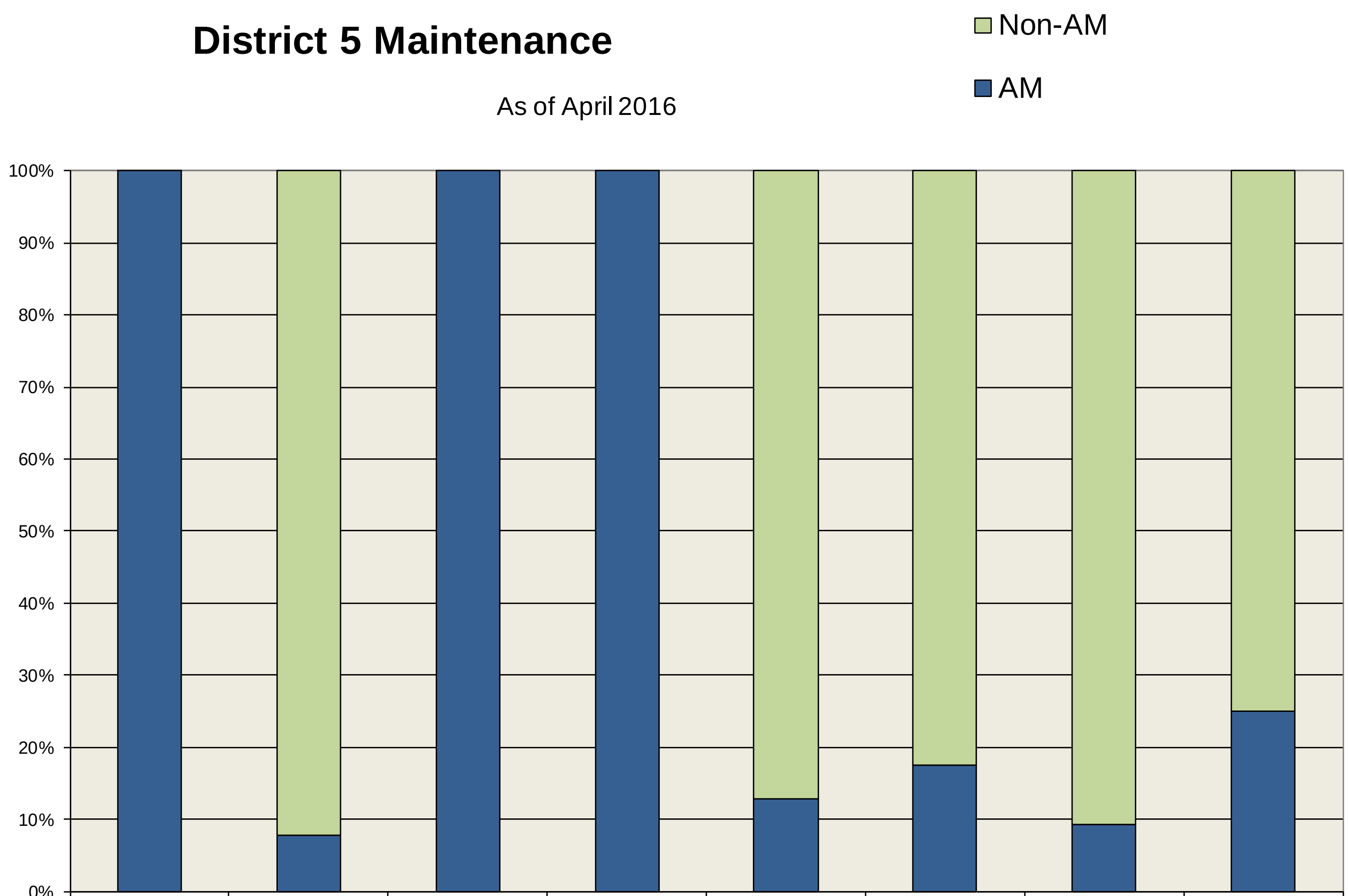
Figure C-39. District 3 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	82	500	0	0	11,293	6,092	4549	54%
AM	210	421	5	5	14,210	14,243	1154	46%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

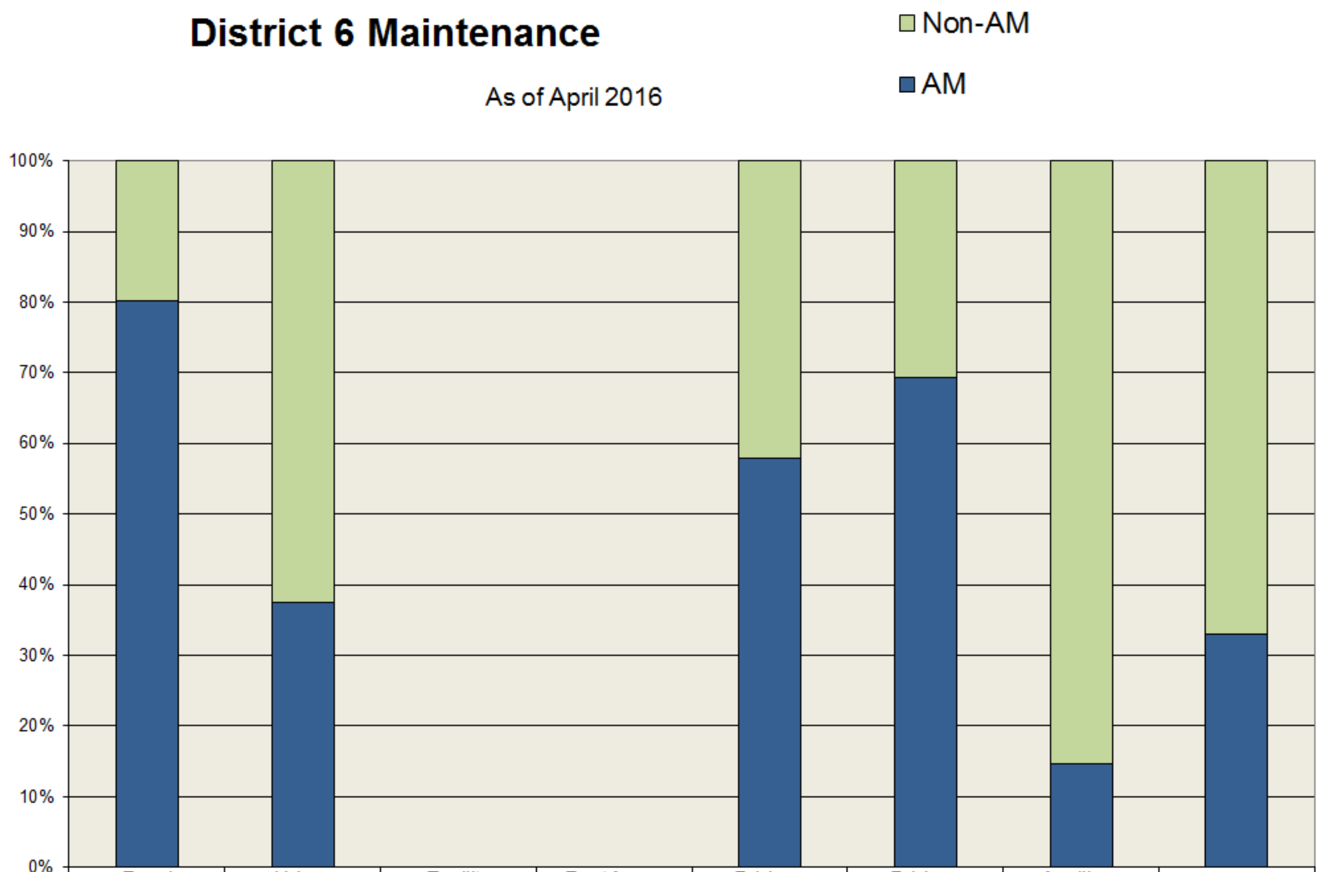
Figure C-40. District 4 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	1101	0	0	20,401	15,274	3437	75%
AM	807	93	14	10	3,003	3,247	355	25%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

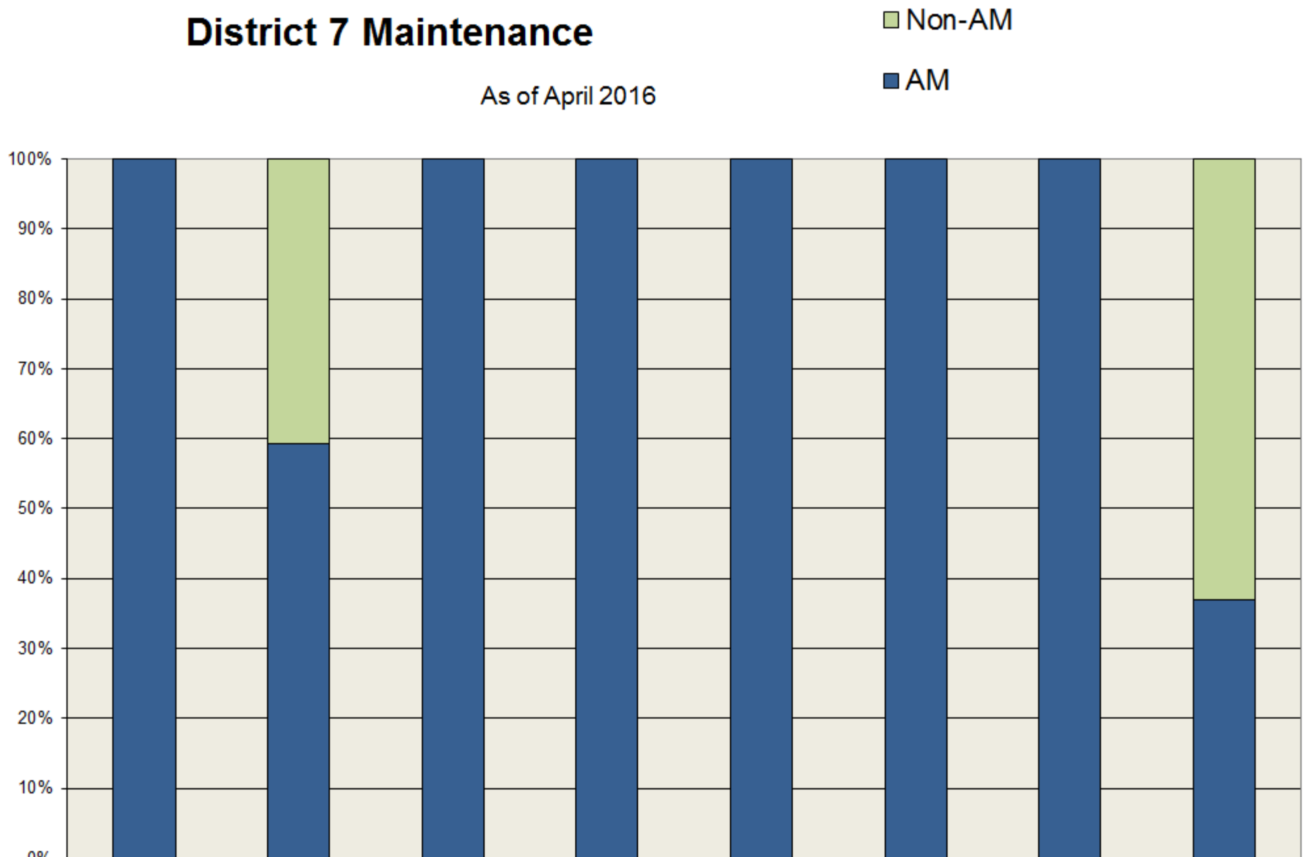
Figure C-41. District 5 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	22	319	0	0	10,082	6,175	4236	67%
AM	88	191	0	0	13,899	13,899	727	33%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

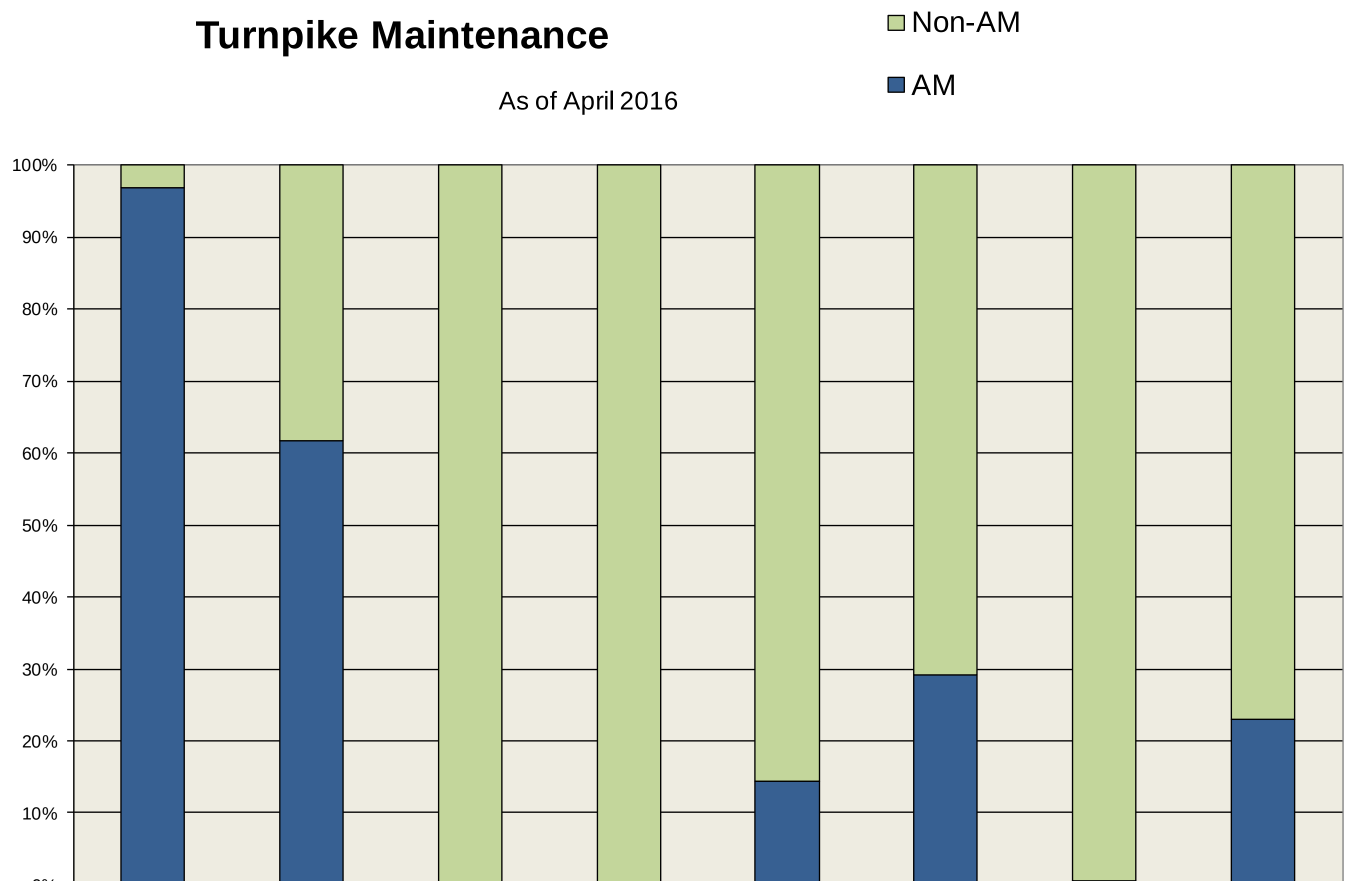
Figure C-42. District 6 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	0	345	0	0	0	0	0	63%
AM	199	503	5	5	27,002	27,002	3340	37%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

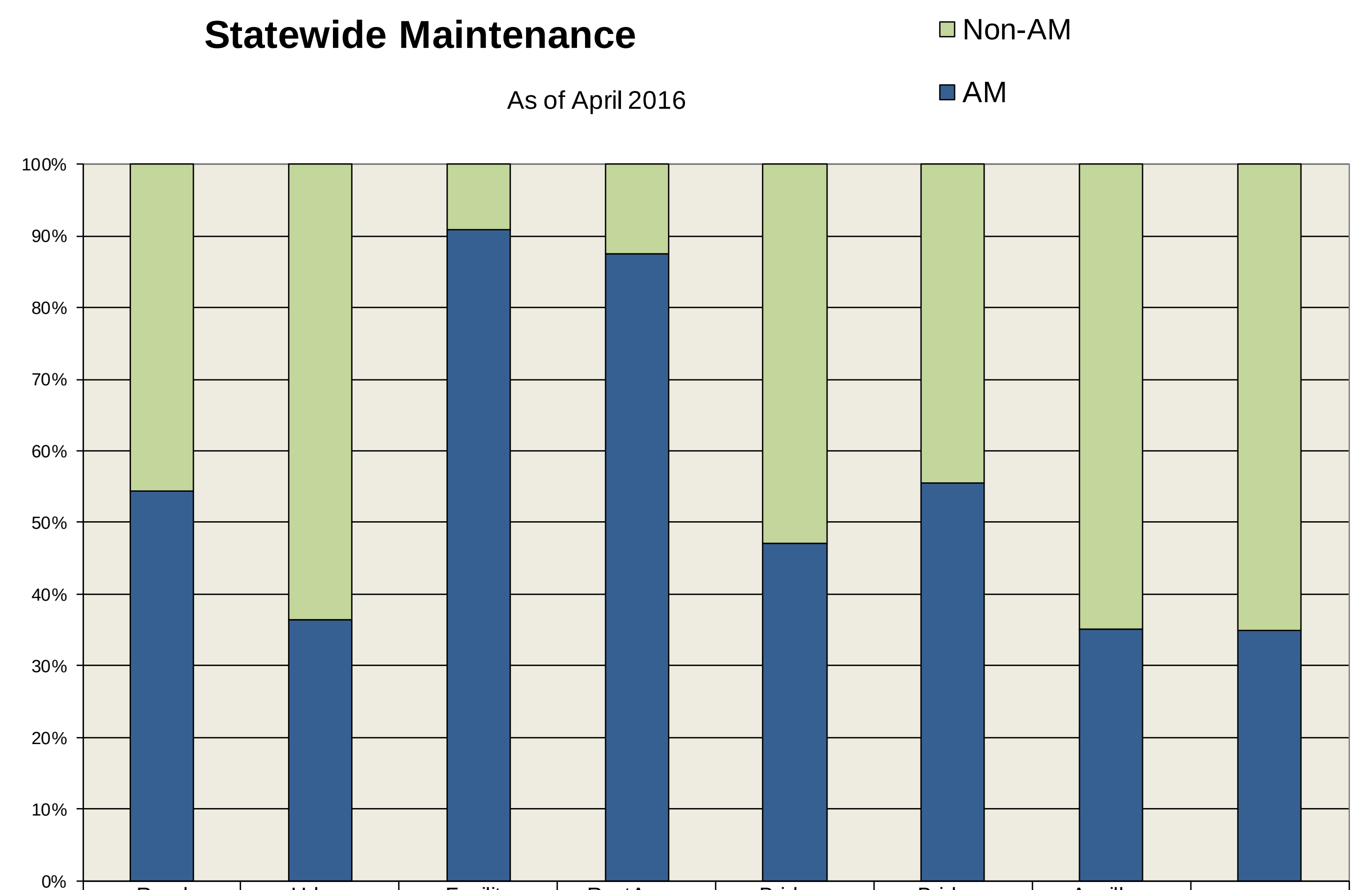
Figure C-43. District 7 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	5	123	8	8	9,222	7,621	1288	77%
AM	152	198	0	0	1,547	3,148	8	23%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

Figure C-44. District 8 2016 Bar Chart



	Rural Roadways	Urban Roadways	Facility Maintain	RestAreas Security	Bridges Inspect	Bridges Maintain	Ancillary Structure	Funding
Non-AM	2659	4013	8	8	97,078	69,231	18750	65%
AM	3176	2291	80	56	86,184	86,365	10148	35%

Centerline Miles **# of Facilities** **Deck Area (1000SF)** **# of Struct**

Figure C-45. Statewide Bar Chart for 2016