



COLORADO
Department of Transportation

Geotechnical and Materials Branch
Applied Research and Innovation Branch

Life Cycle Cost Analysis Rehabilitation Costs

Melody A. Perkins
CDOT Pavement Design

Report No. CDOT-2015-03
July 2015

The contents of this report reflect the views of the author(s), who is (are) responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views of the Colorado Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Technical Report Documentation Page

1. Report No. CDOT-2015-03		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle LIFE CYCLE COST ANALYSIS REHABILITATION COSTS				5. Report Date July 2015	
				6. Performing Organization Code	
7. Author(s) Melody A. Perkins				8. Performing Organization Report No. CDOT-2015-03	
9. Performing Organization Name and Address Colorado Department of Transportation Materials and Geotechnical Branch				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Colorado Department of Transportation - Research 4201 E. Arkansas Ave. Denver, CO 80222				13. Type of Report and Period Covered Final Report	
				14. Sponsoring Agency Code	
15. Supplementary Notes Prepared in cooperation with the US Department of Transportation, Federal Highway Administration					
16. Abstract <p>This study evaluates data from CDOT's Cost Data books and Pavement Management Program. Cost indices were used to normalize project data to year 2014. Data analyzed in the study was obtained from the CDOT's Cost Data books and the Pavement Management Program. Cost indices were used to nominalize project data to year 2014. The results were obtained for heater remixing (process mat, rejuvenating agent, and furnish hot-mix asphalt), heater scarifying and its rejuvenating agent, cold in-place recycling process (rejuvenating agent and hydrated lime), and full-depth reclamation. Concrete, hot-mix asphalt overlays and hot-mix asphalt mill-and-fill projects were categorized by quantities less than or greater than 10,000 square yards or tons. Subcategories of thickness were made for concrete and product type for asphalt.</p> <p>Implementation The purpose of this study is to evaluate the cost of rehabilitation techniques used on interstates, state highways, and principal arterials dating back to 2009 for use in LCCAs. The rehabilitation techniques used in this study include cold in-place recycling, hot in-place recycling, full-depth reclamation, hot-mix asphalt overlays, hot-mix asphalt mill-and-fill, and portland cement concrete pavement. Hot in-place recycling was further broken into three categories; heater remixing, heater repaving, and heater scarifying.</p>					
17. Keywords LCCA, Life Cycle Cost Analysis, rehabilitation costs, heater remixing, heater scarifying, cold in-place recycling, full-depth reclamation, concrete, HMA overlay, HMA mill-and-fill			18. Distribution Statement This document is available on CDOT's website http://www.coloradodot.info/programs/research/pdfs		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages	22. Price

ACKNOWLEDGEMENTS

The author would like to thank Eric Chavez and Stephen Henry of CDOT's Pavement Management Program; Michael Stanford of CDOT's Asphalt Program; the Region Materials Engineers and Assistants including Bob Mero, Craig Wieden, Jody Pieper, Gary Dewitt, Stephen Heimmer, Jeremy Lucero, Tim Webb, and Patrick Murphy who assisted with this study. Without their efforts, this research study would not have been possible.

EXECUTIVE SUMMARY

The purpose of this study is to evaluate the cost of rehabilitation techniques used on interstates, state highways, and principal arterials dating back to 2009. The rehabilitation techniques used in this study include cold in-place recycling, hot in-place recycling, full-depth reclamation, hot-mix asphalt overlays, hot-mix asphalt mill-and-fill, and portland cement concrete pavement. Hot in-place recycling was further broken into three categories: heater remixing, heater repaving, and heater scarifying.

Data analyzed in the study was obtained from the CDOT's Cost Data books and the Pavement Management Program. Cost indices were used to normalize project data to year 2014. The results of this analysis indicate heater remixing for the process mat is \$3.41 per square yard, the cost per gallon of rejuvenating agent is \$45.45, and the cost per ton of furnish hot-mix asphalt is \$1.78. The cost for heater scarifying is \$1.03 per square yard and \$1.35 per gallon for the rejuvenating agent. Analysis of the cold in-place recycling process resulted in \$1.43 per square yard, \$1.64 per gallon for the rejuvenating agent, and \$100.45 per ton for hydrated lime. Cost for full depth reclamation was \$1.80 per square yard.

Data from 2009 to 2014 was used for the analysis of concrete, hot-mix asphalt overlays, and hot-mix asphalt mill-and-fill projects. The analysis divided each of the aforementioned categories by quantities less than or greater than 10,000 square yards or tons. Concrete averaged \$64.35 for projects less than 10,000 square yards and \$36.41 for projects greater than 10,000 square yards. Hot-mix asphalt (HMA) overlay analysis resulted in an average of \$79.79 for projects less than 10,000 tons and \$57.97 per ton for projects greater than 10,000 tons. Similarly, HMA mill-and-fill projects less than 10,000 tons have an average of \$76.61 per ton and projects greater than 10,000 tons averaged \$72.56 per ton.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iv
EXECUTIVE SUMMARY.....	v
TABLE OF CONTENTS.....	6
TABLE OF TABLES.....	7
TABLE OF FIGURES	8
APPENDICES	14
1.0 INTRODUCTION.....	15
2.0 PURPOSE	15
3.0 BACKGROUND.....	15
4.0 METHODOLOGY.....	15
5.0 RESULTS.....	16
6.0 RECOMMENDATIONS	25

TABLE OF TABLES

Table 1. Number of Projects in Study 18

Table 2. Results of Heater Remixing 19

Table 3. Results of Heater Scarifying..... 19

Table 4. Results of Full Depth Reclamation 19

Table 5. Cold In-Place Recycling..... 20

Table 6. Portland Cement Concrete Pavement Projects < 10,000 Square Yards 20

Table 7. Portland Cement Concrete Pavement Projects > 10,000 Square Yards 21

Table 8. HMA Overlay Projects < 10,000 Tons..... 22

Table 9. HMA Overlay Projects > 10,000 Tons..... 23

Table 10. HMA Mill and Fill < 10,000 Tons 24

Table 11. HMA Mill and Fill Projects > 10,000 Tons 25

TABLE OF FIGURES

Figure 1 PCCP Normalized Dollar Amount per Year27

Figure 2 PCCP Normalized Dollar Amount per Thickness27

Figure 3 PCCP Normalized Dollar Amount per Thickness28

Figure 4 HMA Overlay Normalized Dollar Amount per Year28

Figure 5 HMA Overlay Normalized Dollar Amount per Product Type29

Figure 6 HMA Overlay Normalized Dollar Amount per Product Type29

Figure 7 HMA Mill and Fill Normalized Dollar Amount per Year30

Figure 8 HMA Mill and Fill Normalized Dollar Amount per Product Type31

Figure 9 HMA Mill and Fill Normalized Dollar Amount per Product Type31

Figure 10 PCCP Normalized Dollar Amount per Total Square Yards for Projects Less Than 10,000 Square Yards33

Figure 11 PCCP Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Square Yards33

Figure 12 PCCP Total Square Yards per Year for Projects Less Than 10,000 Square Yards34

Figure 13 PCCP Total Normalized Dollar Amount per Year for Projects Less Than 10,000 Square Yards34

Figure 14 PCCP Projects Less Than 10,000 Square Yards per Year35

Figure 15 PCCP Normalized Dollar Amount for Projects of 6 Inches or Less in Thickness and Less Than 10,000 Square Yards35

Figure 16 PCCP Normalized Dollar Amount for Projects of 8 to 9 Inches in Thickness and Less Than 10,000 Square Yards36

Figure 17 PCCP Normalized Dollar Amount for Projects of 9 to 10 Inches in Thickness and Less Than 10,000 Square Yards36

Figure 18 PCCP Normalized Dollar Amount for Projects of 10 to 11 Inches in Thickness and Less Than 10,000 Square Yards37

Figure 19 PCCP Normalized Dollar Amount for Projects of 11 to 12 Inches in Thickness and Less Than 10,000 Square Yards37

Figure 20 PCCP Normalized Dollar Amount for Projects of 12 Inches or Greater in Thickness and Less Than 10,000 Square Yards38

Figure 21 PCCP Normalized Dollar Amount per Total Square Yards for Projects Greater Than 10,000 Square Yards39

Figure 22 PCCP Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Square Yards39

Figure 23 PCCP Total Square Yards per Year for Projects Greater Than 10,000 Square Yards40

Figure 24 PCCP Total Normalized Dollar Amount per Year for Projects Greater Than 10,000 Square Yards	40
Figure 25 PCCP Projects Greater Than 10,000 Square Yards per Year	41
Figure 26 PCCP Normalized Dollar Amount for Projects of 8 to 9 Inches in Thickness and Greater Than 10,000 Square Yards	41
Figure 27 PCCP Normalized Dollar Amount for Projects of 9 to 10 Inches in Thickness and Greater Than 10,000 Square Yards	42
Figure 28 PCCP Normalized Dollar Amount for Projects of 10 to 11 Inches in Thickness and Greater Than 10,000 Square Yards	42
Figure 29 PCCP Normalized Dollar Amount for Projects of 11 to 12 Inches in Thickness and Greater Than 10,000 Square Yards	43
Figure 30 PCCP Normalized Dollar Amount for Projects of 12 Inches or Greater in Thickness and Greater Than 10,000 Square Yards	43
Figure 31 HMA Overlay Normalized Dollar Amount for Projects Less Than 10,000 Tons	45
Figure 32 HMA Overlay Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons	45
Figure 33 HMA Overlay Total Tons per Year for Projects Less Than 10,000 Tons	46
Figure 34 HMA Overlay Total Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons	46
Figure 35 HMA Overlay Projects Less Than 10,000 Tons per Year	47
Figure 36 HMA Overlay Normalized Unit Costs for SX(100) PG 64-28 on Projects Less Than 10,000 Tons	47
Figure 37 HMA Overlay Average Normalized Dollar Amount for SX(100) PG 64-28 per Year for Projects Less Than 10,000 Tons	48
Figure 38 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 64-28 and Less Than 10,000 Tons	48
Figure 39 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 64-28 and Less Than 10,000 Tons	49
Figure 40 HMA Overlay Projects Using SX(100) PG 64-28 Less Than 10,000 Tons per Year	49
Figure 41 HMA Overlay Normalized Unit Costs for SX(100) PG 64-22 on Projects Less Than 10,000 Tons	50
Figure 42 HMA Overlay Average Normalized Dollar Amount for SX(100) PG 64-22 per Year for Projects Less Than 10,000 Tons	50
Figure 43 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 64-22 and Less Than 10,000 Tons	51
Figure 44 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 64-22 and Less Than 10,000 Tons	51
Figure 45 HMA Overlay Projects Using SX(100) PG 64-22 Less Than 10,000 Tons per Year	52

Figure 46 HMA Overlay Normalized Unit Costs for SX(100) PG 58-28 on Projects Less Than 10,000 Tons.....	52
Figure 47 HMA Overlay Normalized Unit Costs for SX(100) PG 76-28 on Projects Less Than 10,000 Tons.....	53
Figure 48 HMA Overlay Normalized Unit Costs for Furnish HMA on Projects Less Than 10,000 Tons.....	53
Figure 49 HMA Overlay Normalized Unit Costs for Projects with Greater than 10,000 Tons.....	54
Figure 50 HMA Overlay Average Normalized Dollar Amount per Year for Projects Greater Than 10,000 Tons.....	54
Figure 51 HMA Overlay Total Tons per Year for Projects Greater Than 10,000 Tons.....	55
Figure 52 HMA Overlay Total Normalized Dollar Amount per Year for Projects Greater Than 10,000 Tons.....	55
Figure 53 HMA Overlay Projects Greater Than 10,000 Tons per Year.....	56
Figure 54 HMA Overlay Normalized Unit Costs for SX(100) PG 64-22 on Projects with Greater than 10,000 Tons.....	56
Figure 55 HMA Overlay Average Normalized Dollar Amount for SX(100) PG 64-22 per Year for Projects Greater Than 10,000 Tons.....	57
Figure 56 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 64-22 and Greater Than 10,000 Tons.....	57
Figure 57 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 64-22 and Greater Than 10,000 Tons.....	58
Figure 58 HMA Overlay Projects Using SX(100) PG 64-22 Greater Than 10,000 Tons per Year..	58
Figure 59 HMA Overlay Normalized Unit Costs for SX(75) on Projects with Greater than 10,000 Tons.....	59
Figure 60 HMA Overlay Average Normalized Dollar Amount for SX(75) per Year for Projects Greater Than 10,000 Tons.....	59
Figure 61 HMA Overlay Total Tons per Year for Projects Using SX(75) and Greater Than 10,000 Tons.....	60
Figure 62 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(75) and Greater Than 10,000 Tons.....	60
Figure 63 HMA Overlay Projects Using SX(75) Greater Than 10,000 Tons per Year.....	61
Figure 64 HMA Overlay Normalized Unit Costs for SX(75) PG 58-28 on Projects with Greater than 10,000 Tons.....	61
Figure 65 HMA Overlay Average Normalized Dollar Amount for SX(75) PG 58-28 per Year for Projects Greater Than 10,000 Tons.....	62
Figure 66 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 58-28 and Greater Than 10,000 Tons.....	62
Figure 67 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(75) PG 58-28 and Less Than 10,000 Tons.....	63

Figure 68 HMA Overlay Projects Using SX(75) PG 58-28 Greater Than 10,000 Tons per Year....	63
Figure 69 HMA Overlay Normalized Unit Costs for SX(100) PG 76-28 on Projects with Greater than 10,000 Tons	64
Figure 70 HMA Overlay Average Normalized Dollar Amount for Projects Using SX(100) PG 76-28 and Greater Than 10,000 Tons per Year	64
Figure 71 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 76-28 and Greater Than 10,000 Tons.....	65
Figure 72 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 76-28 and Less Than 10,000 Tons	65
Figure 73 HMA Overlay Normalized Unit Costs for Projects Using SX(100) PG 64-22 and Greater than 10,000 Tons	66
Figure 74 HMA Overlay Normalized Unit Costs for SX(100) PG 64-28 on Projects with Greater than 10,000 Tons	66
Figure 75 HMA Mill and Fill Normalized Unit Costs for Projects with Less than 10,000 Tons	68
Figure 76 HMA Overlay Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons	68
Figure 77 HMA Overlay Total Tons per Year for Projects Less Than 10,000 Tons	69
Figure 78 HMA Overlay Total Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons	69
Figure 79 HMA Mill and Fill Normalized Unit Costs for Projects Less Than 10,000 Tons	70
Figure 80 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 64-22 and Less than 10,000 Tons	70
Figure 81 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 76-28 and Less than 10,000 Tons	71
Figure 82 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 58-28 and Less than 10,000 Tons	71
Figure 83 HMA Mill and Fill Normalized Unit Costs for Projects Greater than 10,000 Tons.....	72
Figure 84 HMA Overlay Average Normalized Dollar Amount for Projects Greater Than 10,000 Tons	72
Figure 85 HMA Overlay Total Tons per Year for Projects Greater Than 10,000 Tons	73
Figure 86 HMA Overlay Total Normalized Dollar Amount per Year for Projects Greater Than 10,000 Tons	73
Figure 87 HMA Mill and Fill Normalized Unit Costs for Projects Greater Than 10,000 Tons	74
Figure 88 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 76-28 and Greater than 10,000 Tons	74
Figure 89 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 58-28 and Greater than 10,000 Tons	75

Figure 90 HMA Mill and Fill Normalized Unit Costs for Projects Using SMA and Greater than 10,000 Tons	75
Figure 91 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 64-22 and Greater than 10,000 Tons	76
Figure 92 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 58-34 and Greater than 10,000 Tons	76
Figure 93 Cold In-Place Recycling Normalized Dollar Amount per Square Yard	78
Figure 94 Cold In-Place Recycling Normalized Dollar Amount per Year	78
Figure 95 Cold In-Place Recycling Projects Total Square Yards per Year	79
Figure 96 Cold In-Place Recycling Projects per Year.....	79
Figure 97 Cold In-Place Recycling Hydrated Lime Normalized Dollar Amount per Ton	80
Figure 98 Cold In-Place Recycling Normalized Dollar Amount for Hydrated Lime per Year	80
Figure 99 Cold In-Place Recycling Gallons of Hydrated Lime per Year	81
Figure 100 Cold In-Place Recycling Projects with Hydrated Lime per Year	81
Figure 101 Cold In-Place Recycling Rejuvenating Agent Normalized Dollar Amount per Gallon .82	
Figure 102 Cold In-Place Recycling Normalized Dollar Amount for Rejuvenating Agent per Year82	
Figure 103 Cold In-Place Recycling Gallons of Rejuvenating Agent per Year.....	83
Figure 104 Cold In-Place Recycling Projects with Rejuvenating Agent per Year	83
Figure 105 Full Depth Reclamation Normalized Dollar Amount per Square Yard.....	85
Figure 106 Full Depth Reclamation Average Normalized Dollar Amount per Square Yard per Year	85
Figure 107 Full Depth Reclamation Total Square Yards per Year	86
Figure 108 Full Depth Reclamation Normalized Dollar Amount per Year	86
Figure 109 Full Depth Reclamation Projects per Year	87
Figure 110 Heater Remixing Process Mat Normalized Dollar Amount per Square Yard	89
Figure 111 Heater Remixing Process Mat Total Square Yards per Year.....	89
Figure 112 Heater Remixing Process Mat Normalized Dollar Amount per Year	90
Figure 113 Heater Remixing Process Mat Projects per Year.....	90
Figure 114 Heater Remixing Furnish HMA Normalized Dollar Amount per Ton.....	91
Figure 115 Heater Remixing Furnish HMA Total Tons per Year	91
Figure 116 Heater Remixing Furnish HMA Normalized Dollar Amount per Year.....	92
Figure 117 Heater Remixing Furnish HMA Projects per Year	92
Figure 118 Heater Remixing Rejuvenating Agent Normalized Dollar Amount per Gallon	93
Figure 119 Heater Remixing Rejuvenating Agent Total Gallons per Year	93
Figure 120 Heater Remixing Rejuvenating Agent Normalized Dollar Amount per Year	94

Figure 121 Heater Remixing Rejuvenating Agent Projects per Year94
Figure 122 Heater Scarifying Process Mat Normalized Dollar Amount per Square Yard96
Figure 123 Heater Scarifying Process Mat Total Square Yards per Year.....96
Figure 124 Heater Scarifying Process Mat Normalized Dollar Amount per Year.....97
Figure 125 Heater Scarifying Process Mat Projects per Year97
Figure 126 Heater Scarifying Rejuvenating Agent Normalized Dollar Amount per Gallon98
Figure 127 Heater Scarifying Rejuvenating Agent Total Gallons per Year98
Figure 128 Heater Scarifying Rejuvenating Agent Normalized Dollar Amount per Year99
Figure 129 Heater Scarifying Rejuvenating Agent Projects per Year99

APPENDICES

COLD IN-PLACE RECYCLING.....	APPENDIX A
HOT IN-PLACE RECYCLING.....	APPENDIX B
FULL DEPTH RECLAMATION.....	APPENDIX C
HOT-MIX ASPHALT.....	APPENDIX D
PORTLAND CONCRETE CEMENT PAVEMENT	APPENDIX E

1.0 INTRODUCTION

Some of the principal factors to be considered in choosing pavement type are soil characteristics, traffic volume and types, climate, life cycle costs, and construction considerations. Although these factors should be considered in any pavement design, life cycle costs have one of the largest impacts. The various costs of design alternatives over an analysis period are used to select the preferred alternative and are referred to as a Life Cycle Cost Analysis (LCCA). An LCCA includes costs of initial design and construction, future maintenance, rehabilitation, and user costs. Careful attention to the variables and calculations will ensure the most realistic and factual comparison between pavement types and rehabilitation strategies.

2.0 PURPOSE

The purpose of this study is to analyze the cost of the various rehabilitation techniques CDOT used on interstates, state highways, and principal arterials since 2009. The costs generated in this report will be another tool engineers may draw upon when making an LCCA. A total of 692 hot-mix asphalt (HMA) and portland concrete cement pavement (PCCP) projects were used in this study.

3.0 BACKGROUND

LCCA uses the initial costs and the discounted future cost of predicted maintenance, reconstruction, rehabilitation, and resurfacing over the life of the project. An LCCA comparing asphalt and concrete should be prepared for all surface treatment projects exceeding \$2,000,000 initial pavement cost. CDOT has a section in the M-E Pavement Design Guide designed to help engineers select the best rehabilitation method. The purpose of this study is to determine the cost associated with each treatment so a better comparison may be made between asphalt and concrete designs.

4.0 METHODOLOGY

CDOT's Pavement Management Program and cost data sheets based on bid prices were used to create a list of potential projects used in this study. Project categories included cold in-place recycling, hot in-place recycling, full-depth reclamation, PCCP, HMA overlay, and HMA mill-and-fill. The initial lists were filtered by the Pavement Design Program and Regional Materials Engineers for projects of adequate size and appropriateness. For example, if less than 100 square yards of full depth reclamation occurred, or if the project was primarily maintenance patching of select areas, the project was eliminated from the list.

Within the list of appropriate projects between 2009 and 2014, subcategories were made for some reconstruction techniques. These include:

- Cold in-place recycling process (years 2001 through 2014)
 - Rejuvenating agent
 - Hydrated lime

- Hot in-place recycling (years 2001 through 2014)
 - Process mat
 - Rejuvenating agent
 - Furnish hot-mix asphalt
- Heater remixing heater scarifying (years 2001 through 2014)
 - Process mat
 - Rejuvenating agent
 - Furnish hot-mix asphalt

Cost analysis for PCCP, HMA overlays, and HMA mill-and-fill was also performed. PCCP was broken into smaller data sets based on project thickness that ranged from 6 inches and less to more than 12 inches. The HMA overlay, mill, and mill-and-fill projects were also broken into smaller data sets based on the specific product used. An analysis of projects less than and greater than 10,000 square yards/tons were performed on all data and sub-data sets.

The following items were not included in this analysis:

- Cold in-place recycling: 3-inch hot-mix asphalt overlay
- Heater remixing: 2-inch hot mix overlay and 10 pounds of hot-mix asphalt per square yard
- Heater scarifying: 2-inch hot mix overlay
- Heater repaving: 1.25-inch of hot-mix asphalt per square yard

Once the projects were placed in the appropriate category, an analysis of the overall costs was made. Since the projects dated from 2001 to 2014, a conversion factor/price adjustment from the Colorado Construction Cost Index was used for each year to normalize the costs to 2014 prices. Analysis determined the amount of material used, the adjusted price cost, and an adjusted cost per item. Table 1 shows the number of projects used in this study.

5.0 RESULTS

As mentioned earlier, data analyzed in the study was obtained from the CDOT's Cost Data books and the Pavement Management Program. Cost indices were used to nominalize project data to year 2014. The results of this analysis are shown on Tables 2 through 11 and Appendices A through H, which indicate the following:

- Heater remixing, Table 2
 - Process mat is \$3.41 per square yard
 - Rejuvenating agent is \$45.45 per gallon
 - Furnish hot-mix asphalt is \$1.78 per ton
- Heater scarifying is \$1.03 per square yard, Table 3
 - Rejuvenating agent is \$1.35 per gallon

- Full-depth reclamation cost is \$1.80 per square yard, Table 4.
- Cold in-place recycling process is 1.43 per square yard, Table 5
 - Rejuvenating agent is \$1.64 per gallon
 - Hydrated lime is \$100.45 per ton

The data from 2009 to 2014 was used for the analysis of concrete, hot-mix asphalt overlays, and hot-mix asphalt mill-and-fill projects. The analysis divided each of the aforementioned categories by quantities less than or greater than 10,000 square yards or tons. For PCCP, additional analysis was also performed based on the thickness of each section; the thickness categories with increments of one inch ranged from 6 inches to more than 12 inches. Additional analysis was performed on HMA overlays and mill-and-fill projects in which various asphalt products were individually analyzed. The results are as follows:

- Concrete (Tables 6 and 7)
 - Less than 10,000 square yards is \$64.35 per square yard
 - Greater than 10,000 square yards is \$36.41 per square yard
- HMA overlays (Tables 8 and 9)
 - Less than 10,000 tons is \$79.79 per ton
 - Greater than 10,000 tons is \$57.97 per ton
- HMA mill-and-fill (Tables 10 and 11)
 - Less than 10,000 tons is \$76.61 per ton
 - Greater than 10,000 tons is \$72.56 per ton

Table 1. Number of Projects in Study

Rehabilitation Technique	Components	Number of Projects
Heater Remixing	Process Mat	49
	Rejuvenating Agent	45
	Hydrating Lime	30
Heater Scarifying	Process Mat	19
	Rejuvenating Agent	17
Full-depth Reclamation	All projects	22
Cold In-place Recycling	All projects	25
	Rejuvenating Agent	20
	Hydrating Lime	23
HMA Overlay < 10,000 tons	All projects	84
	SX(100) PG 64-28	22
	SX(100) PG 64-22	34
	SX(100) PG 58-28	7
	SX(100) PG 76-28	7
	Furnish HMA	7
HMA Overlay > 10,000 tons	All projects	121
	SX(100) PG 64-22	36
	SX(100) PG 76-28	12
	SX(100) PG 58-28	11
	SX(100) PG 64-28	9
	SX(75)	21
HMA Mill-and-fill < 10,000 tons	All projects	51
	SX(100) PG 64-22	15
	SX(100) PG 76-28	17
	SX(75) PG 58-28	7
HMA Mill-and-fill > 10,000 tons	All projects	63
	SX(100) PG 64-22	10
	SX(75) PG 58-28	21
	SX(100) PG 64-28	5
	SX(100) PG 58-34	4
	SMA	13
Portland Cement Concrete Pavement < 10,000 square yards	All projects	184
Portland Cement Concrete Pavement > 10,000 square yards	All projects	67
Total		692

Table 2. Results of Heater Remixing

	Item	Amount
Process Mat	Number of Projects	49
	Total Square Yards	10,448,936
	Total Normalized Dollar Amount	\$35,675,622
	Normalized Average per Square Yard	\$3.41
Rejuvenating Agent	Number of Projects	45
	Total Gallons	698,230
	Total Normalized Dollar Amount	\$1,243,166
	Normalized Average per Gallon	\$45.45
Furnish HMA	Number of Projects	30
	Total Tons	115,302
	Total Normalized Dollar Amount	\$5,330,720
	Normalized Average per Ton	\$1.78

Table 3. Results of Heater Scarifying

	Item	Amount
Process Mat	Number of Projects	19
	Total Square Yards	3,676,832
	Total Normalized Dollar Amount	\$3,785,756
	Normalized Average per Square Yard	\$1.03
Rejuvenating Agent	Number of Projects	17
	Total Gallons	288,676
	Total Normalized Dollar Amount	\$388,644
	Normalized Average per Gallon	\$1.35

Table 4. Results of Full Depth Reclamation

Item	Amount
Number of Projects	22
Total Square Yards	2,033,398
Total Normalized Dollar Amount	\$3,992,506
Normalized Average per Square Yard	\$1.80

Table 5. Cold In-Place Recycling

	Item	Amount
All projects	Number of Projects	25
	Total Square Yards	4,809,986
	Total Normalized Dollar Amount	\$3,785,756
	Normalized Average per Square Yard	\$1.43
Rejuvenating Agent	Number of Projects	20
	Total Gallons	5,159,599
	Total Normalized Dollar Amount	\$10,037,689
	Normalized Average per Gallon	\$1.64
Hydrated Lime	Number of Projects	23
	Total Tons	15,876
	Total Normalized Dollar Amount	\$1,594,706
	Normalized Average per Ton	\$100.45

Table 6. Portland Cement Concrete Pavement Projects < 10,000 Square Yards

	Item	Amount
All projects	Number of Projects	184
	Total Square Yards	383,088
	Total Normalized Dollar Amount	\$24,650,614
	Normalized Average per Square Yard	\$64.35
6 inches or less	Number of Projects	42
	Total Square Yards	31,569
	Total Normalized Dollar Amount	\$1,161,058
	Normalized Average per Square Yard	\$36.78
7 to 8 inches	Number of Projects	1
	Total Square Yards	5,917
	Total Normalized Dollar Amount	\$172,757
	Normalized Average per Square Yard	\$29.20
8 to 9 inches	Number of Projects	29
	Total Square Yards	55,627
	Total Normalized Dollar Amount	\$3,206,541
	Normalized Average per Square Yard	\$57.64
9 to 10 inches	Number of Projects	30
	Total Square Yards	81,124
	Total Normalized Dollar Amount	\$5,771,991
	Normalized Average per Square Yard	\$71.15
10 to 11 inches	Number of Projects	33
	Total Square Yards	84,032
	Total Normalized Dollar Amount	\$6,172,580
	Normalized Average per Square Yard	\$73.46

11 to 12 inches	Number of Projects	24
	Total Square Yards	58,018
	Total Normalized Dollar Amount	\$4,330,870
	Normalized Average per Square Yard	\$74.65
more than 12 inches	Number of Projects	19
	Total Square Yards	55,623
	Total Normalized Dollar Amount	2,895,314
	Normalized Average per Square Yard	\$52.04

Table 7. Portland Cement Concrete Pavement Projects > 10,000 Square Yards

	Item	Amount
All projects	Number of Projects	67
	Total Square Yards	3,599,664
	Total Normalized Dollar Amount	\$131,056,876
	Normalized Average per Square Yard	\$36.41
4 to 7 inches	Number of Projects	3
	Total Square Yards	300,164
	Total Normalized Dollar Amount	\$6,576,434
	Normalized Average per Square Yard	\$21.91
8 to 9 inches	Number of Projects	10
	Total Square Yards	253,232
	Total Normalized Dollar Amount	\$11,911,473
	Normalized Average per Square Yard	\$47.04
9 to 10 inches	Number of Projects	17
	Total Square Yards	487,941
	Total Normalized Dollar Amount	\$22,002,017
	Normalized Average per Square Yard	\$45.09
10 to 11 inches	Number of Projects	10
	Total Square Yards	359,992
	Total Normalized Dollar Amount	\$12,380,592
	Normalized Average per Square Yard	\$34.39
11 to 12 inches	Number of Projects	7
	Total Square Yards	482,129
	Total Normalized Dollar Amount	\$18,558,033
	Normalized Average per Square Yard	\$38.49
More than 12 inches	Number of Projects	13
	Total Square Yards	978,159
	Total Normalized Dollar Amount	\$37,517,776
	Normalized Average per Square Yard	\$38.36

Table 8. HMA Overlay Projects < 10,000 Tons

	Item	Amount
All projects	Number of Projects	84
	Total Tons	328,045
	Total Normalized Dollar Amount	\$26,368,555
	Normalized Average per Ton	\$79.79
SX(100) PG 64-28	Number of Projects	22
	Total Tons	65,638
	Total Normalized Dollar Amount	\$5,736,291
	Normalized Average per Ton	\$87.39
SX(100) PG 64-22	Number of Projects	34
	Total Tons	169,785
	Total Normalized Dollar Amount	\$12,741,234
	Normalized Average per Ton	\$82.66
SX(100) PG 58-28	Number of Projects	7
	Total Tons	37,083
	Total Normalized Dollar Amount	\$2,477,618
	Normalized Average per Ton	\$66.81
SX(100) PG 76-28	Number of Projects	7
	Total Tons	32,173
	Total Normalized Dollar Amount	\$2,330,107
	Normalized Average per Ton	\$72.42
Furnish HMA	Number of Projects	7
	Total Tons	23,435
	Total Normalized Dollar Amount	\$1,496,769
	Normalized Average per Ton	\$63.87

Table 9. HMA Overlay Projects > 10,000 Tons

	Item	Amount
All projects	Number of Projects	121
	Total Tons	4,282,222
	Total Normalized Dollar Amount	\$248,255,442
	Normalized Average per Ton	\$57.97
SX(100) PG 64-28	Number of Projects	9
	Total Tons	196,537
	Total Normalized Dollar Amount	\$10,871,686
	Normalized Average per Ton	\$55.32
SX(100) PG 64-22	Number of Projects	36
	Total Tons	1,210,798
	Total Normalized Dollar Amount	\$68,523,424
	Normalized Average per Ton	\$56.59
SX(100) PG 58-28	Number of Projects	11
	Total Tons	416,493
	Total Normalized Dollar Amount	\$30,887,680
	Normalized Average per Ton	\$74.16
SX(100) PG 76-28	Number of Projects	11
	Total Tons	416,493
	Total Normalized Dollar Amount	\$30,887,680
	Normalized Average per Ton	\$79.73
SX (75)	Number of Projects	21
	Total Tons	719,034
	Total Normalized Dollar Amount	\$23,675,171
	Normalized Average per Ton	\$32.93

Table 10. HMA Mill-and-Fill < 10,000 Tons

	Item	Amount
All projects	Number of Projects	51
	Total Tons	212,732
	Total Normalized Dollar Amount	\$16,296,645
	Normalized Average per Ton	\$76.61
SX(100) PG 64-22	Number of Projects	15
	Total Tons	28,333
	Total Normalized Dollar Amount	\$2,418,438
	Normalized Average per Ton	\$85.36
SX(100) PG 58-28	Number of Projects	7
	Total Tons	21,216
	Total Normalized Dollar Amount	2,730,082
	Normalized Average per Ton	\$128.68
SX(100) PG 76-28	Number of Projects	17
	Total Tons	110,791
	Total Normalized Dollar Amount	\$7,000,0711
	Normalized Average per Ton	\$63.18

Table 11. HMA Mill-and-Fill Projects > 10,000 Tons

	Item	Amount
All projects	Number of Projects	63
	Total Tons	1,751,060
	Total Normalized Dollar Amount	\$127,667,932
	Normalized Average per Ton	\$72.56
SX(100) PG 58-34	Number of Projects	4
	Total Tons	95,697
	Total Normalized Dollar Amount	\$8,251,056
	Normalized Average per Ton	\$86.22
SX(100) PG 64-22	Number of Projects	5
	Total Tons	136,753
	Total Normalized Dollar Amount	\$9,562,261
	Normalized Average per Ton	\$69.92
SX(100) PG 58-28	Number of Projects	21
	Total Tons	688,657
	Total Normalized Dollar Amount	\$48,738,394
	Normalized Average per Ton	\$70.77
SX(100) PG 76-28	Number of Projects	10
	Total Tons	207,138
	Total Normalized Dollar Amount	\$12,558,276
	Normalized Average per Ton	\$60.63
SMA	Number of Projects	13
	Total Tons	345,467
	Total Normalized Dollar Amount	\$30,229,383
	Normalized Average per Ton	\$87.50

6.0 RECOMMENDATIONS

This study was performed to determine the cost of various rehabilitation techniques used by CDOT in an effort to fine tune some of the costs used during the pavement selection process and the Life Cycle Cost Analysis. Although the results of the study are helpful in this process, it is recommended that the service life of each of the analyzed processes also be established. The cost of a process may initially appear beneficial; however, if the treatment only lasts 2 to 3 years versus a more expensive treatment that has historically performed for 10+ years, the final analysis may show the second treatment to be financially cheaper over a longer period. Additionally, we recommend this study be updated on a yearly or bi-yearly basis to show current prices and project totals.

Appendix A
Summary Tables

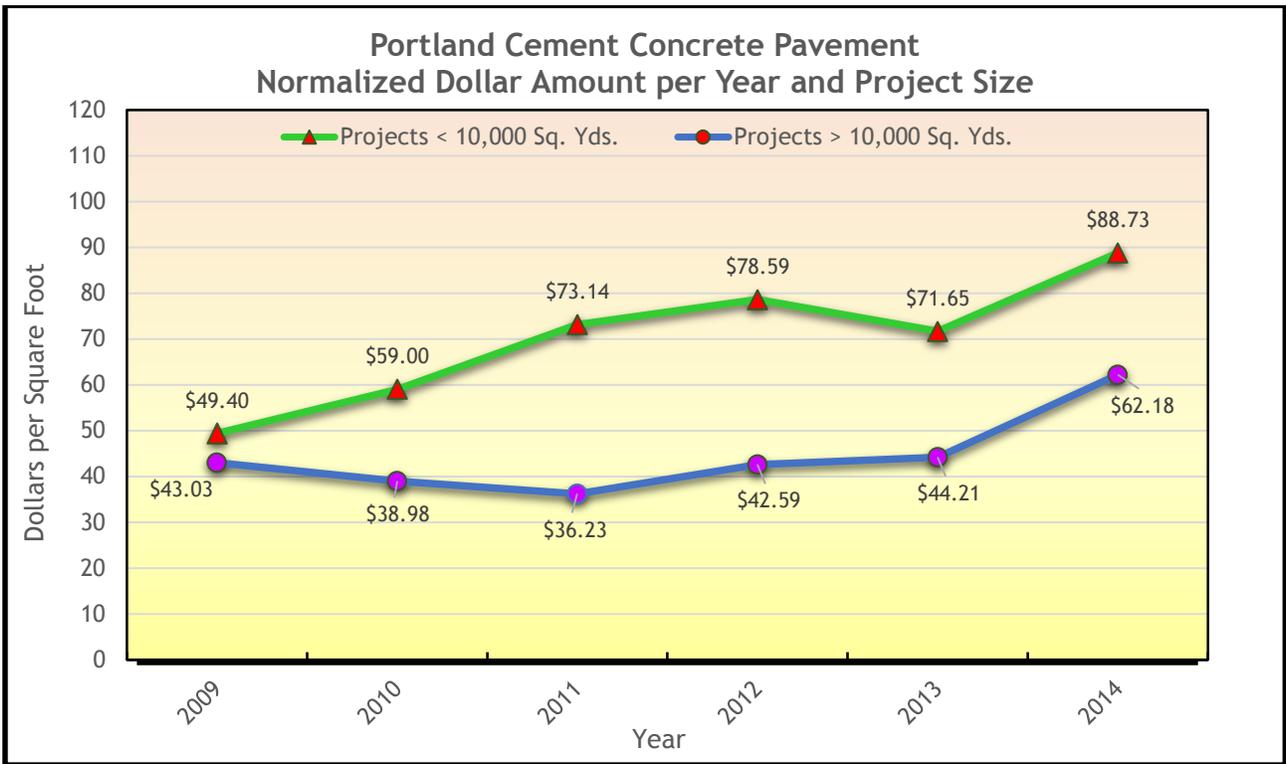


Figure 1 PCCP Normalized Dollar Amount per Year

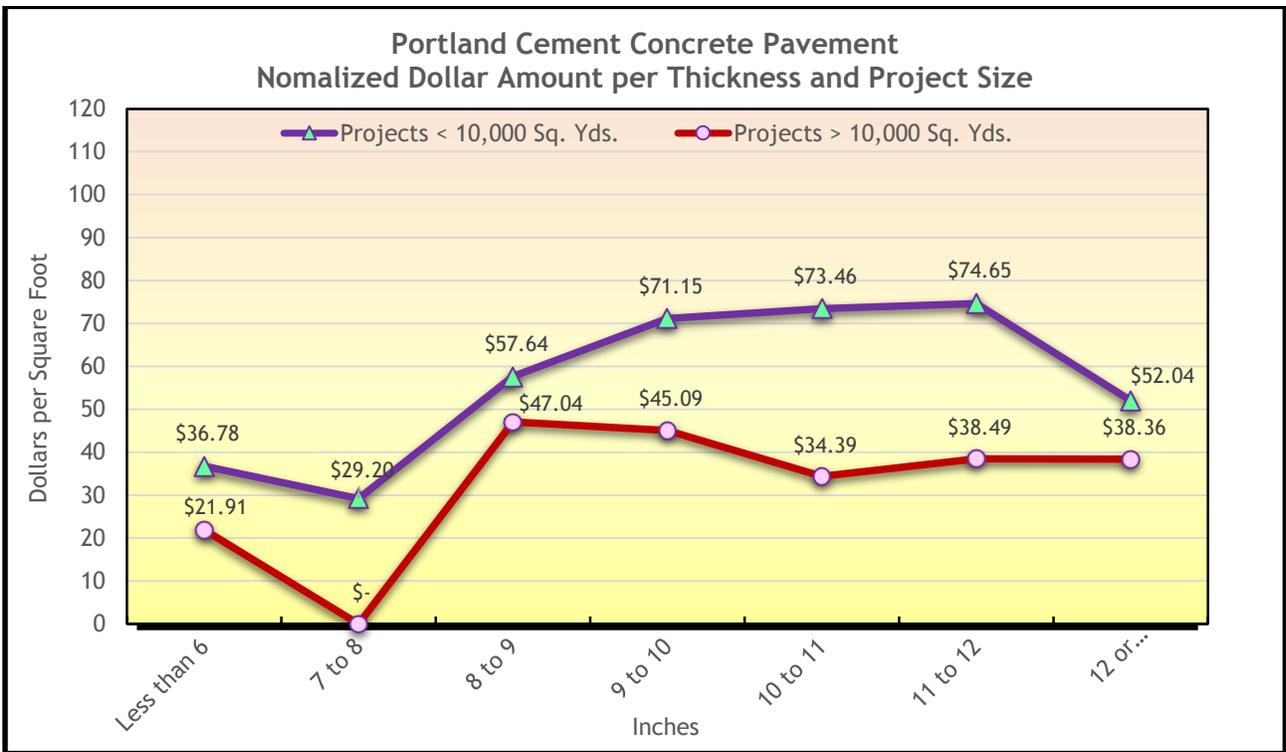


Figure 2 PCCP Normalized Dollar Amount per Thickness

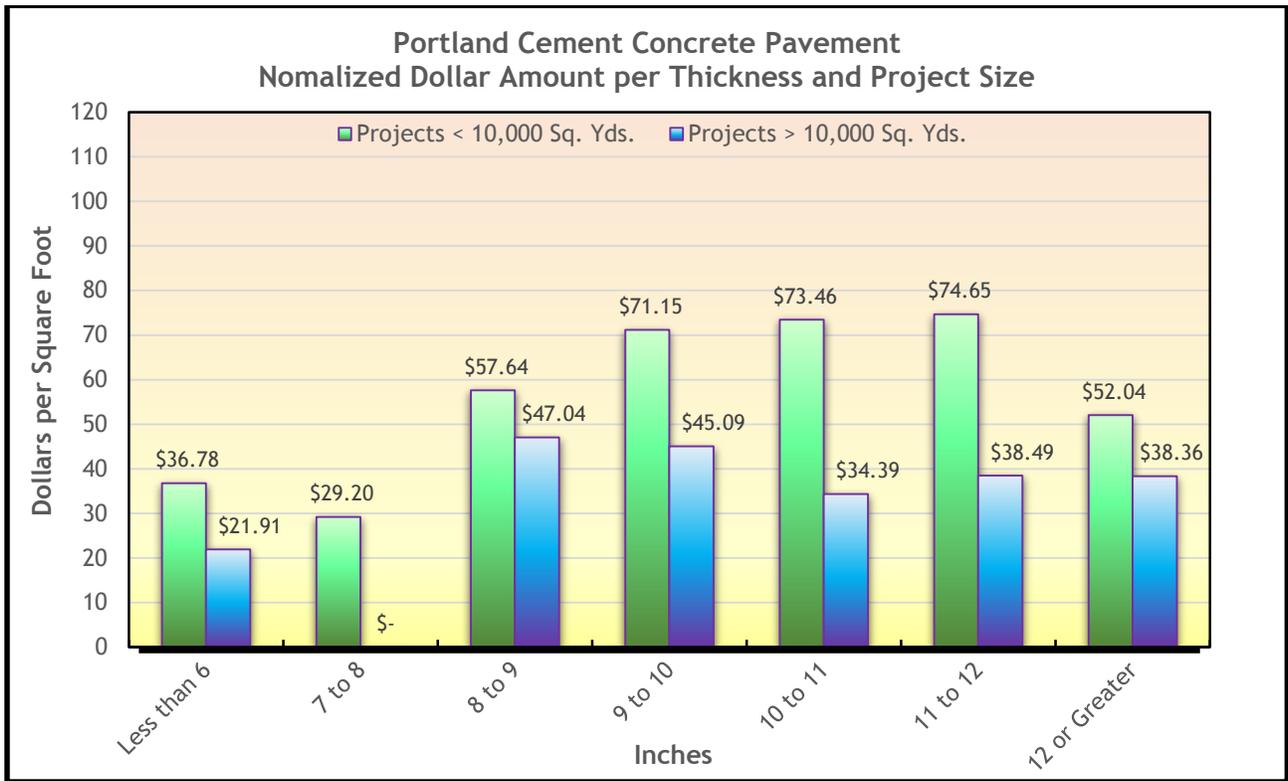


Figure 3 PCCP Normalized Dollar Amount per Thickness

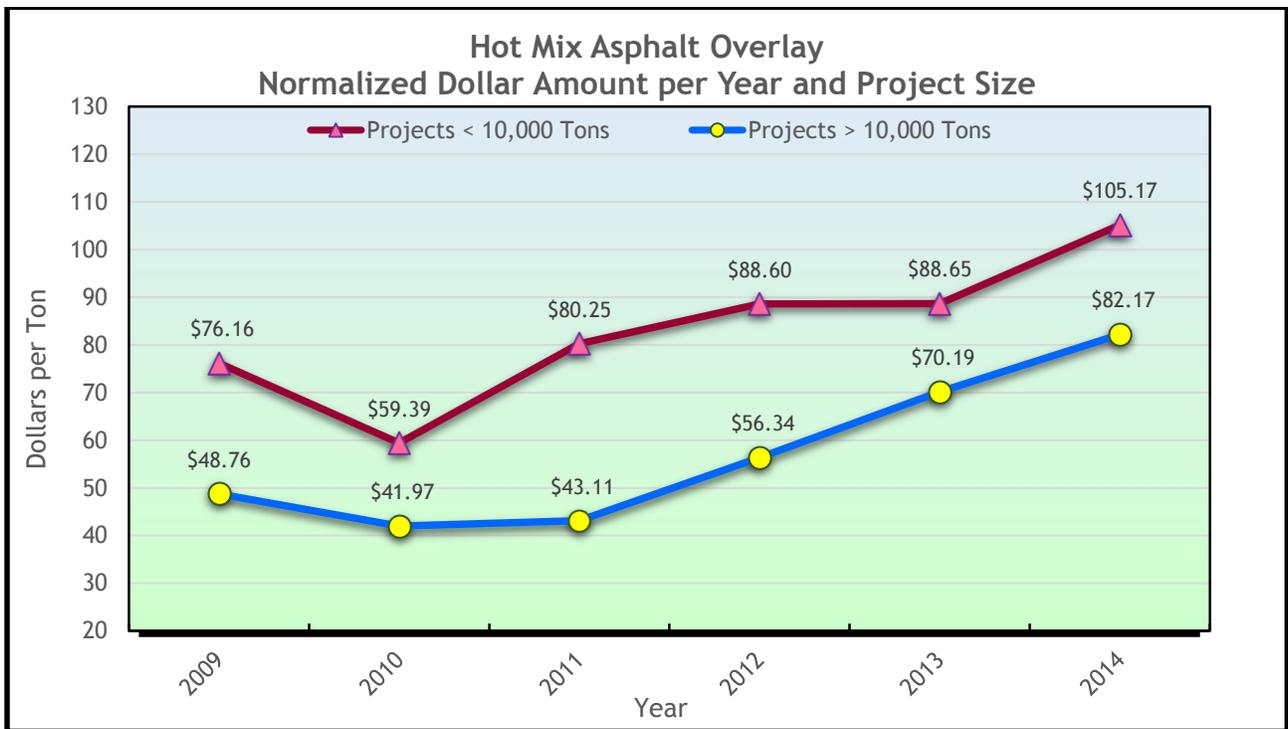


Figure 4 HMA Overlay Normalized Dollar Amount per Year

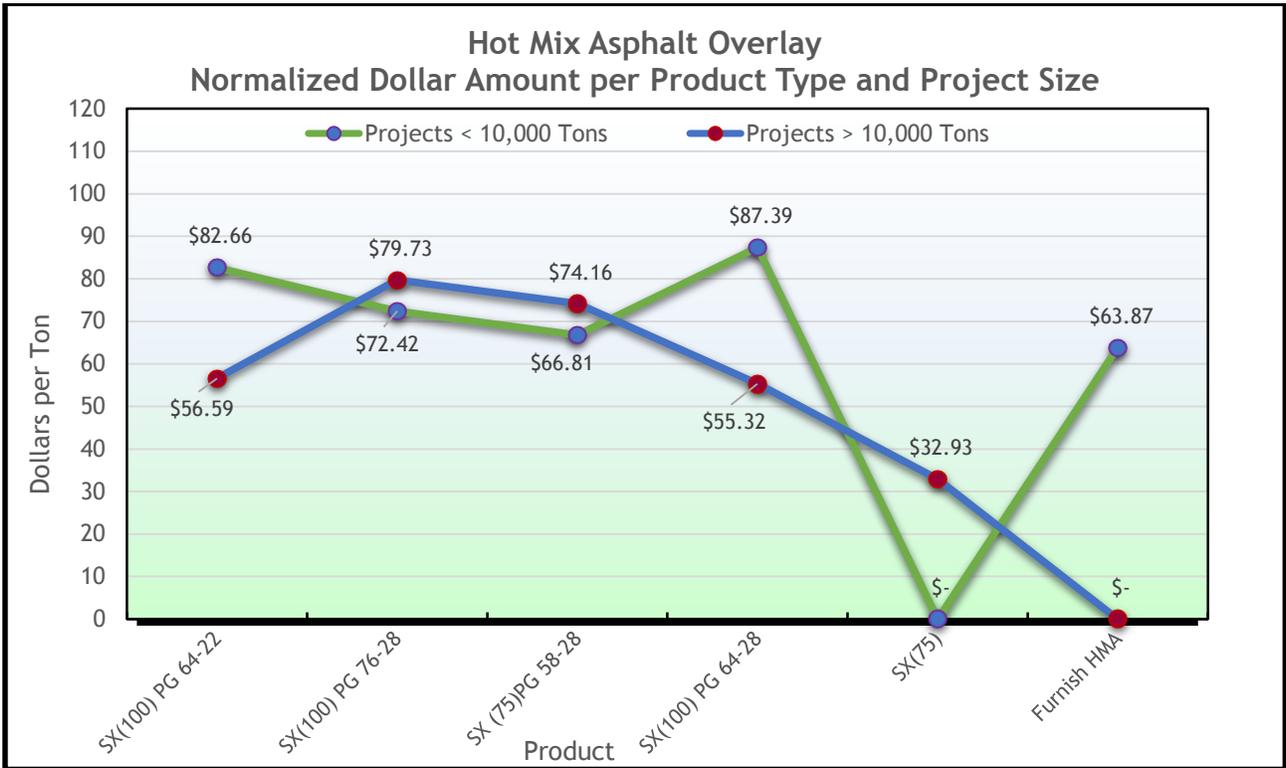


Figure 5 HMA Overlay Normalized Dollar Amount per Product Type

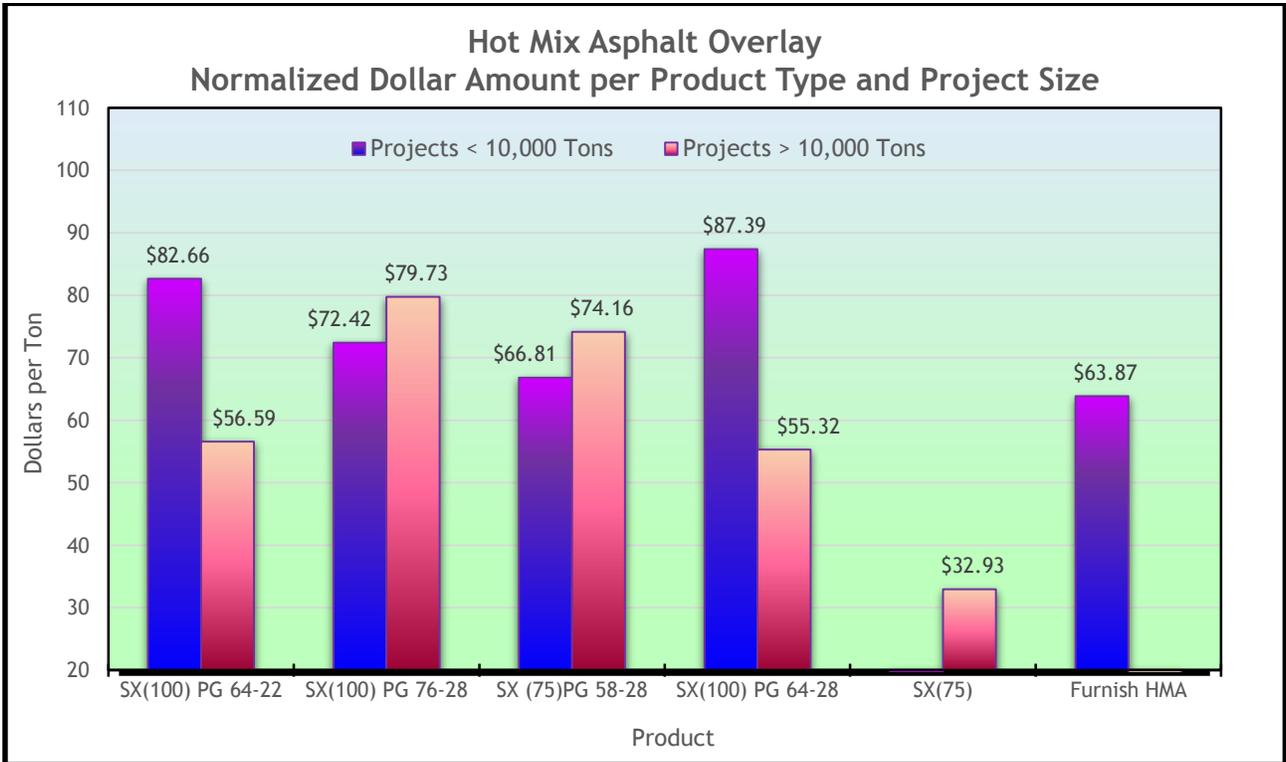


Figure 6 HMA Overlay Normalized Dollar Amount per Product Type

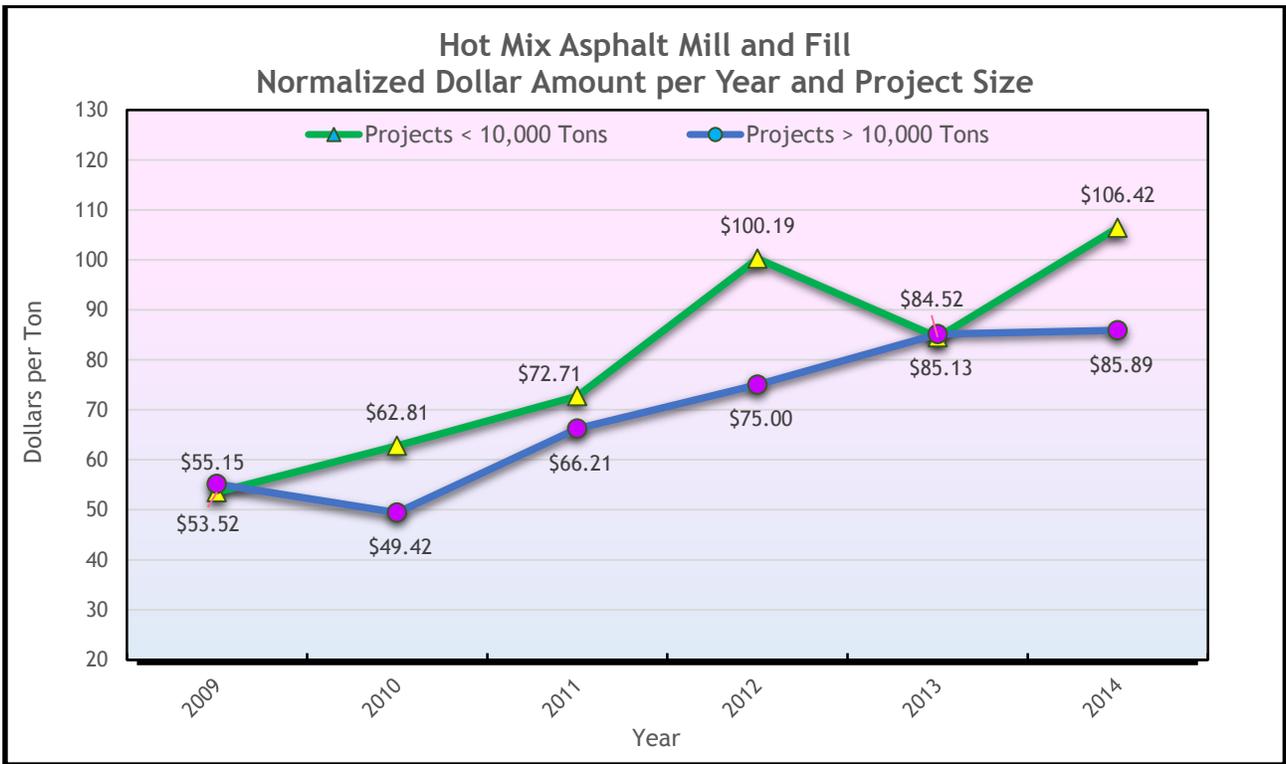


Figure 7 HMA Mill and Fill Normalized Dollar Amount per Year

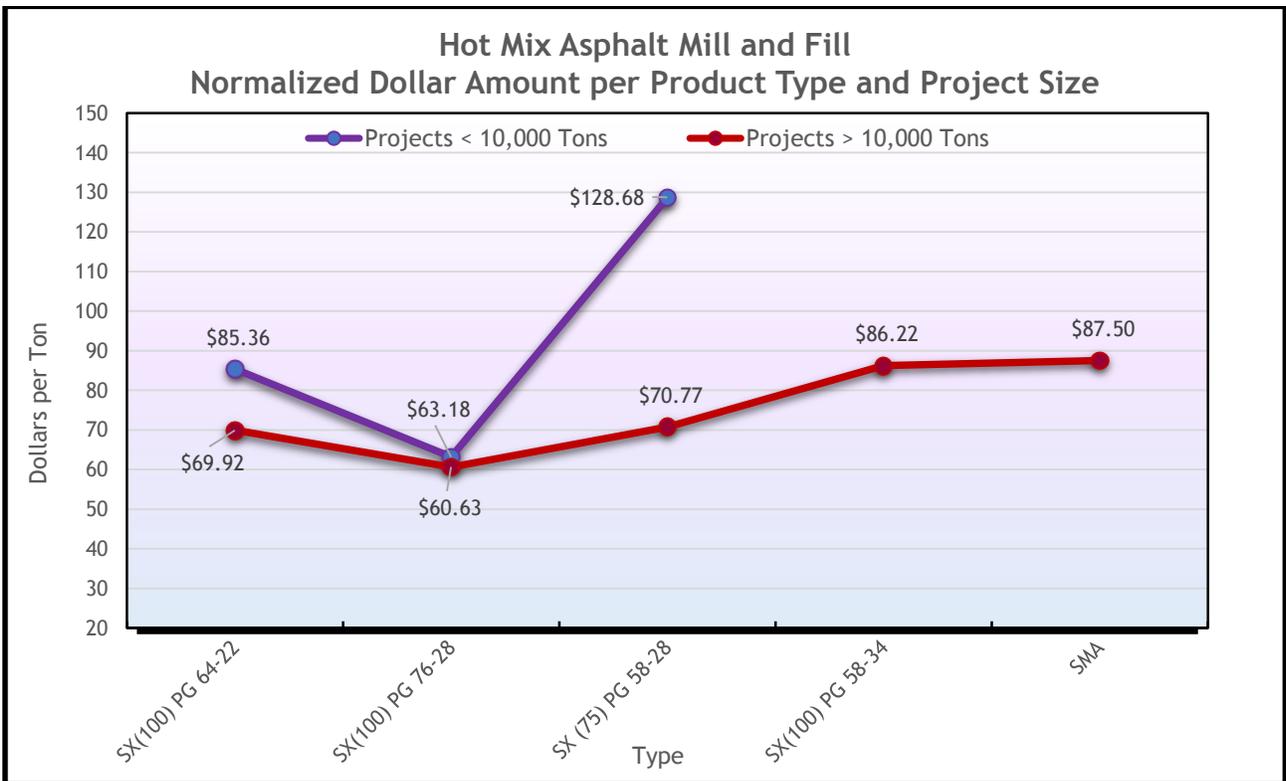


Figure 8 HMA Mill and Fill Normalized Dollar Amount per Product Type

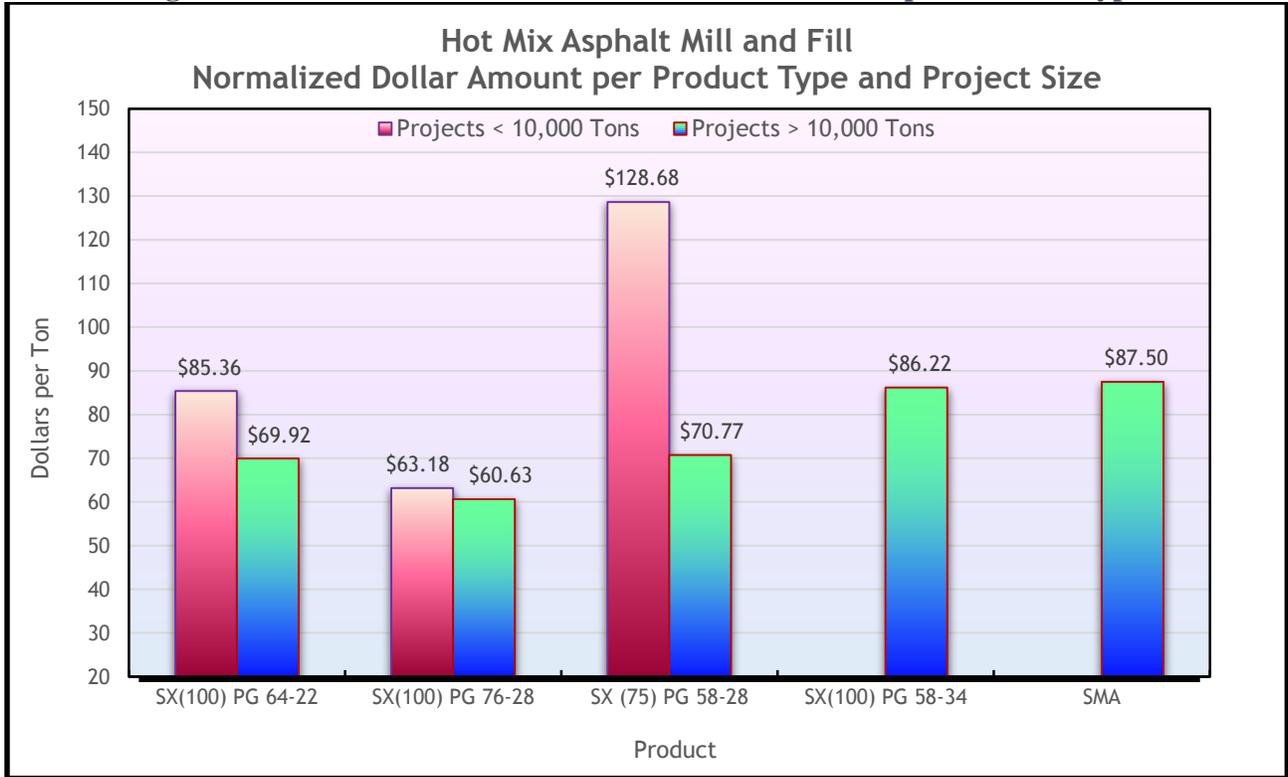


Figure 9 HMA Mill and Fill Normalized Dollar Amount per Product Type

Appendix B
Portland Concrete Cement Pavement

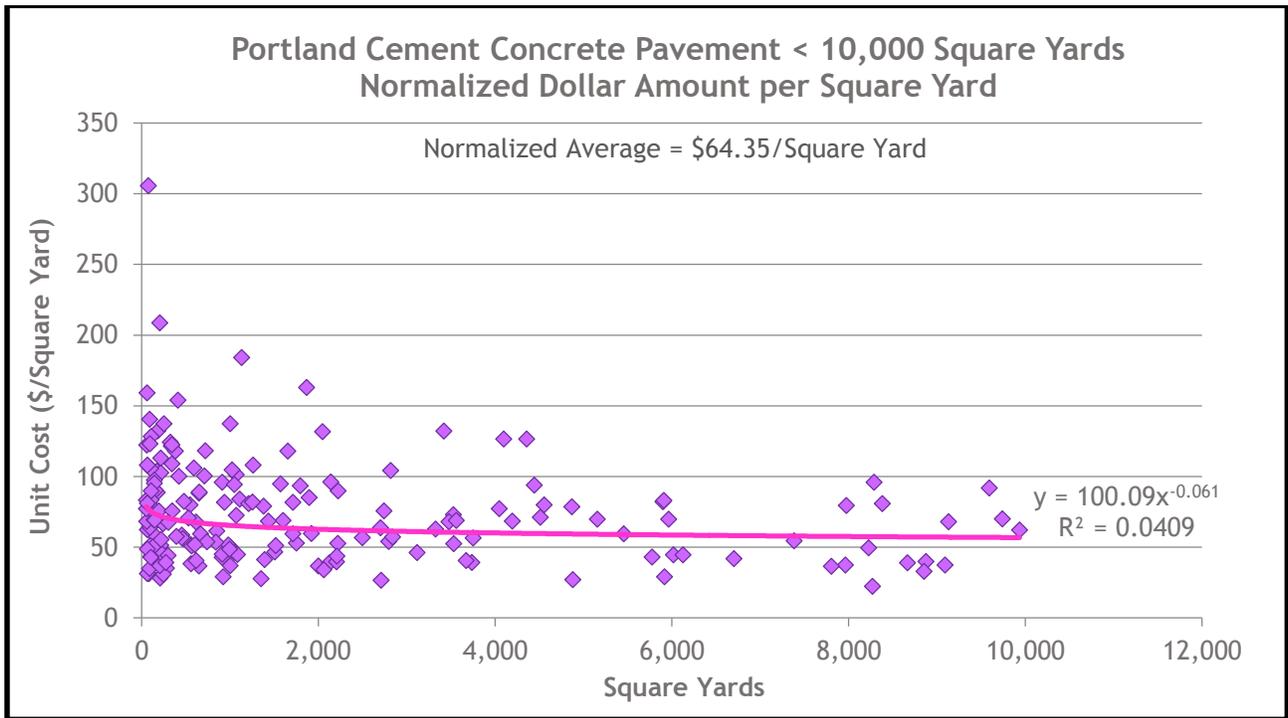


Figure 10 PCCP Normalized Dollar Amount per Total Square Yards for Projects Less Than 10,000 Square Yards

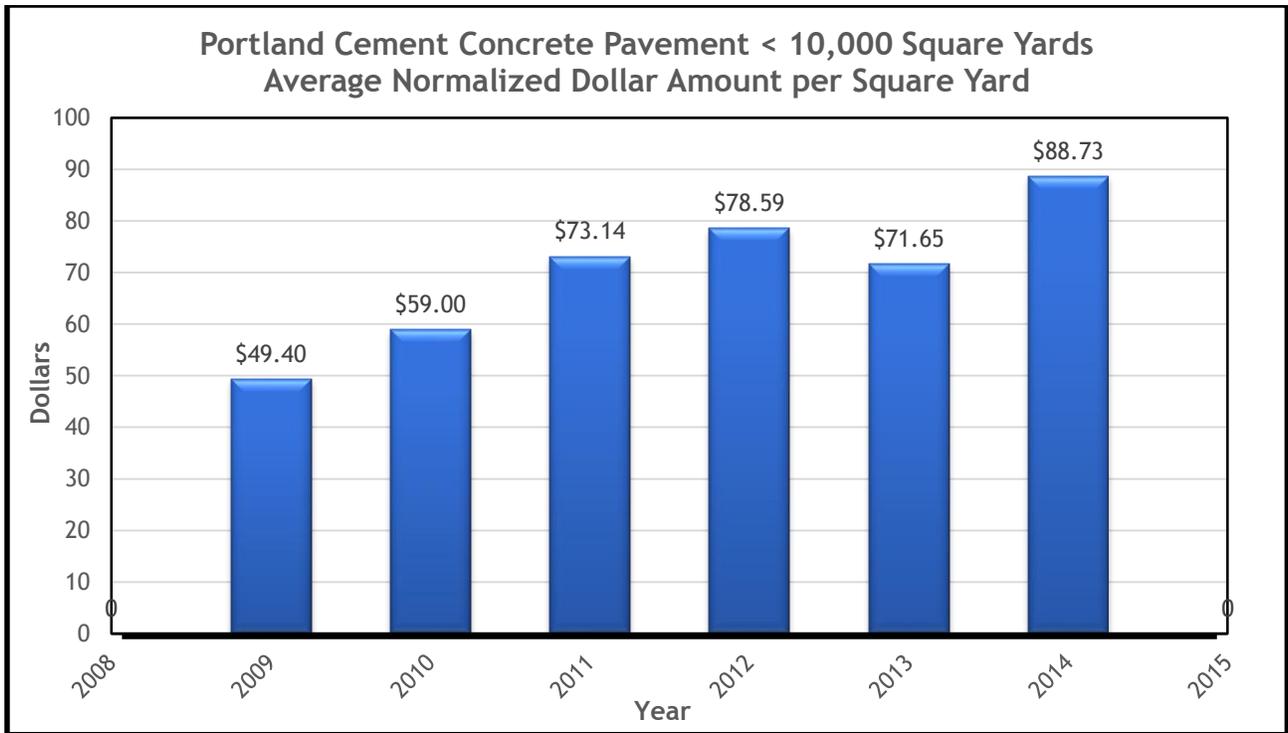


Figure 11 PCCP Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Square Yards

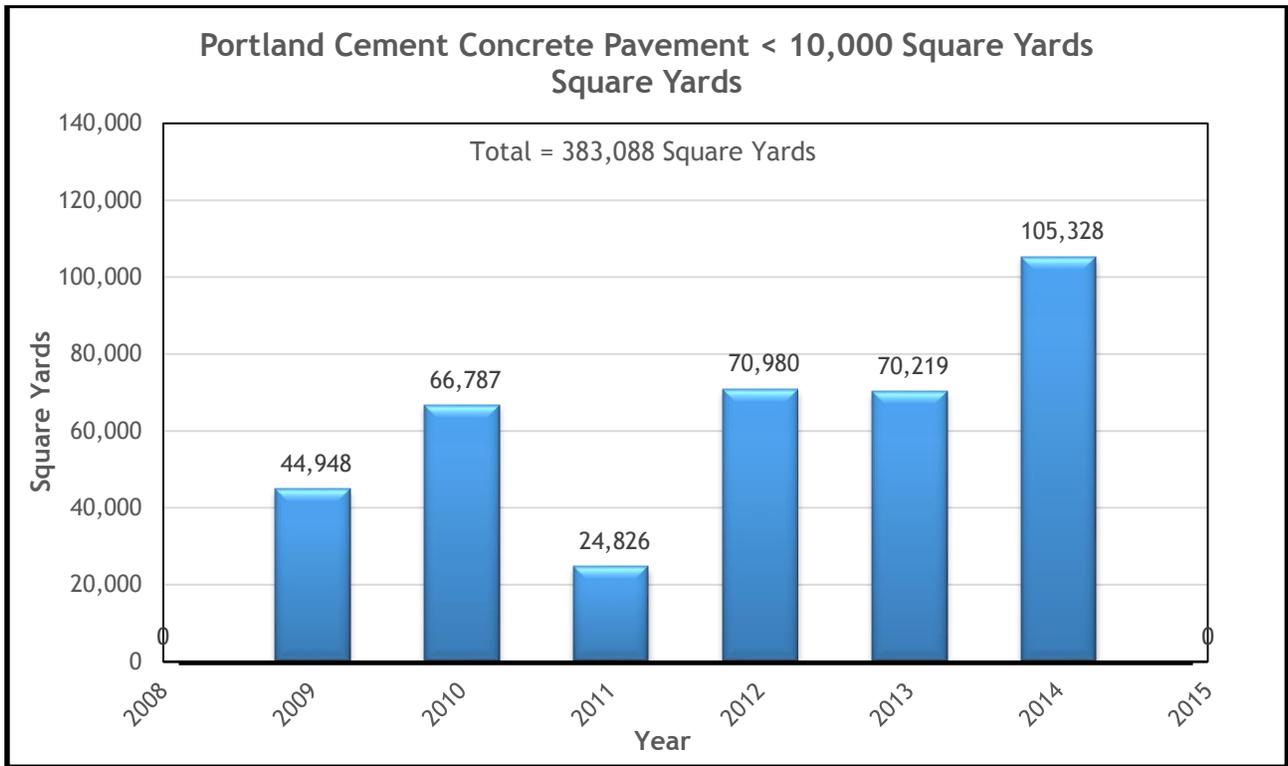


Figure 12 PCCP Total Square Yards per Year for Projects Less Than 10,000 Square Yards

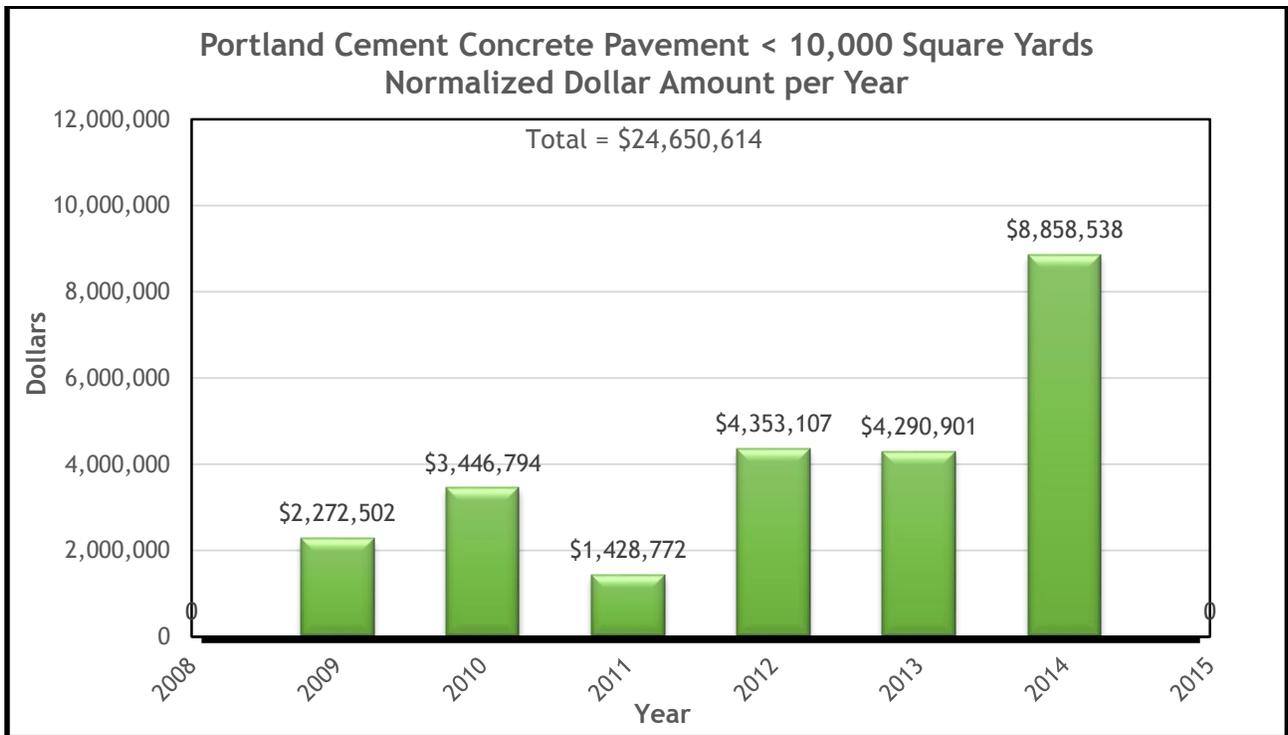


Figure 13 PCCP Total Normalized Dollar Amount per Year for Projects Less Than 10,000 Square Yards

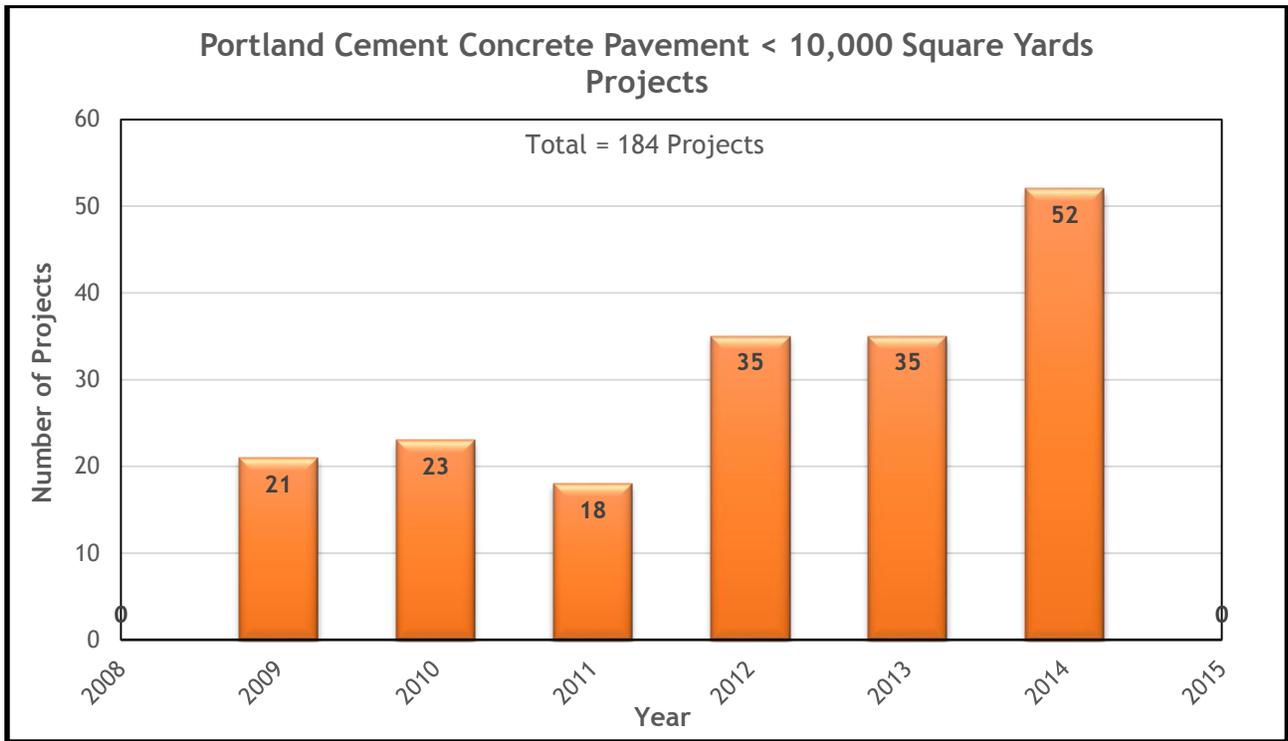


Figure 14 PCCP Projects Less Than 10,000 Square Yards per Year

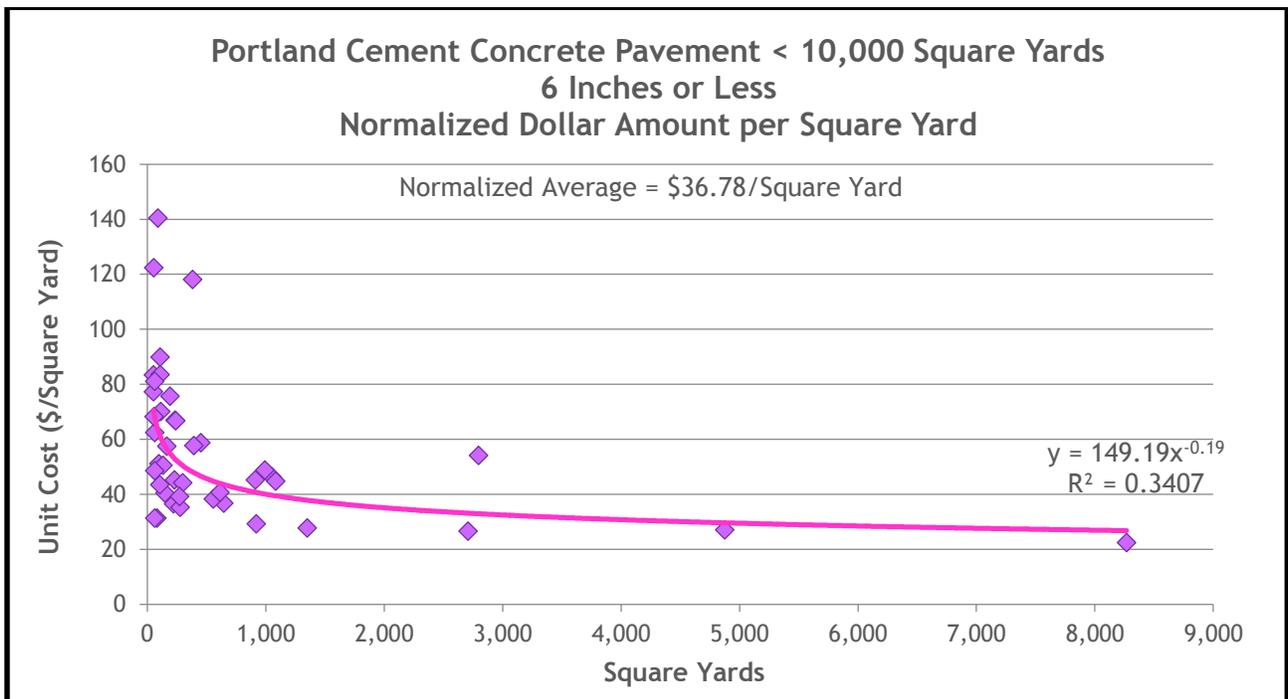


Figure 15 PCCP Normalized Dollar Amount for Projects of 6 Inches or Less in Thickness and Less Than 10,000 Square Yards

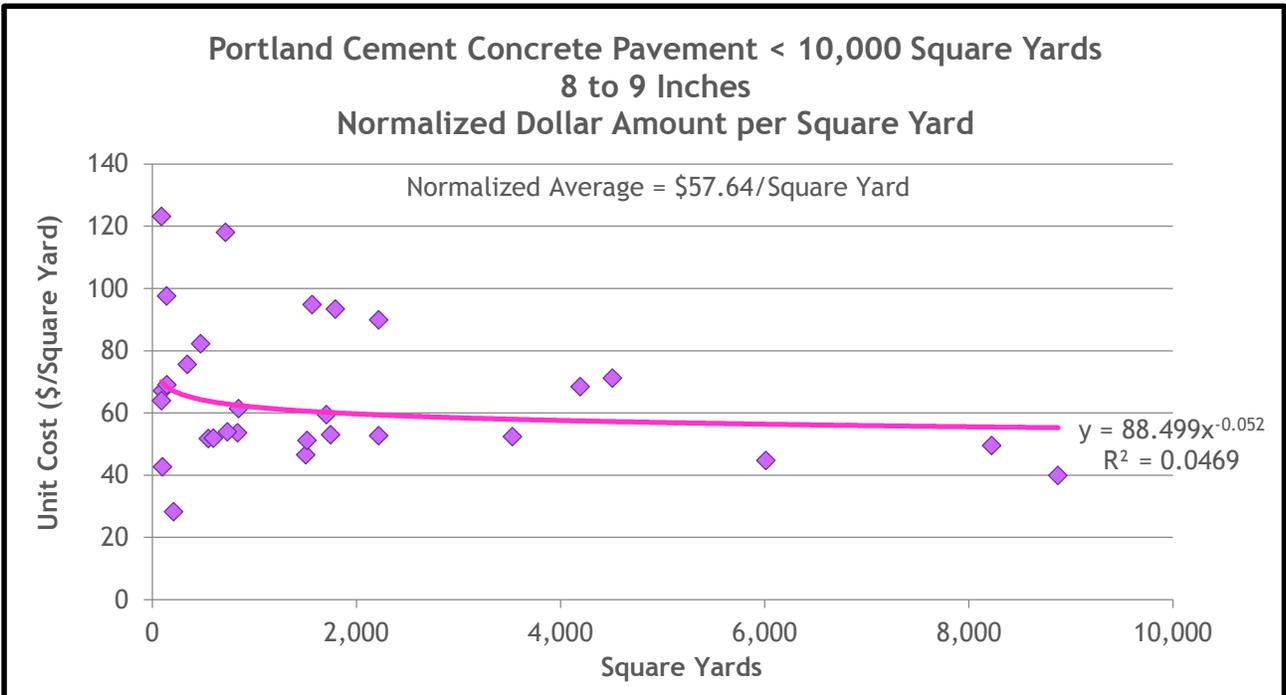


Figure 16 PCCP Normalized Dollar Amount for Projects of 8 to 9 Inches in Thickness and Less Than 10,000 Square Yards

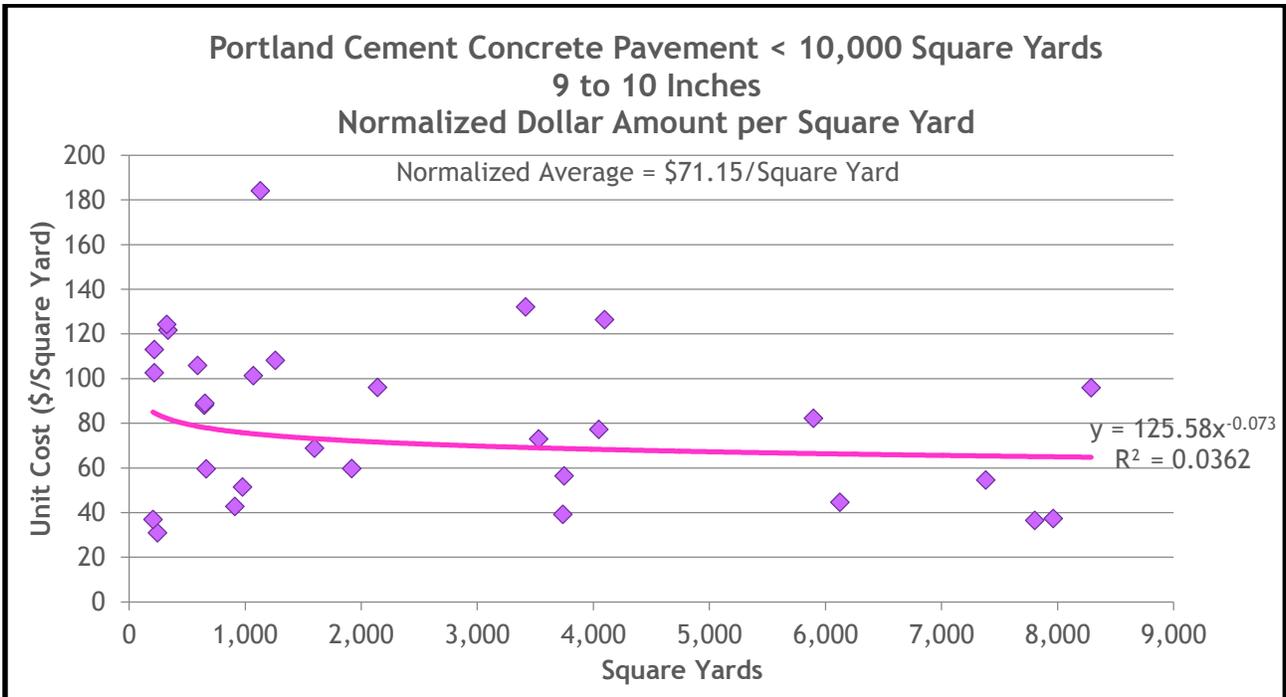


Figure 17 PCCP Normalized Dollar Amount for Projects of 9 to 10 Inches in Thickness and Less Than 10,000 Square Yards

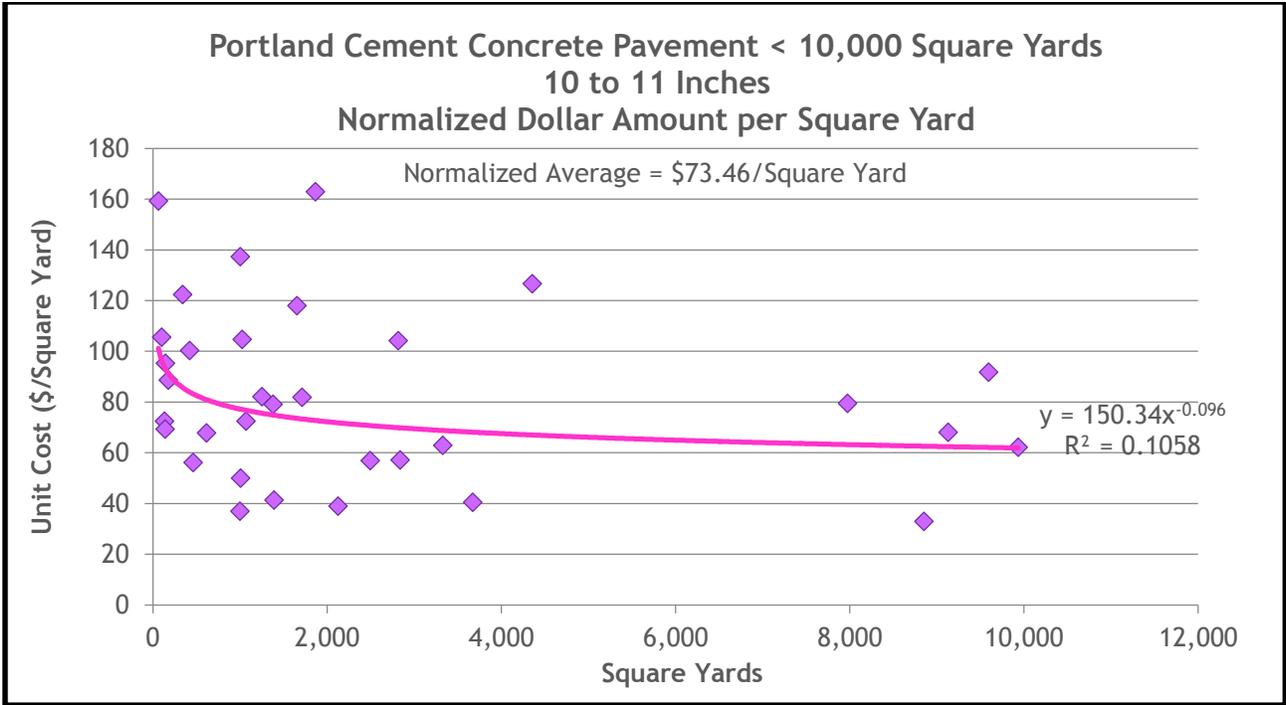


Figure 18 PCCP Normalized Dollar Amount for Projects of 10 to 11 Inches in Thickness and Less Than 10,000 Square Yards

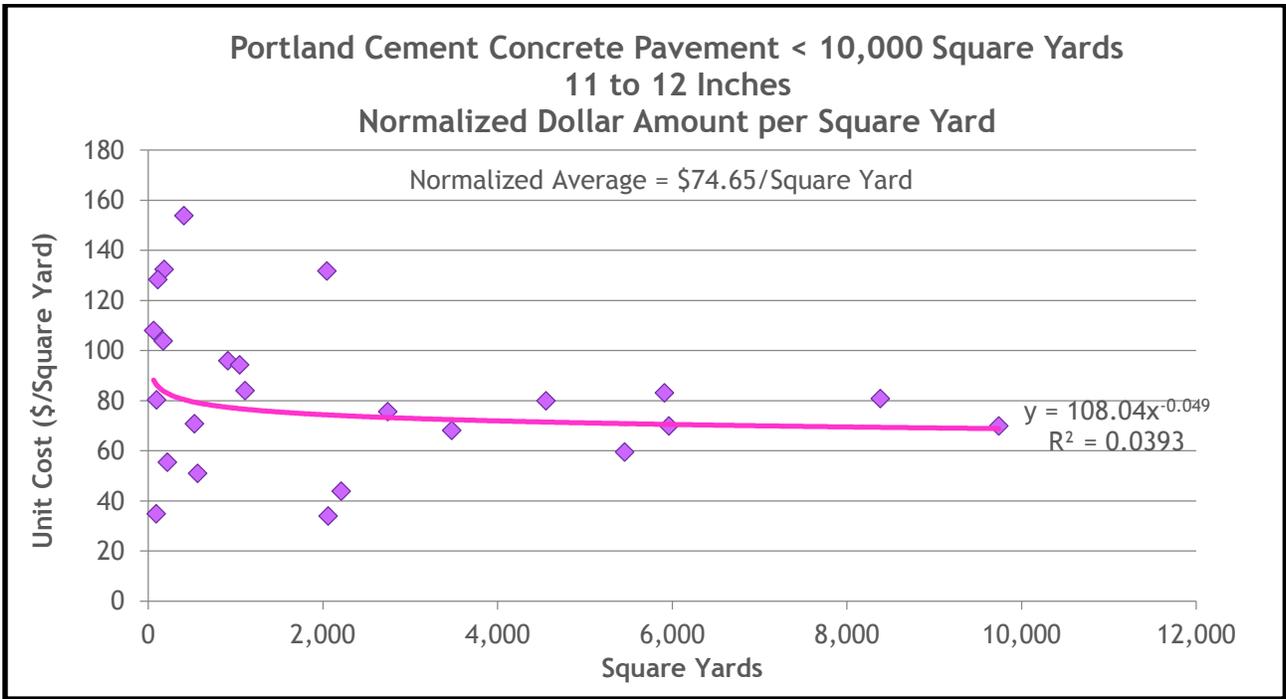


Figure 19 PCCP Normalized Dollar Amount for Projects of 11 to 12 Inches in Thickness and Less Than 10,000 Square Yards

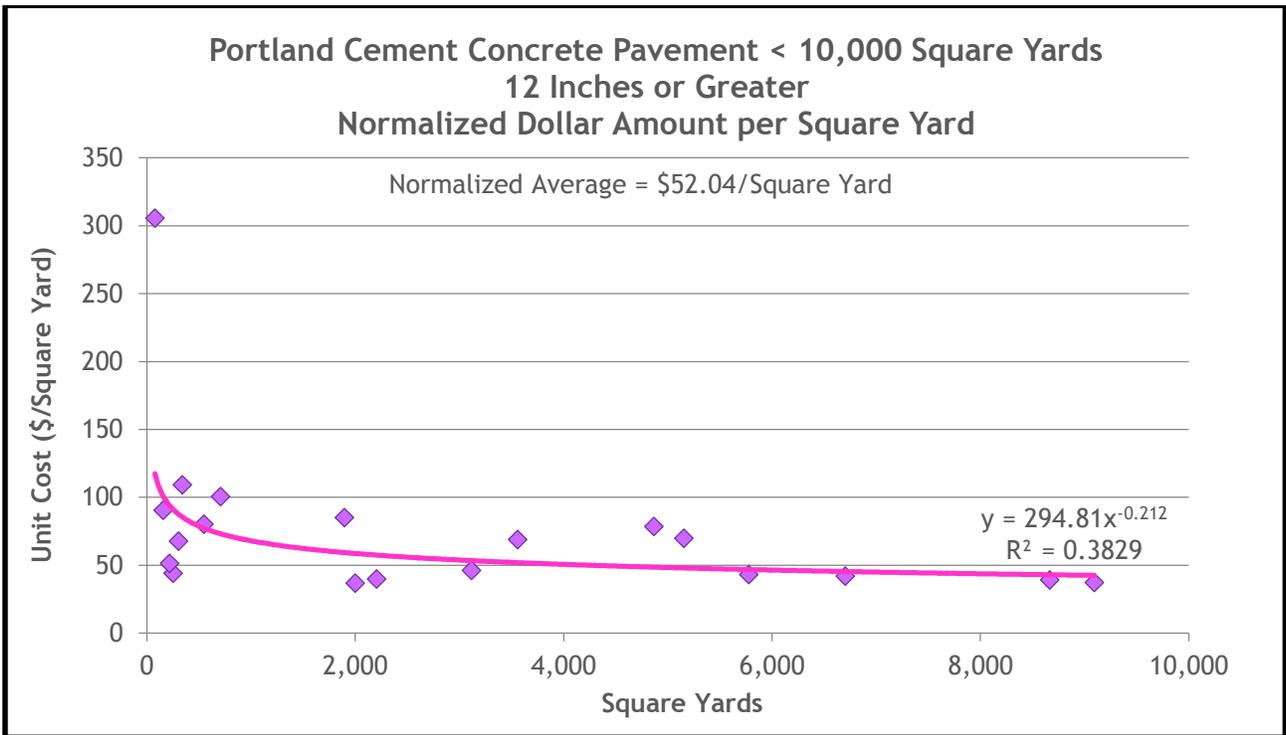


Figure 20 PCCP Normalized Dollar Amount for Projects of 12 Inches or Greater in Thickness and Less Than 10,000 Square Yards

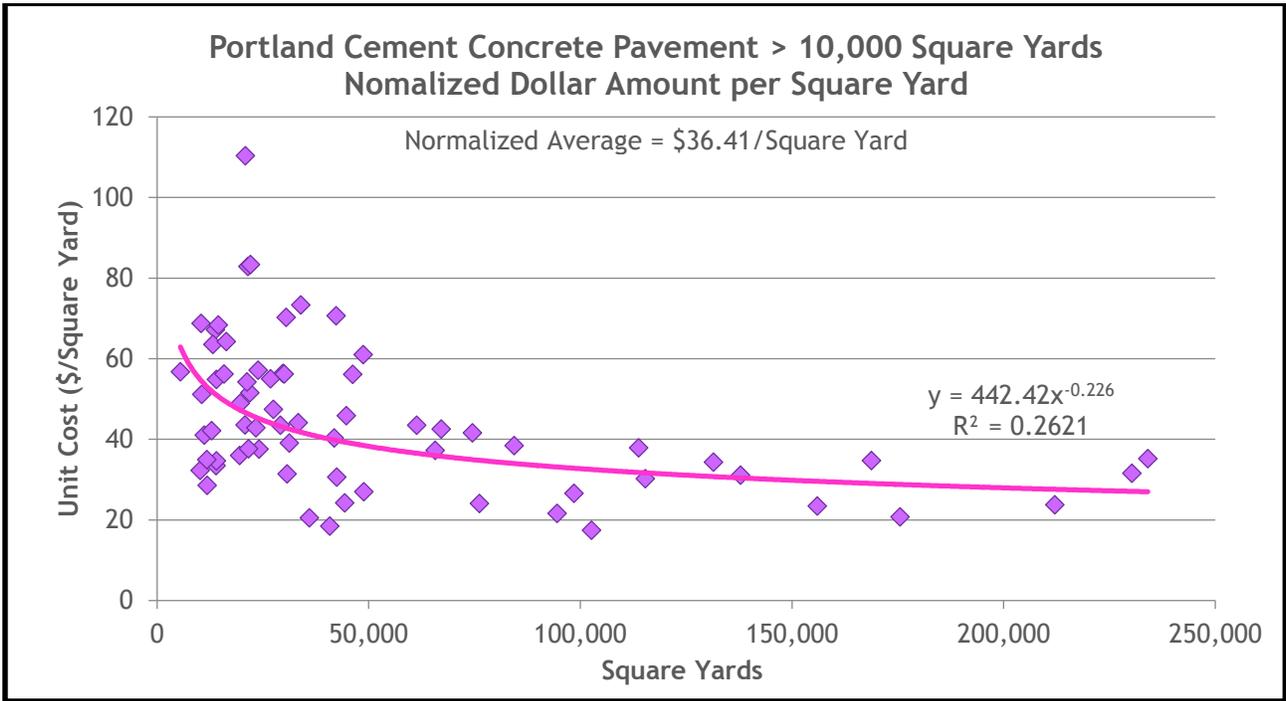


Figure 21 PCCP Normalized Dollar Amount per Total Square Yards for Projects Greater Than 10,000 Square Yards

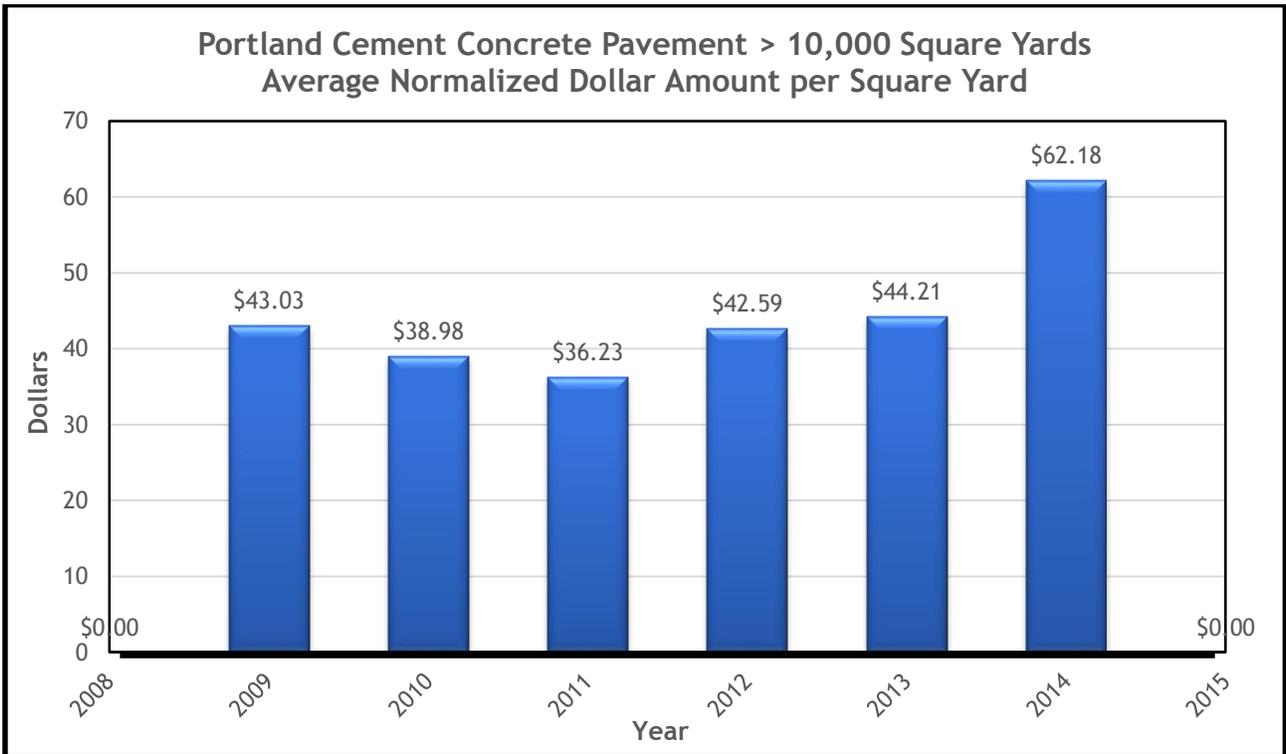


Figure 22 PCCP Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Square Yards

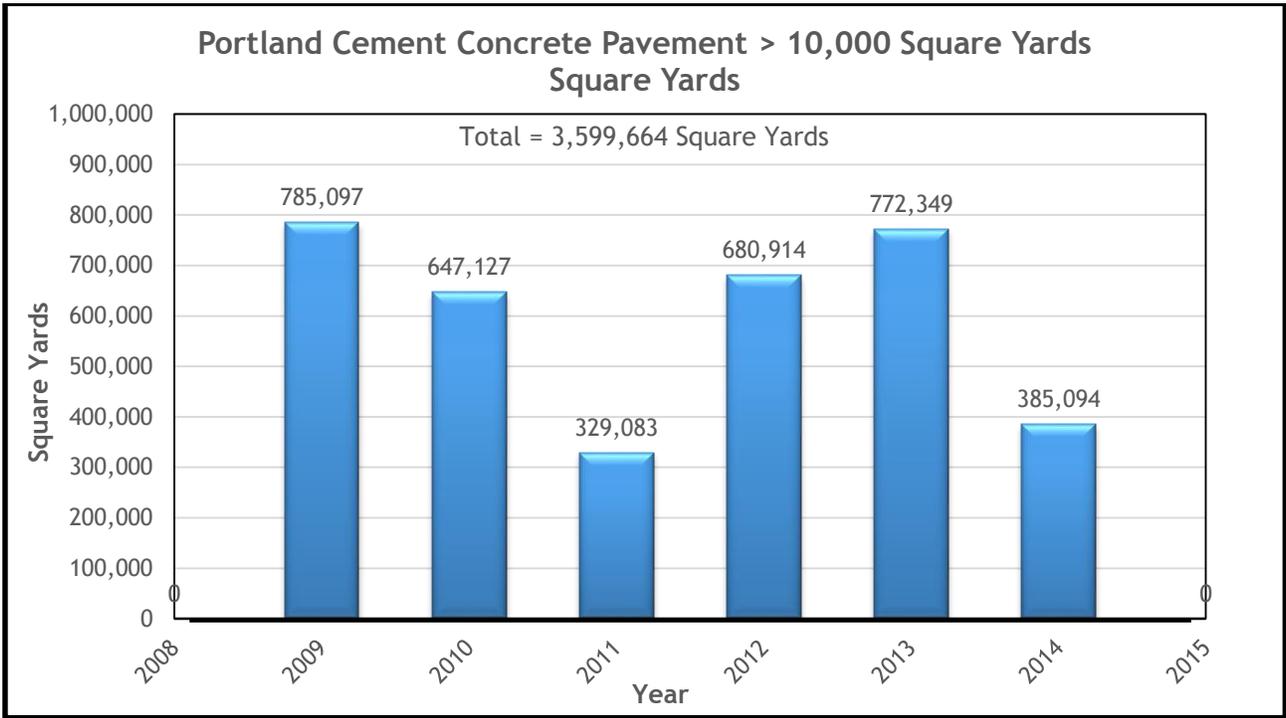


Figure 23 PCCP Total Square Yards per Year for Projects Greater Than 10,000 Square Yards

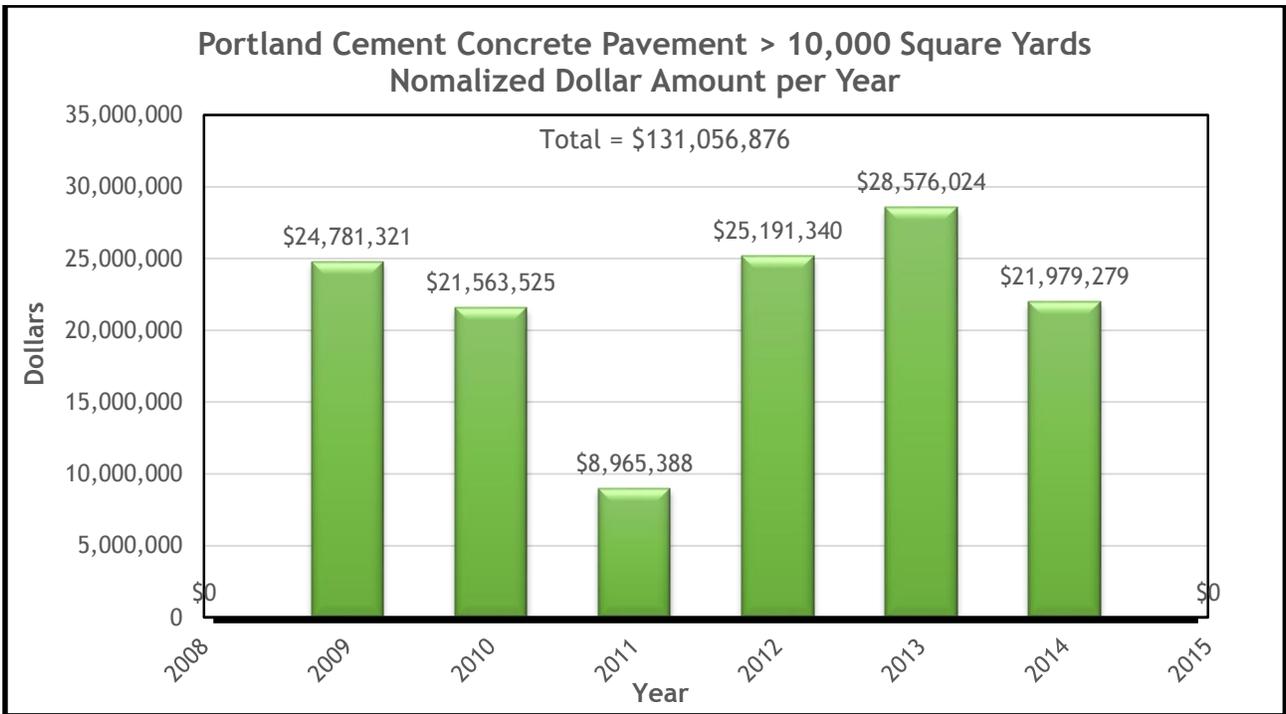


Figure 24 PCCP Total Normalized Dollar Amount per Year for Projects Greater Than 10,000 Square Yards

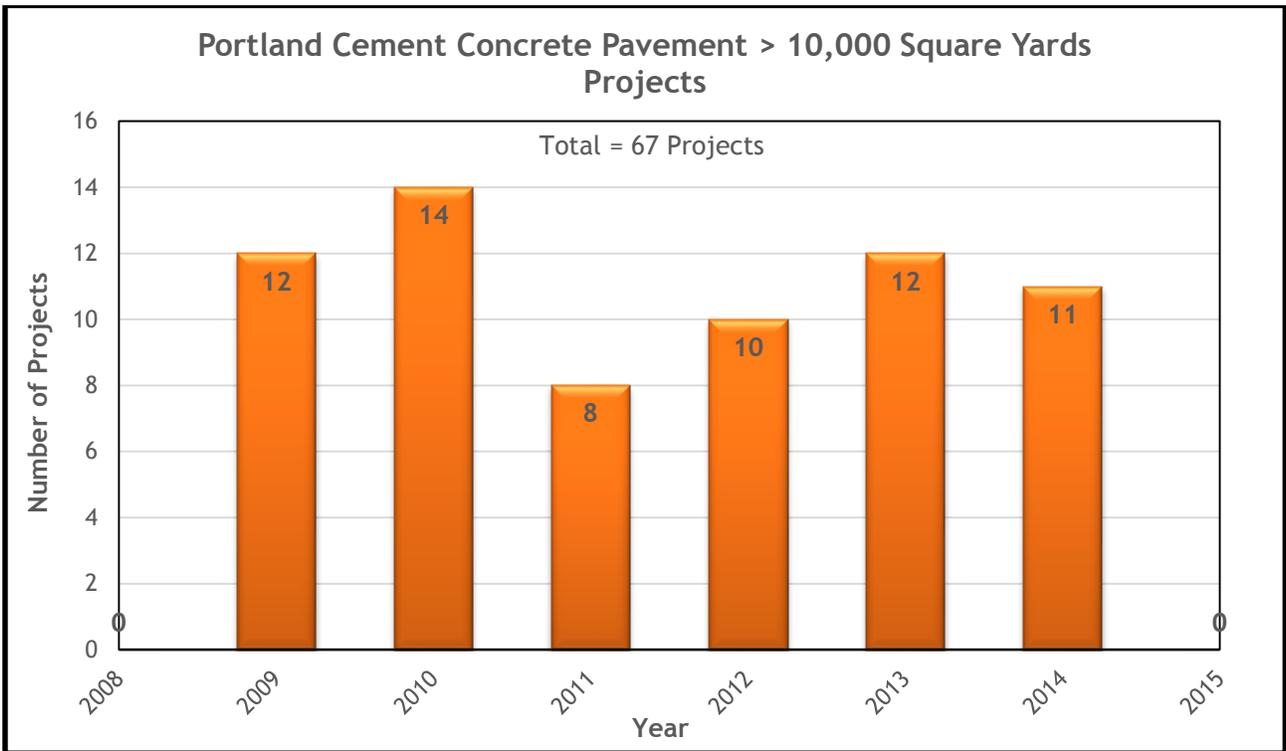


Figure 25 PCCP Projects Greater Than 10,000 Square Yards per Year

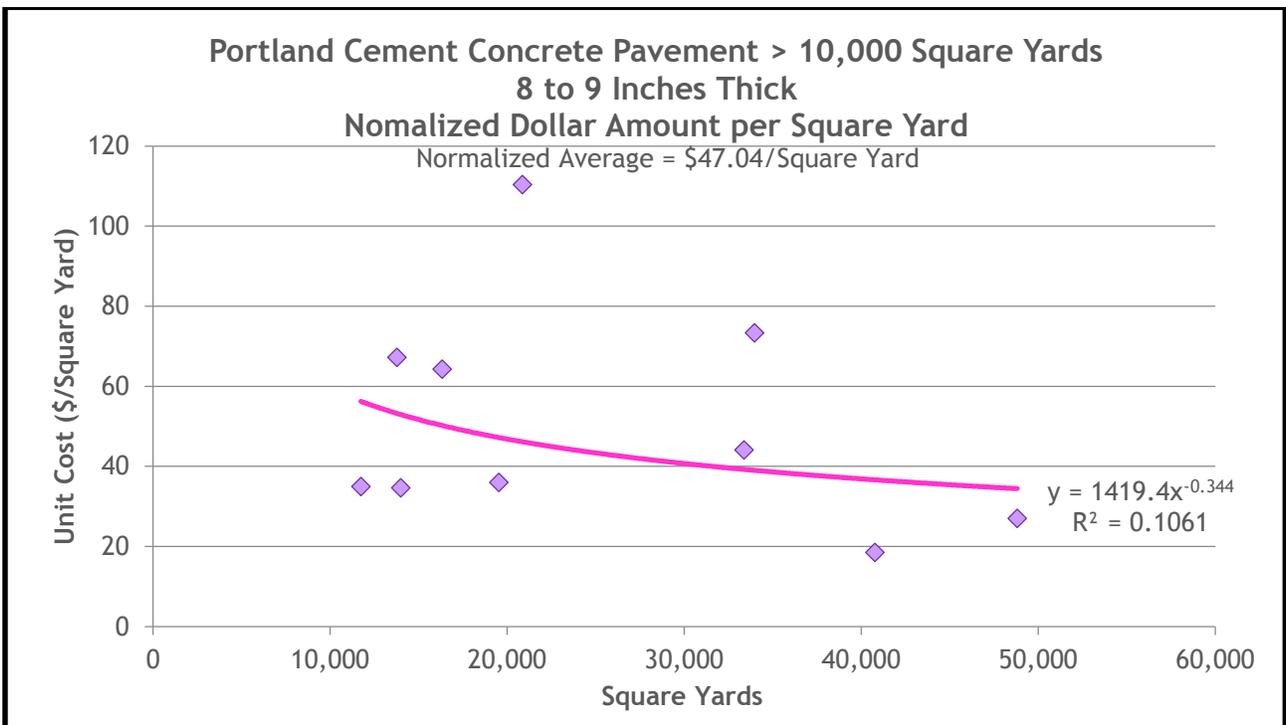


Figure 26 PCCP Normalized Dollar Amount for Projects of 8 to 9 Inches in Thickness and Greater Than 10,000 Square Yards

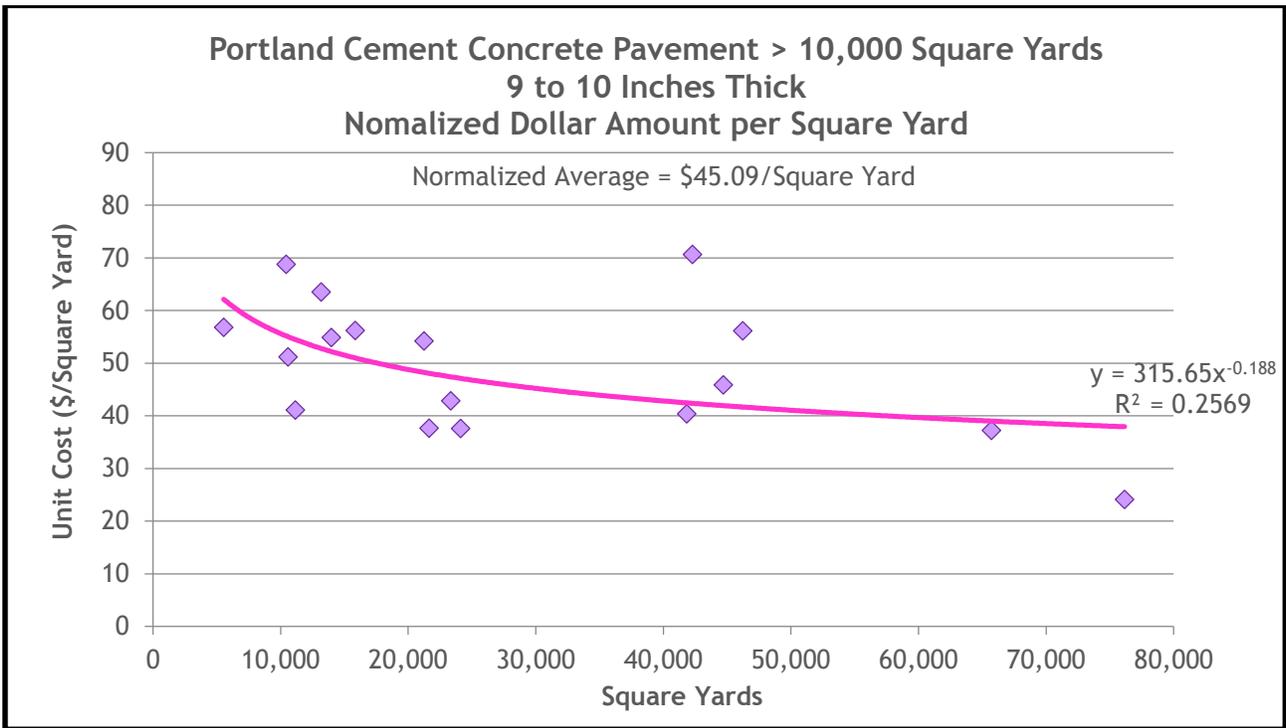


Figure 27 PCCP Normalized Dollar Amount for Projects of 9 to 10 Inches in Thickness and Greater Than 10,000 Square Yards

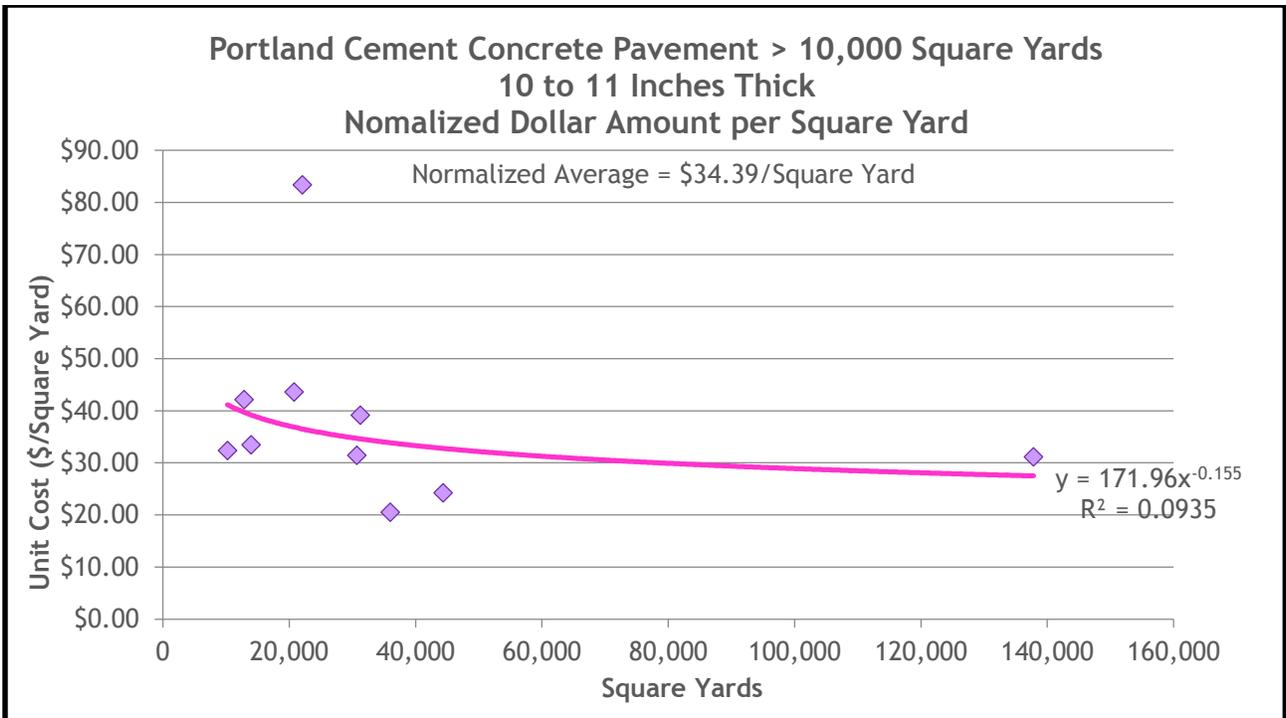


Figure 28 PCCP Normalized Dollar Amount for Projects of 10 to 11 Inches in Thickness and Greater Than 10,000 Square Yards

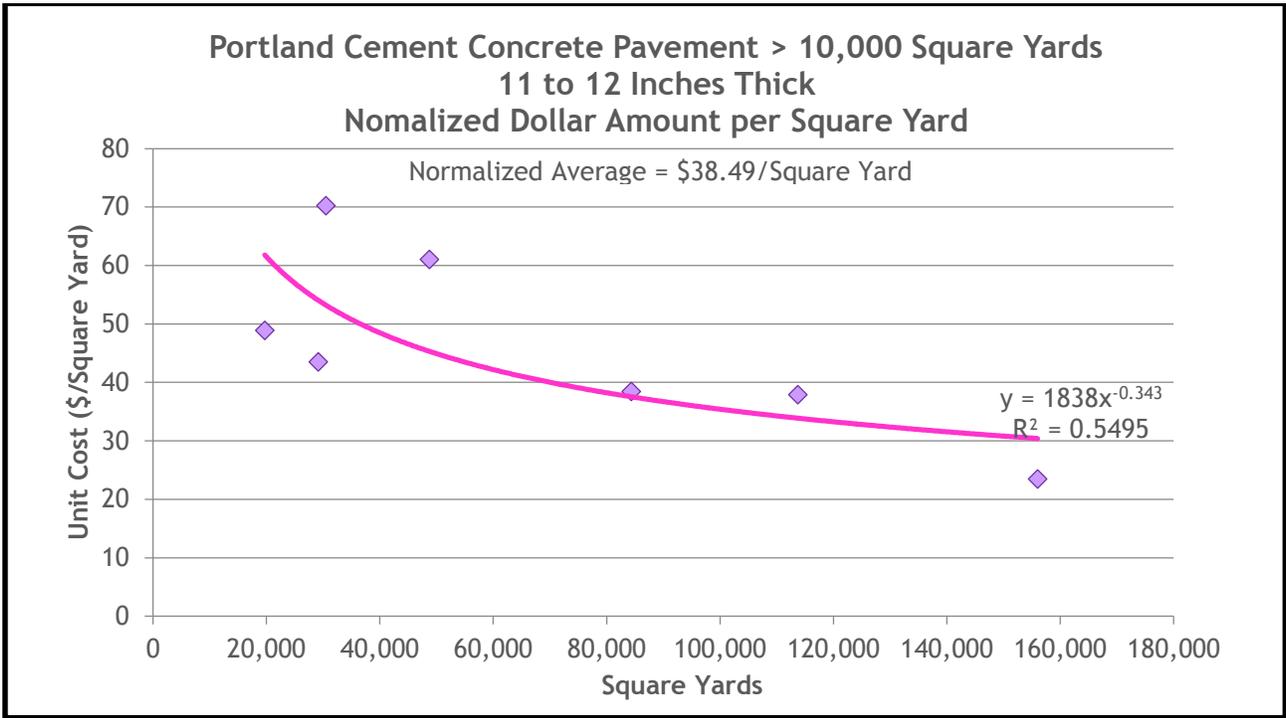


Figure 29 PCCP Normalized Dollar Amount for Projects of 11 to 12 Inches in Thickness and Greater Than 10,000 Square Yards

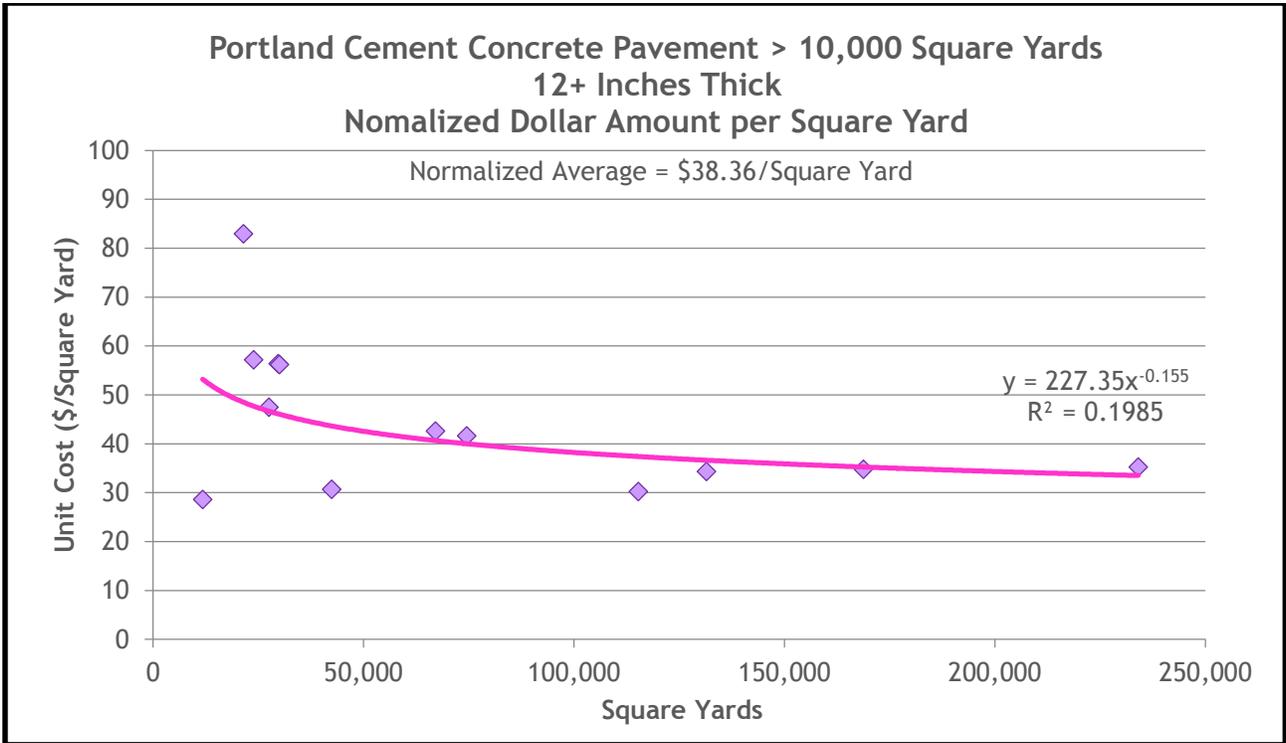


Figure 30 PCCP Normalized Dollar Amount for Projects of 12 Inches or Greater in Thickness and Greater Than 10,000 Square Yards

Appendix C
HMA Overlay

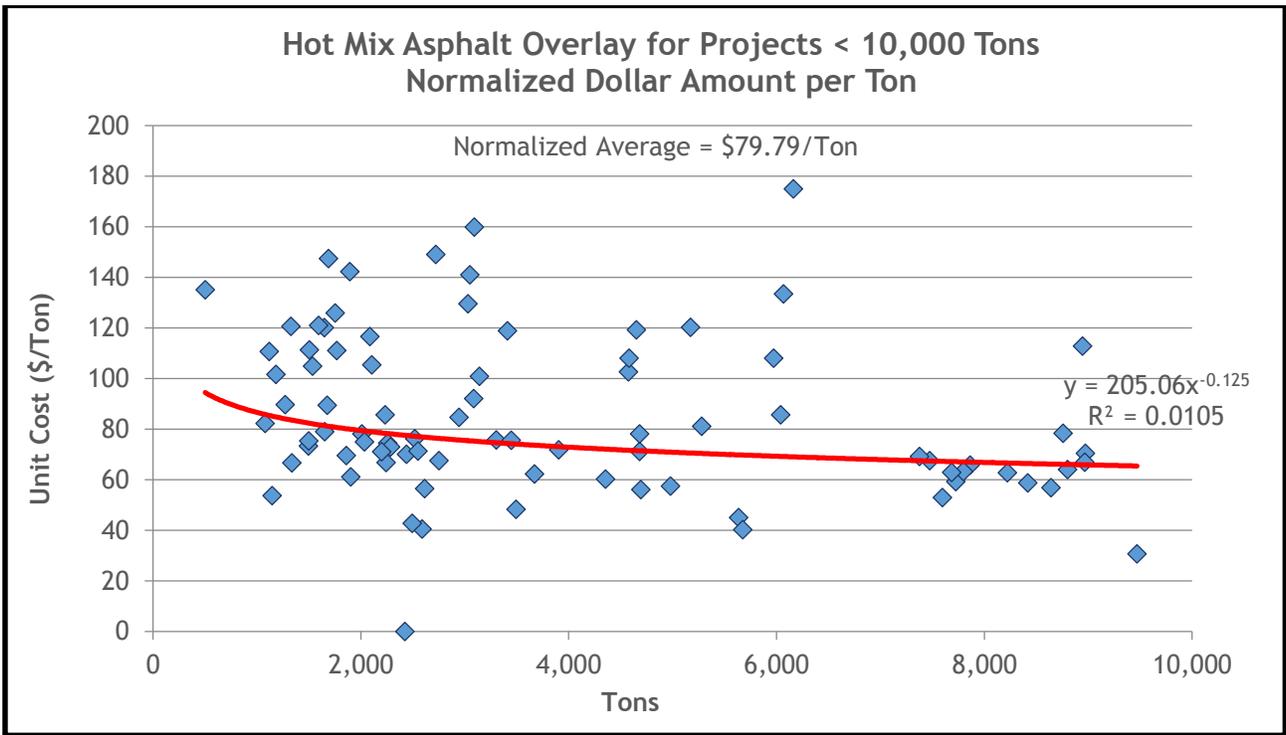


Figure 31 HMA Overlay Normalized Dollar Amount for Projects Less Than 10,000 Tons

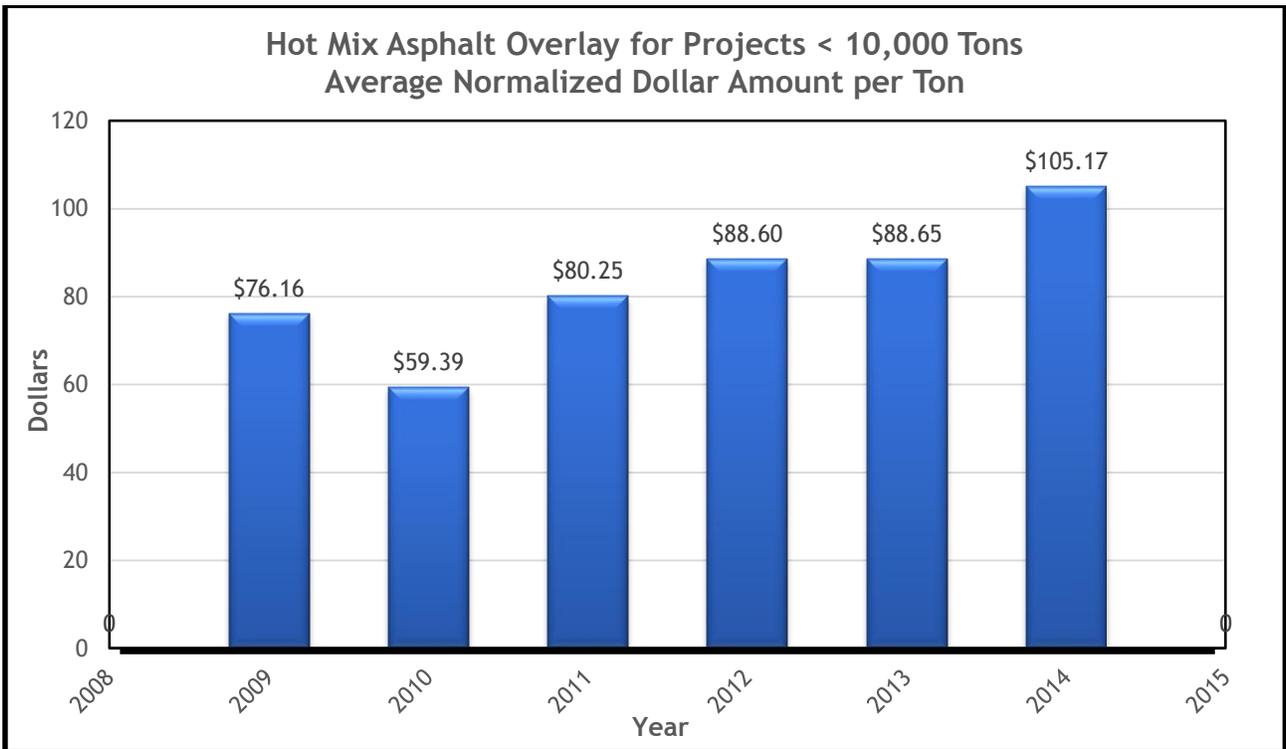


Figure 32 HMA Overlay Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons

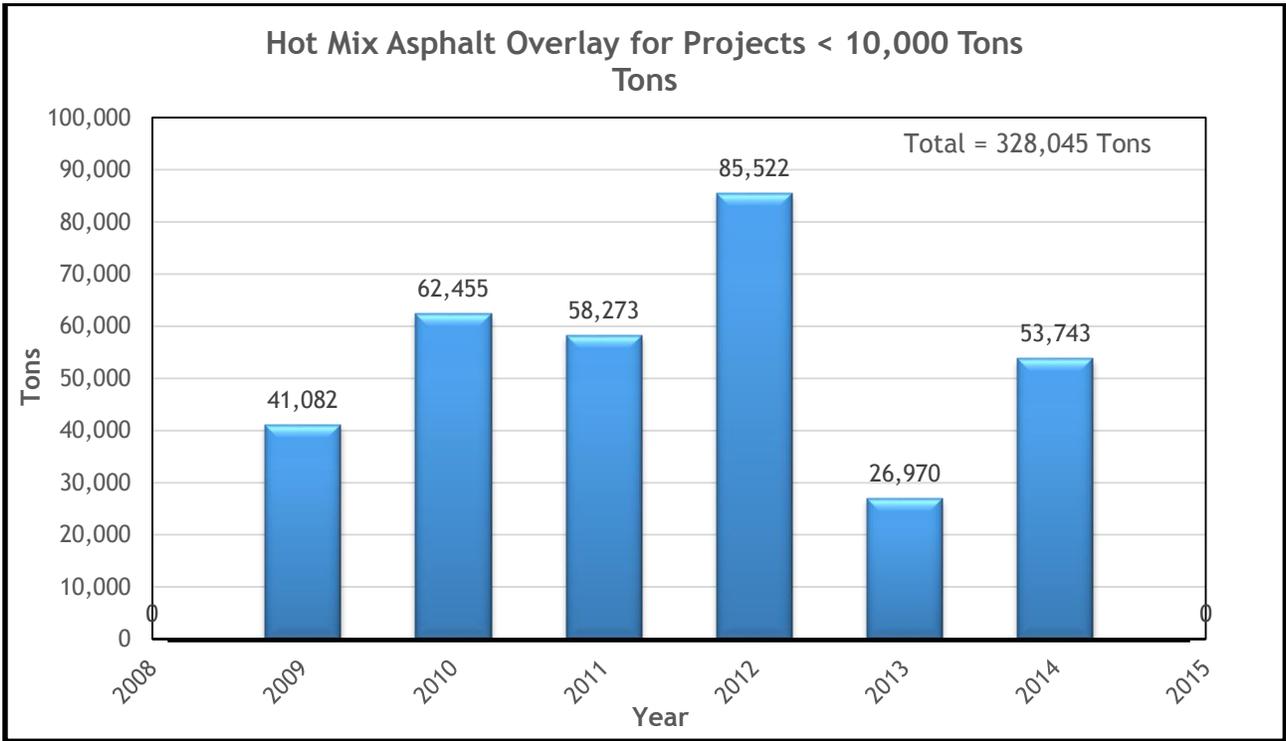


Figure 33 HMA Overlay Total Tons per Year for Projects Less Than 10,000 Tons

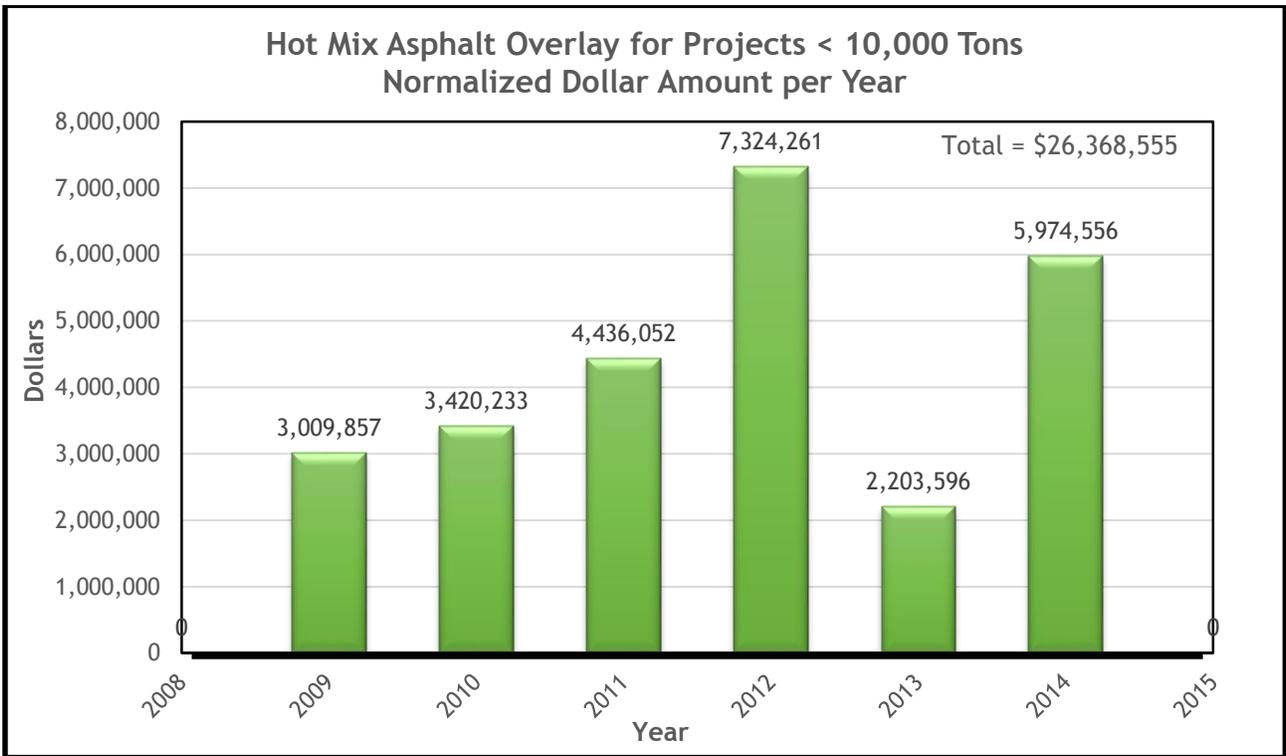


Figure 34 HMA Overlay Total Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons

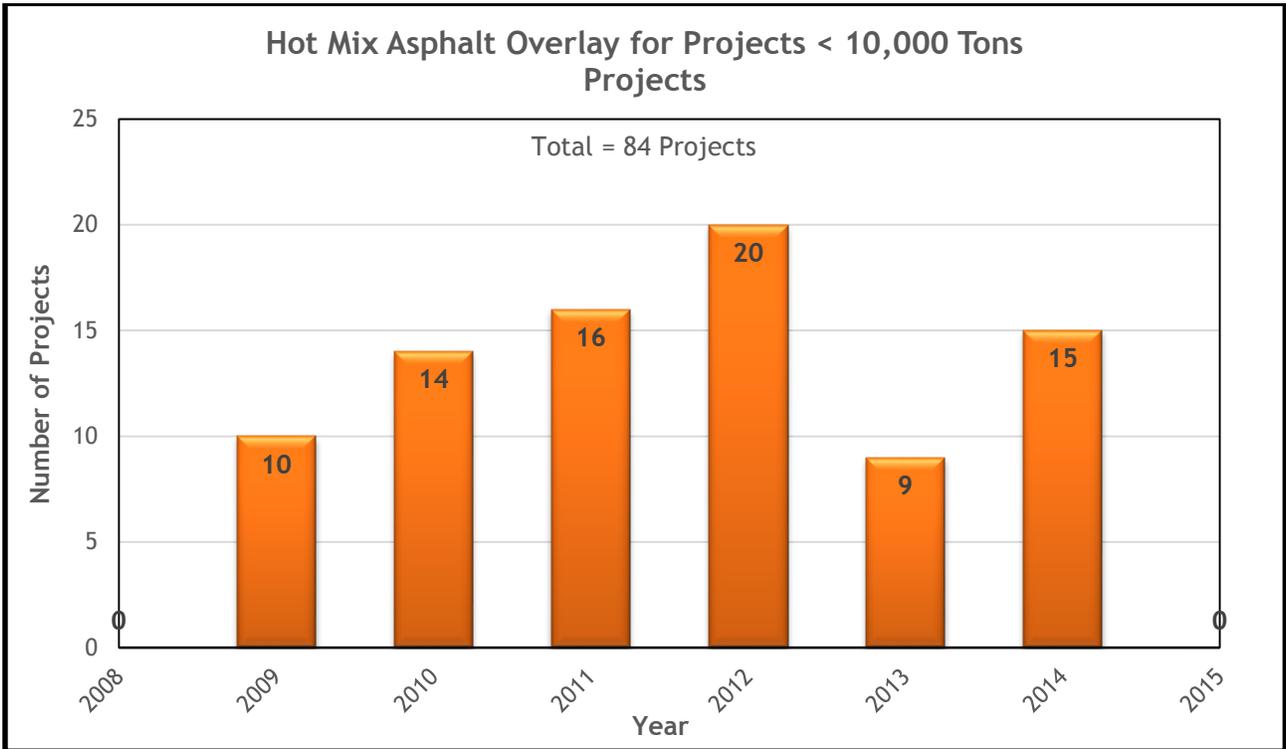


Figure 35 HMA Overlay Projects Less Than 10,000 Tons per Year

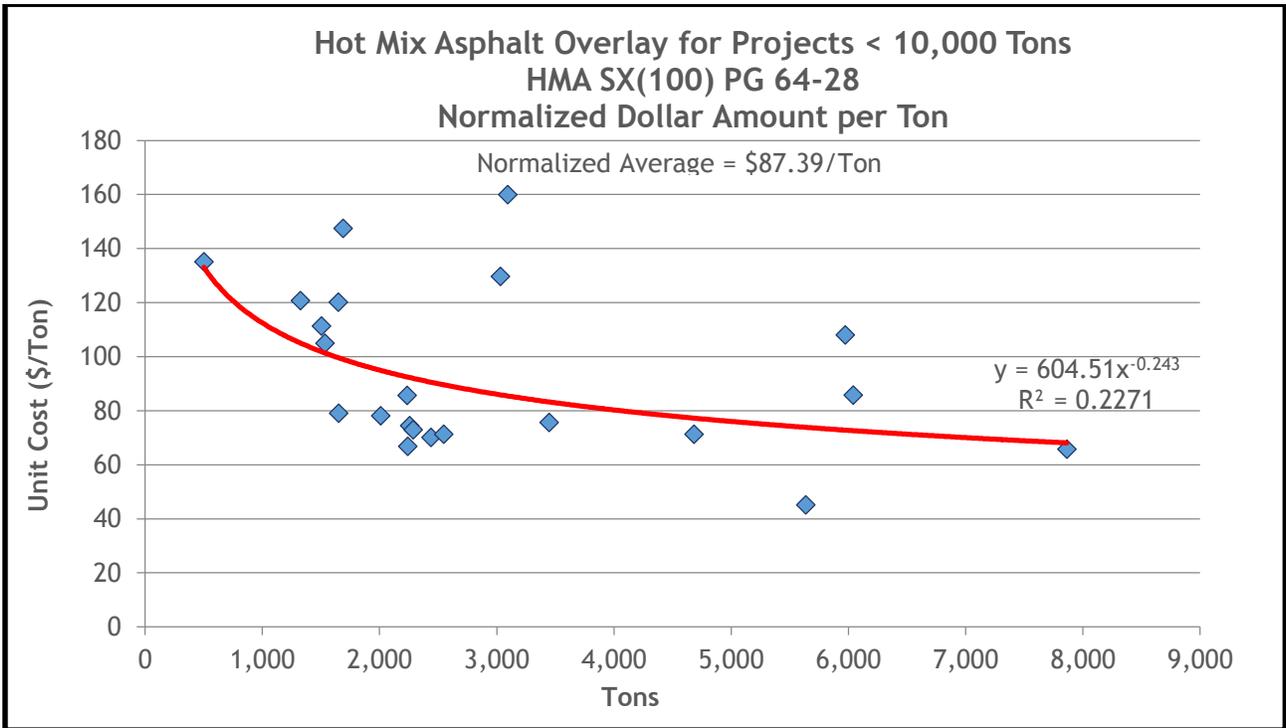


Figure 36 HMA Overlay Normalized Unit Costs for SX(100) PG 64-28 on Projects Less Than 10,000 Tons

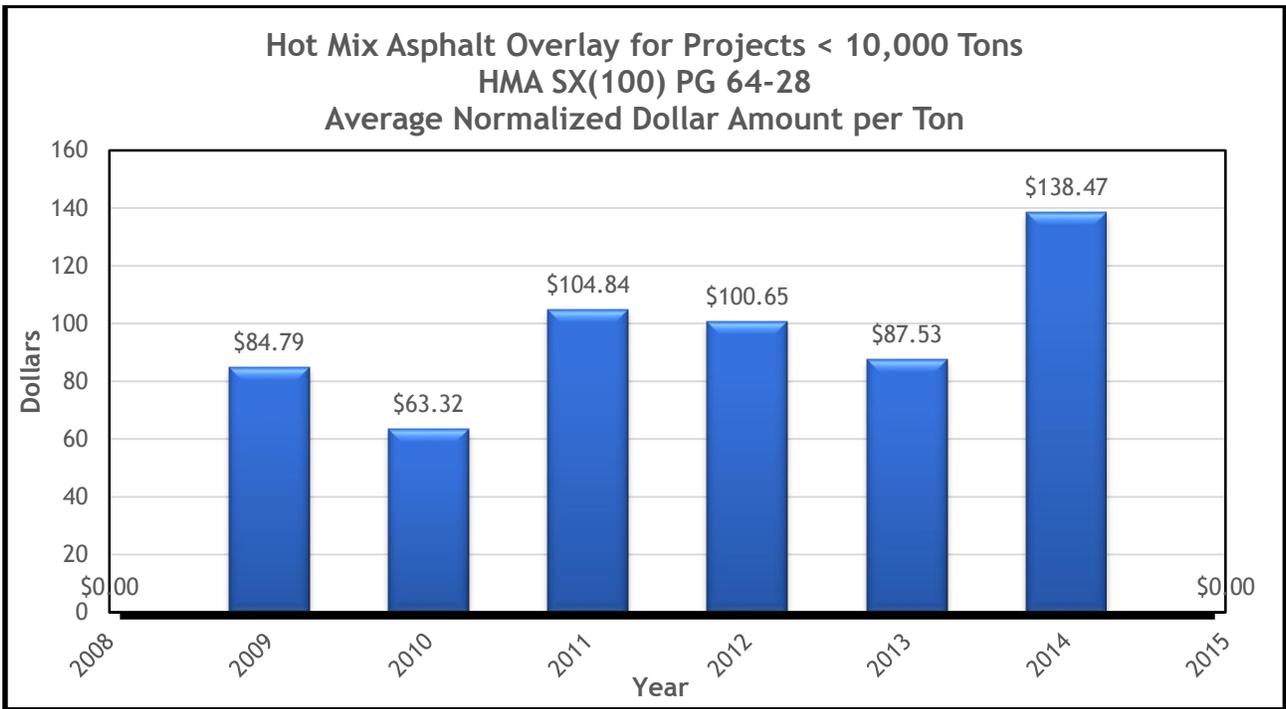


Figure 37 HMA Overlay Average Normalized Dollar Amount for SX(100) PG 64-28 per Year for Projects Less Than 10,000 Tons

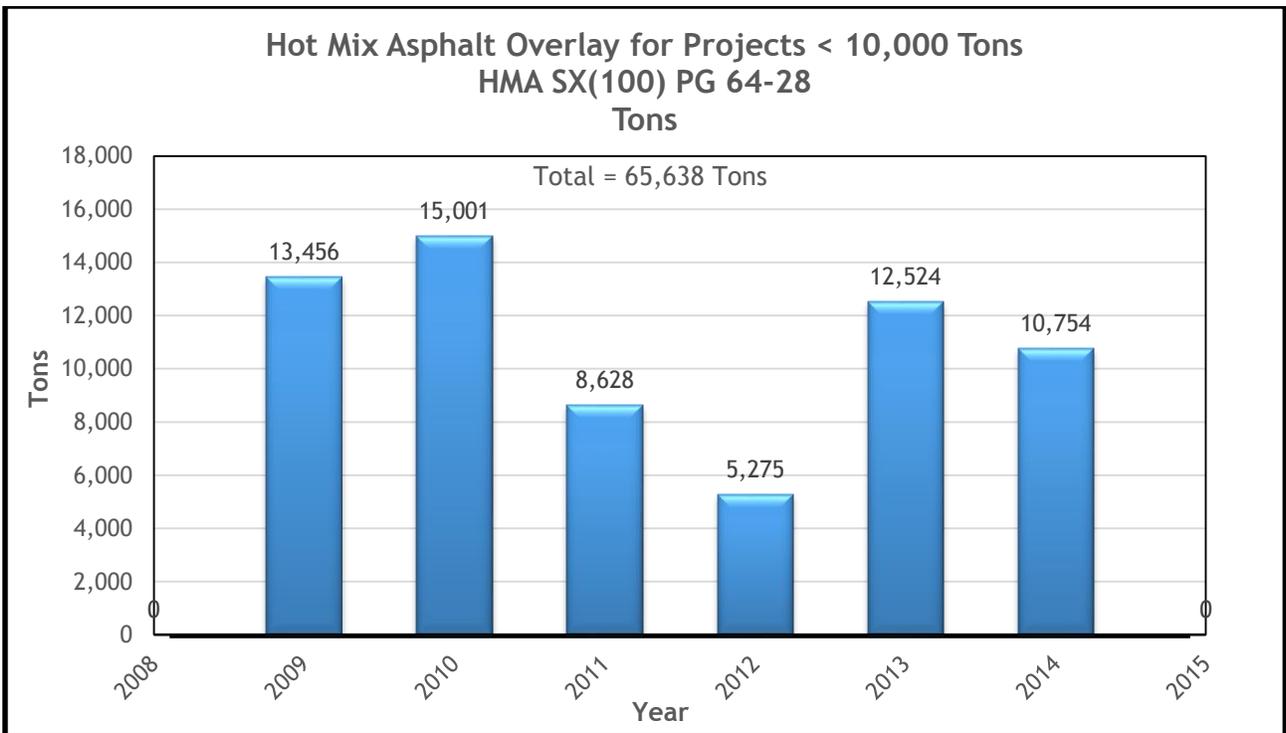


Figure 38 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 64-28 and Less Than 10,000 Tons

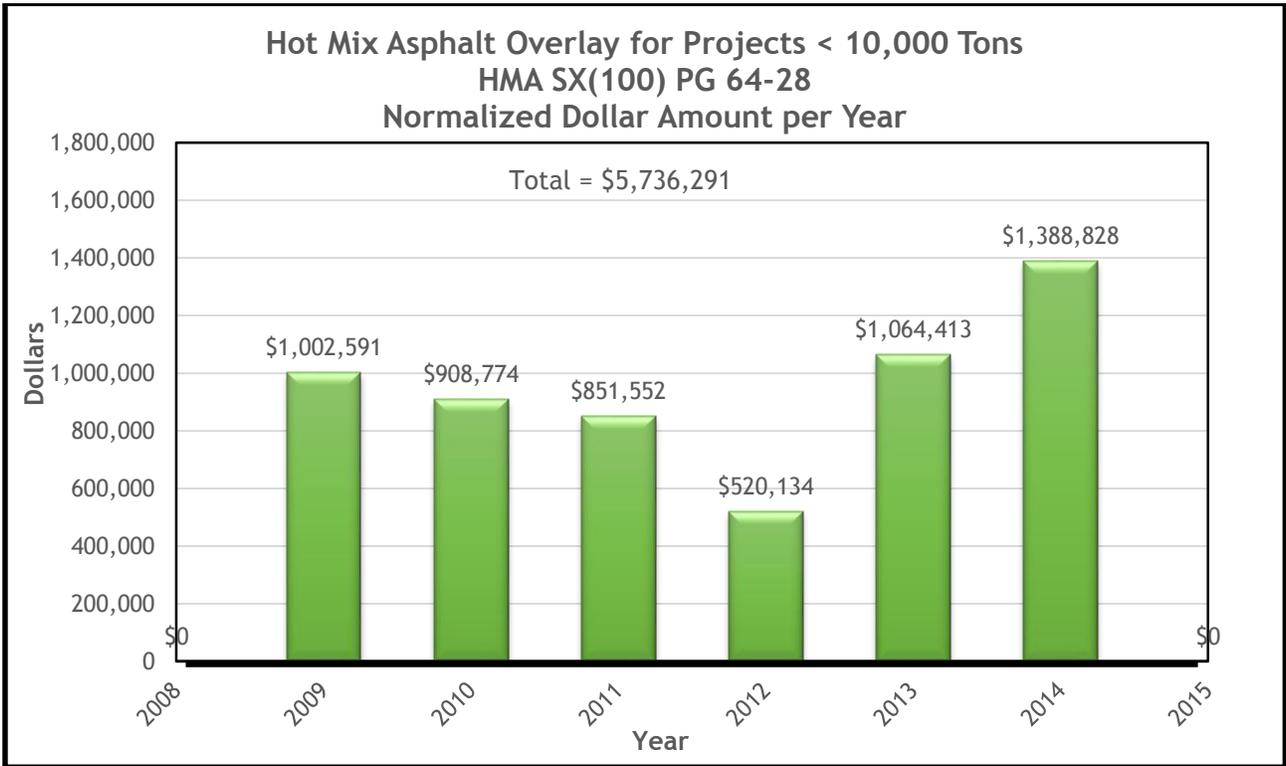


Figure 39 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 64-28 and Less Than 10,000 Tons

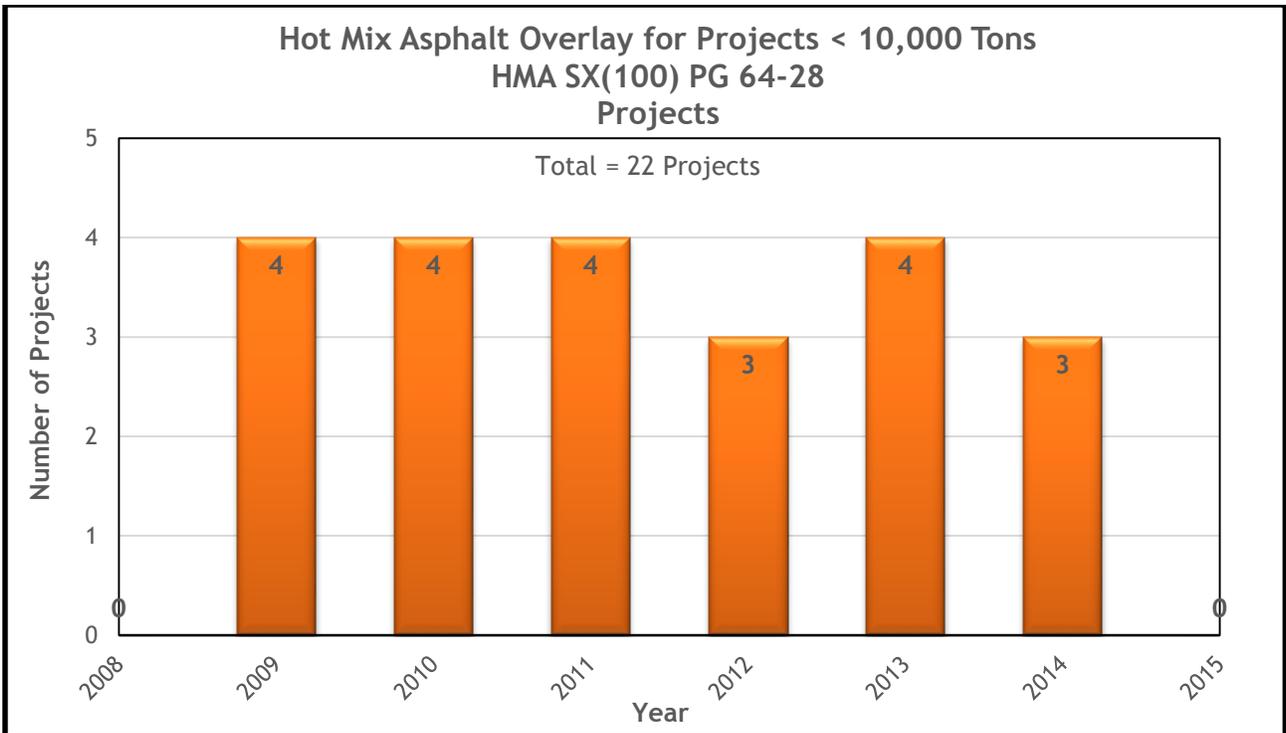


Figure 40 HMA Overlay Projects Using SX(100) PG 64-28 Less Than 10,000 Tons per Year

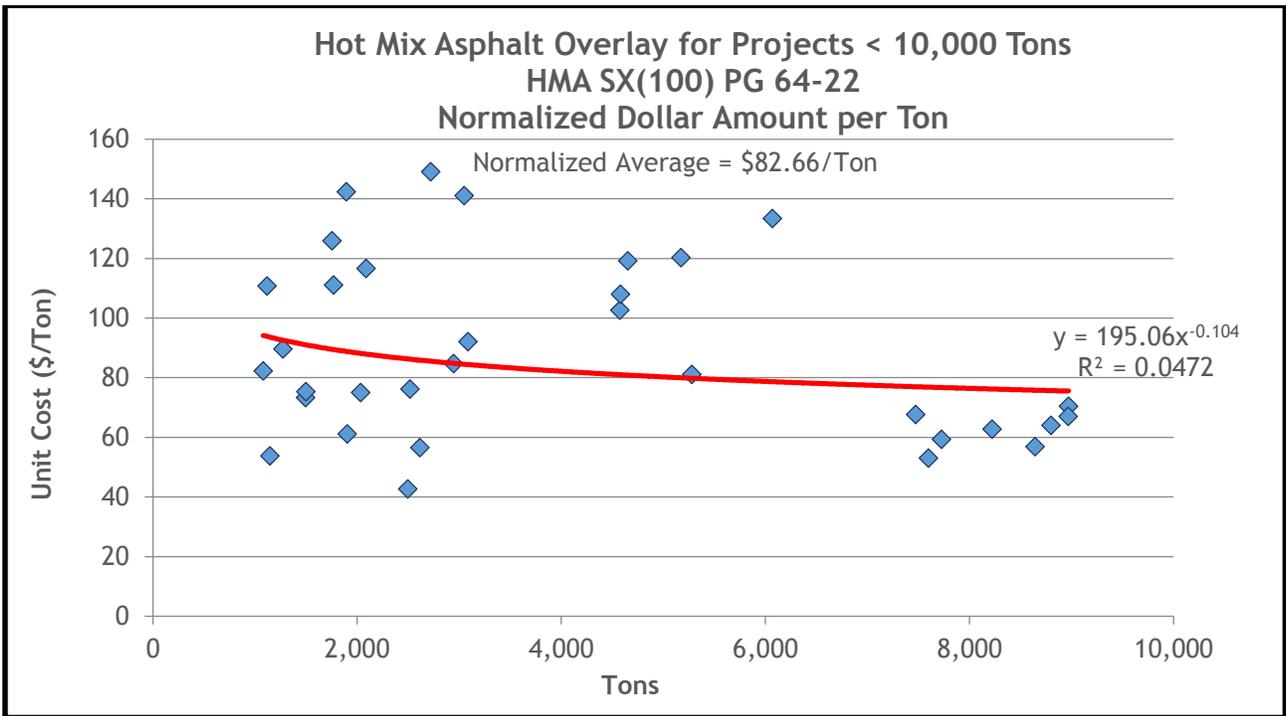


Figure 41 HMA Overlay Normalized Unit Costs for SX(100) PG 64-22 on Projects Less Than 10,000 Tons

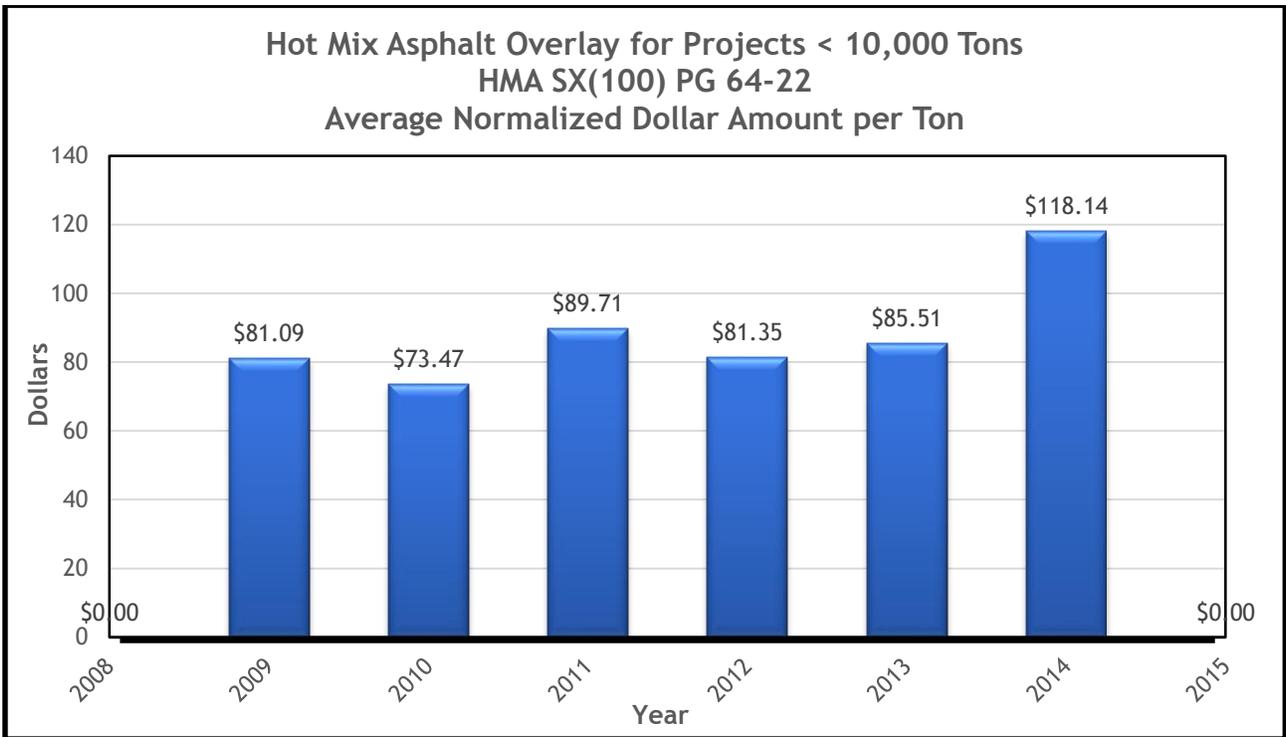


Figure 42 HMA Overlay Average Normalized Dollar Amount for SX(100) PG 64-22 per Year for Projects Less Than 10,000 Tons

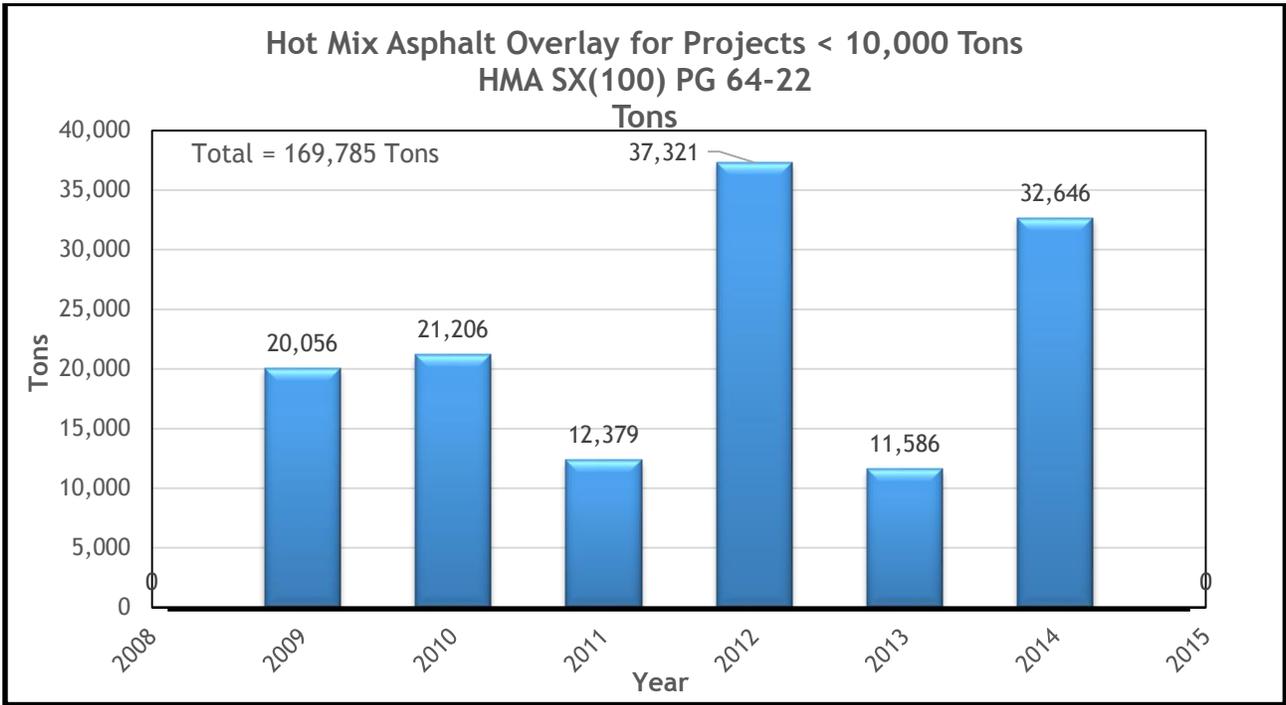


Figure 43 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 64-22 and Less Than 10,000 Tons

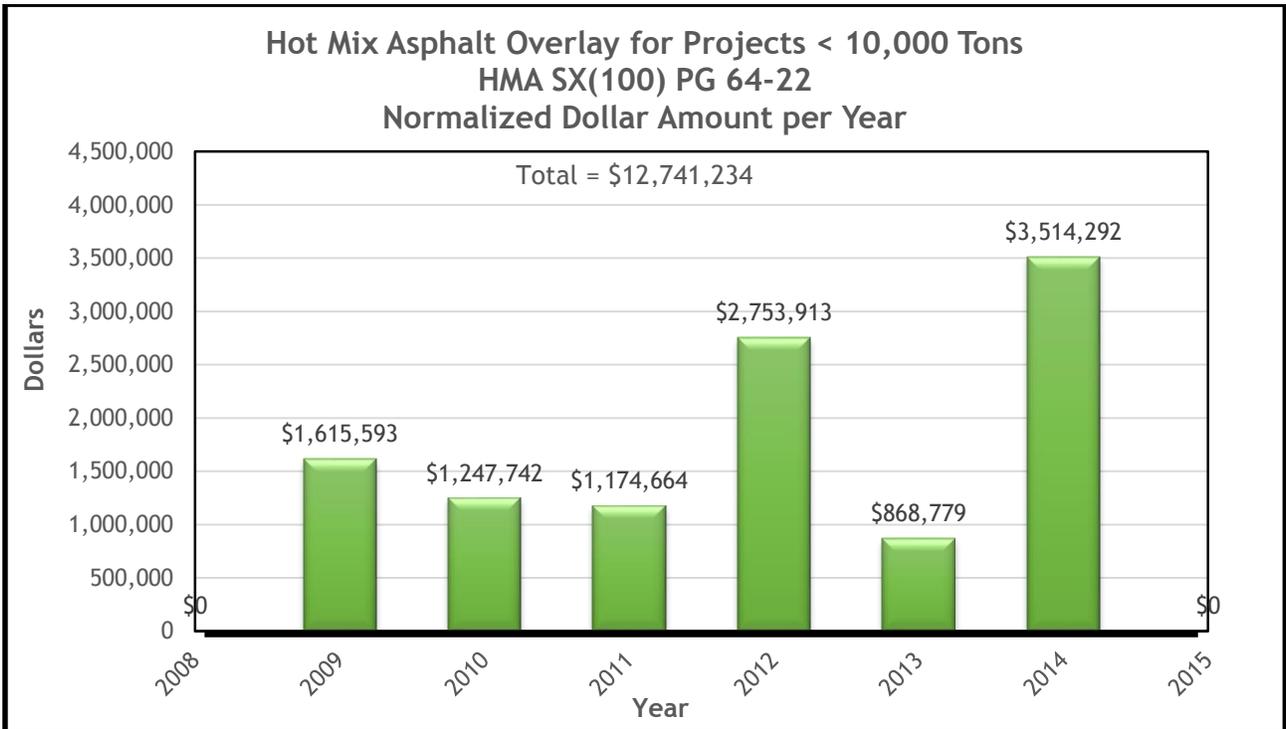


Figure 44 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 64-22 and Less Than 10,000 Tons

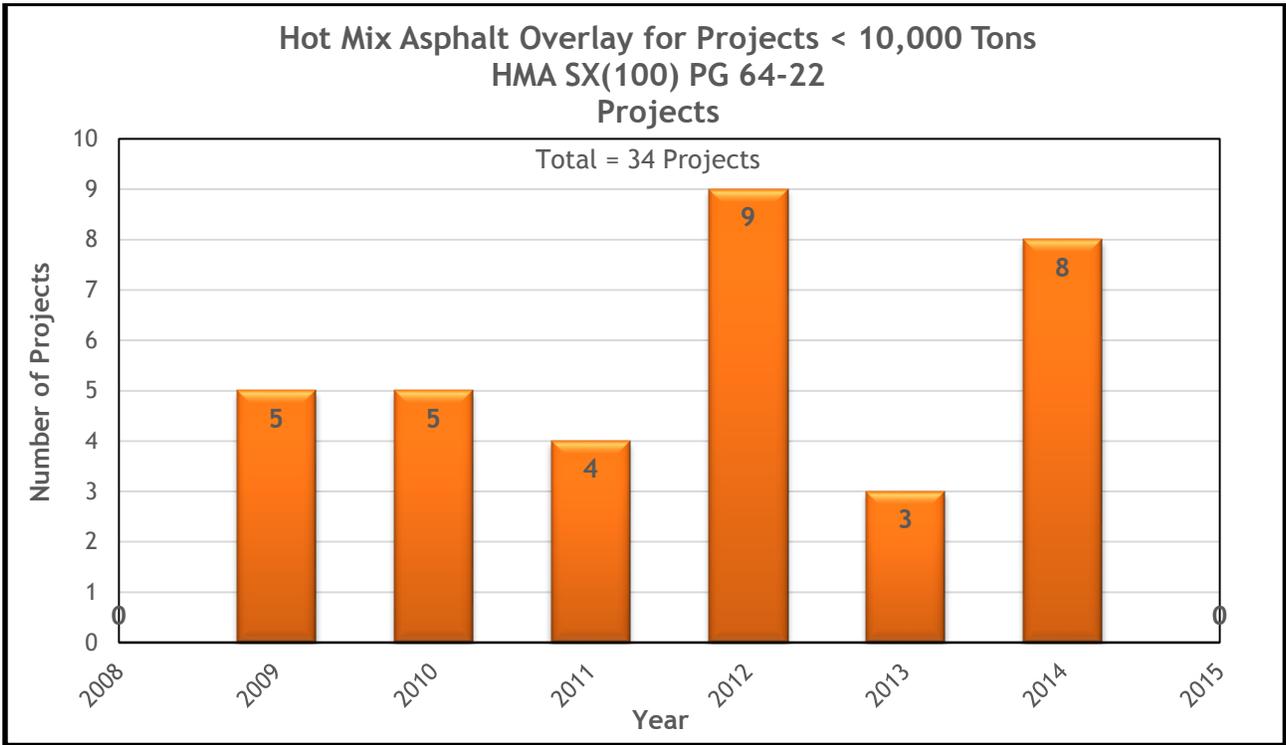


Figure 45 HMA Overlay Projects Using SX(100) PG 64-22 Less Than 10,000 Tons per Year

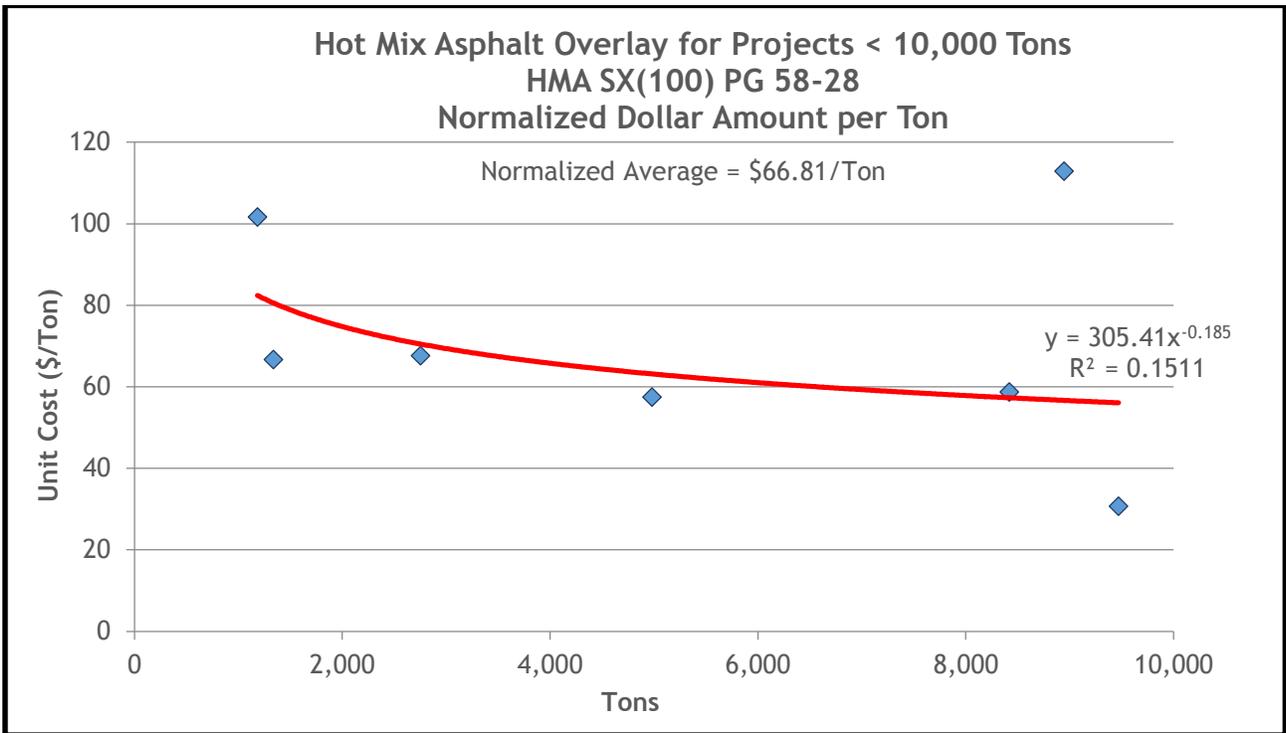


Figure 46 HMA Overlay Normalized Unit Costs for SX(100) PG 58-28 on Projects Less Than 10,000 Tons

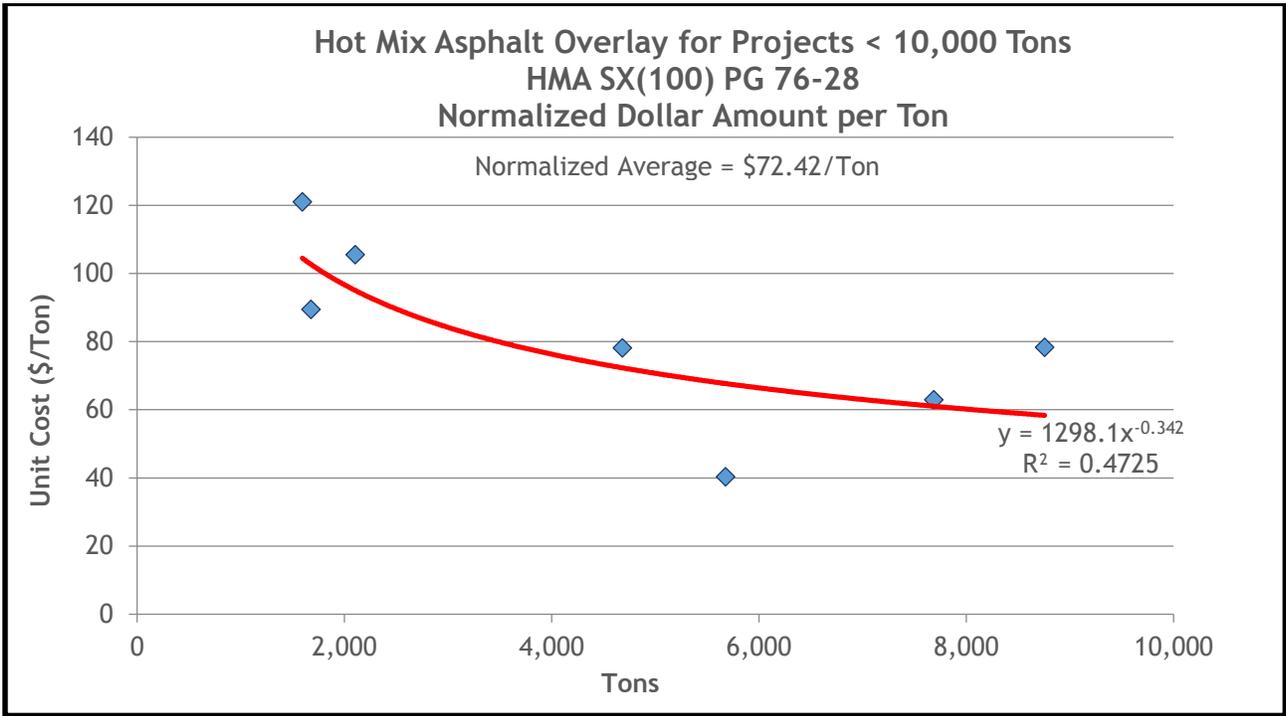


Figure 47 HMA Overlay Normalized Unit Costs for SX(100) PG 76-28 on Projects Less Than 10,000 Tons

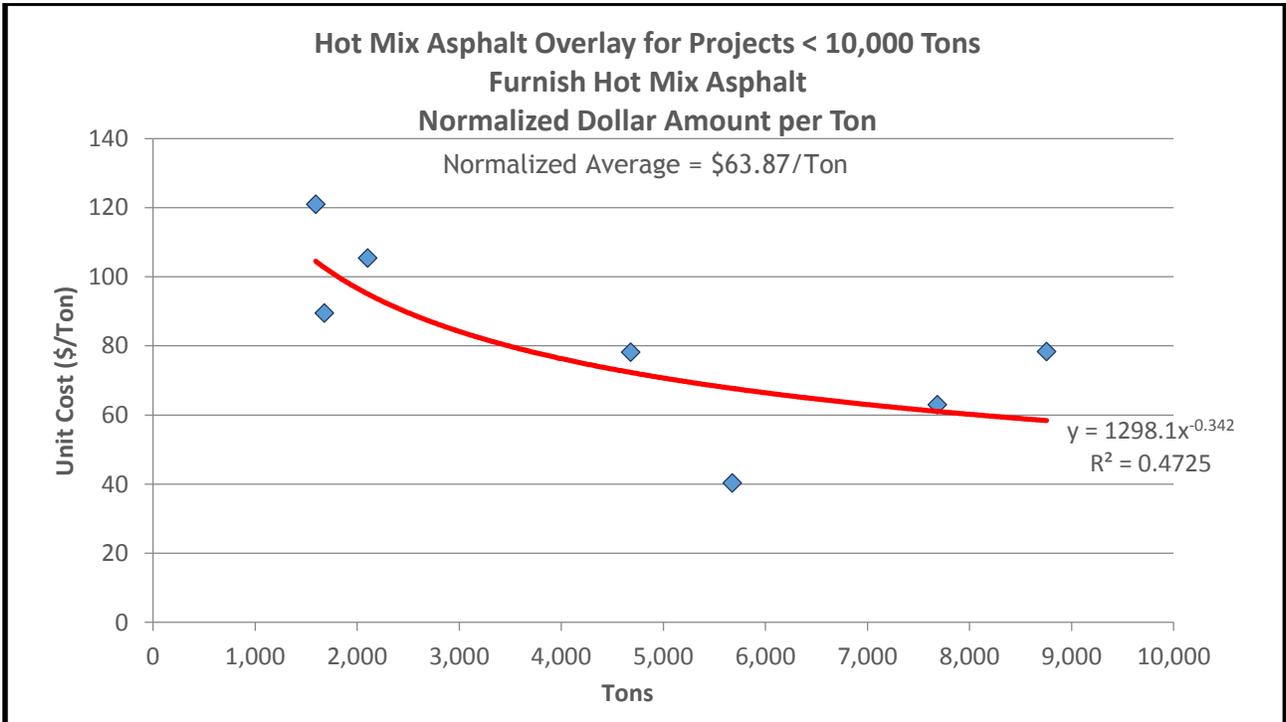


Figure 48 HMA Overlay Normalized Unit Costs for Furnish HMA on Projects Less Than 10,000 Tons

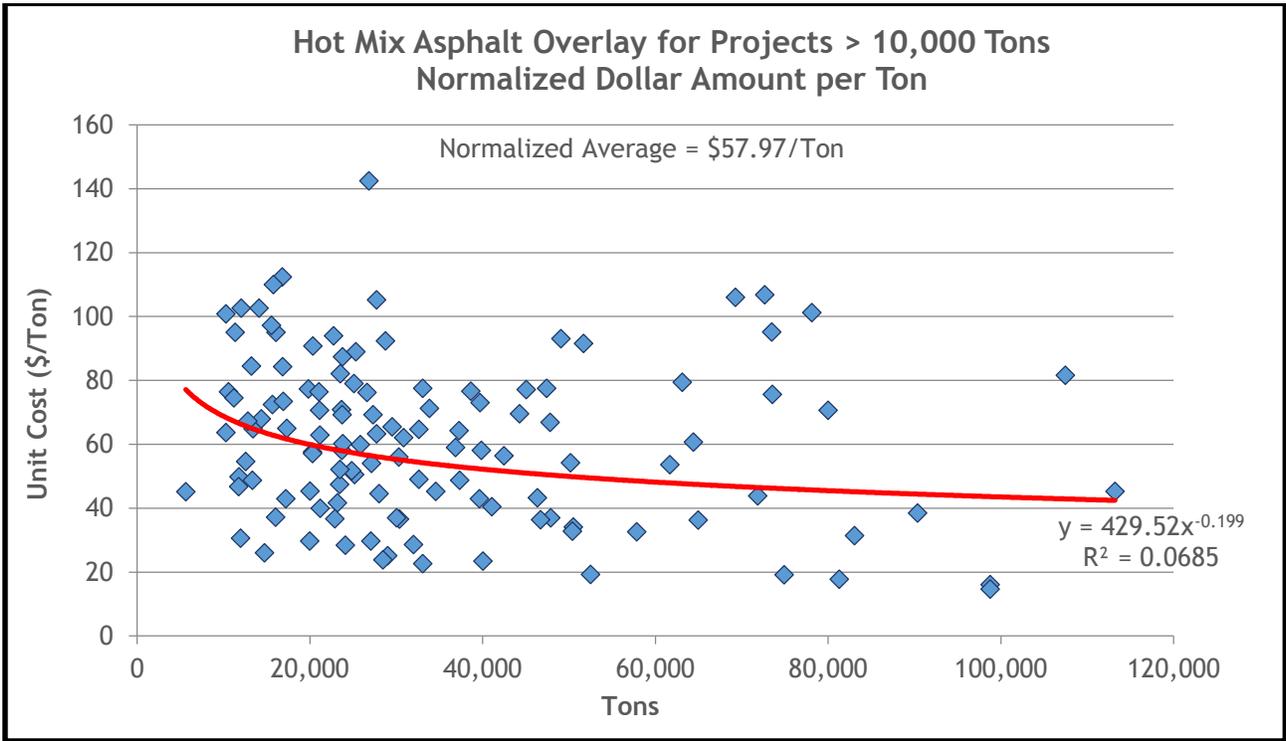


Figure 49 HMA Overlay Normalized Unit Costs for Projects with Greater than 10,000 Tons

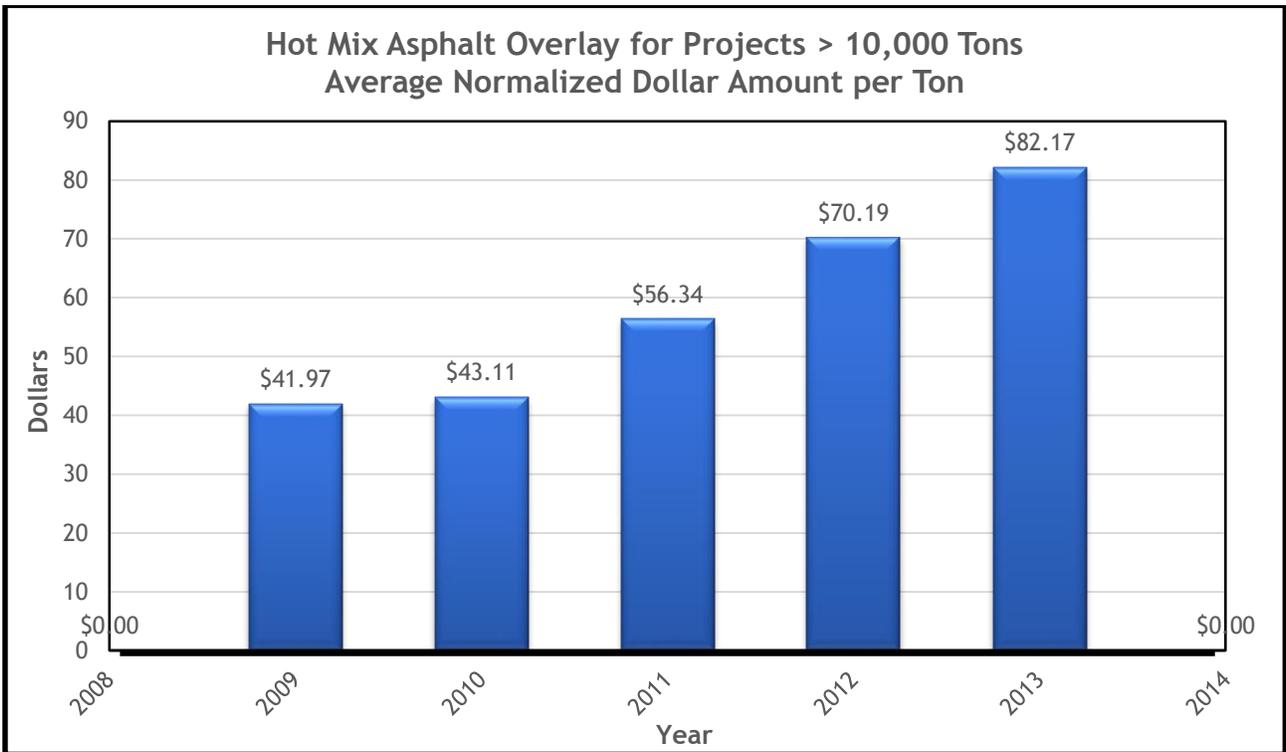


Figure 50 HMA Overlay Average Normalized Dollar Amount per Year for Projects Greater Than 10,000 Tons

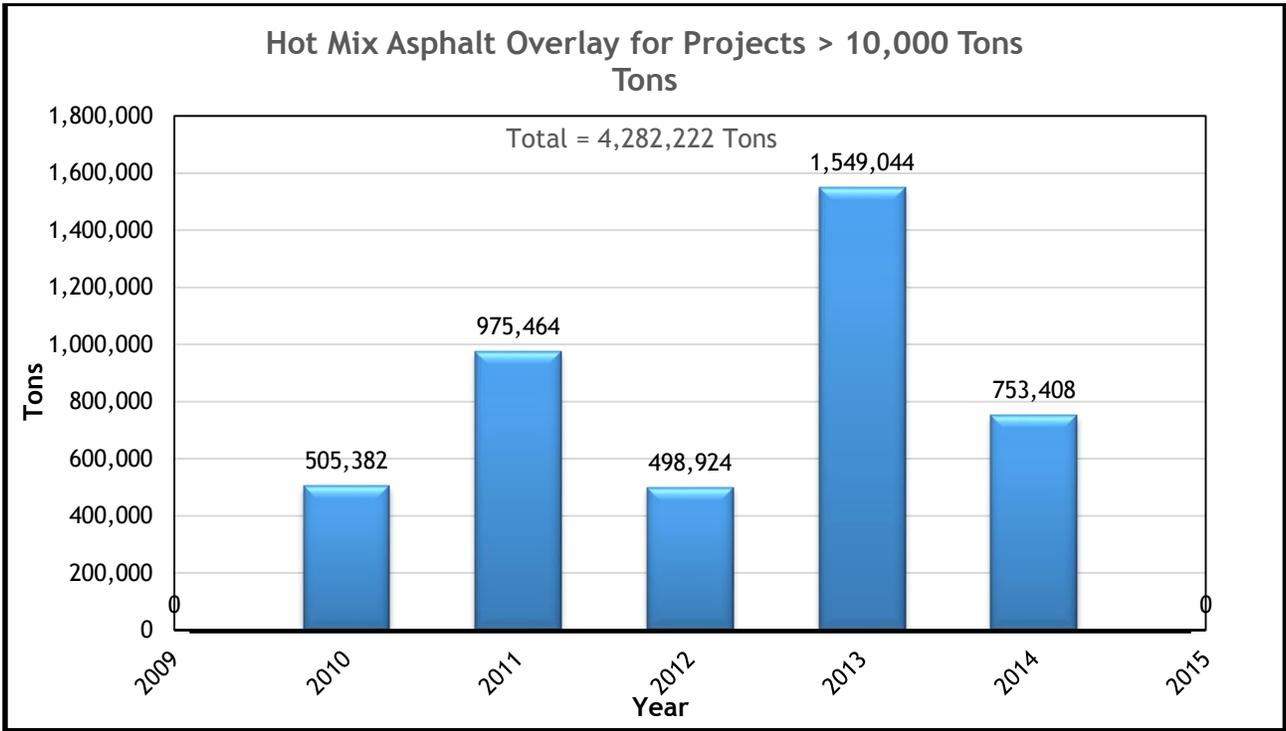


Figure 51 HMA Overlay Total Tons per Year for Projects Greater Than 10,000 Tons

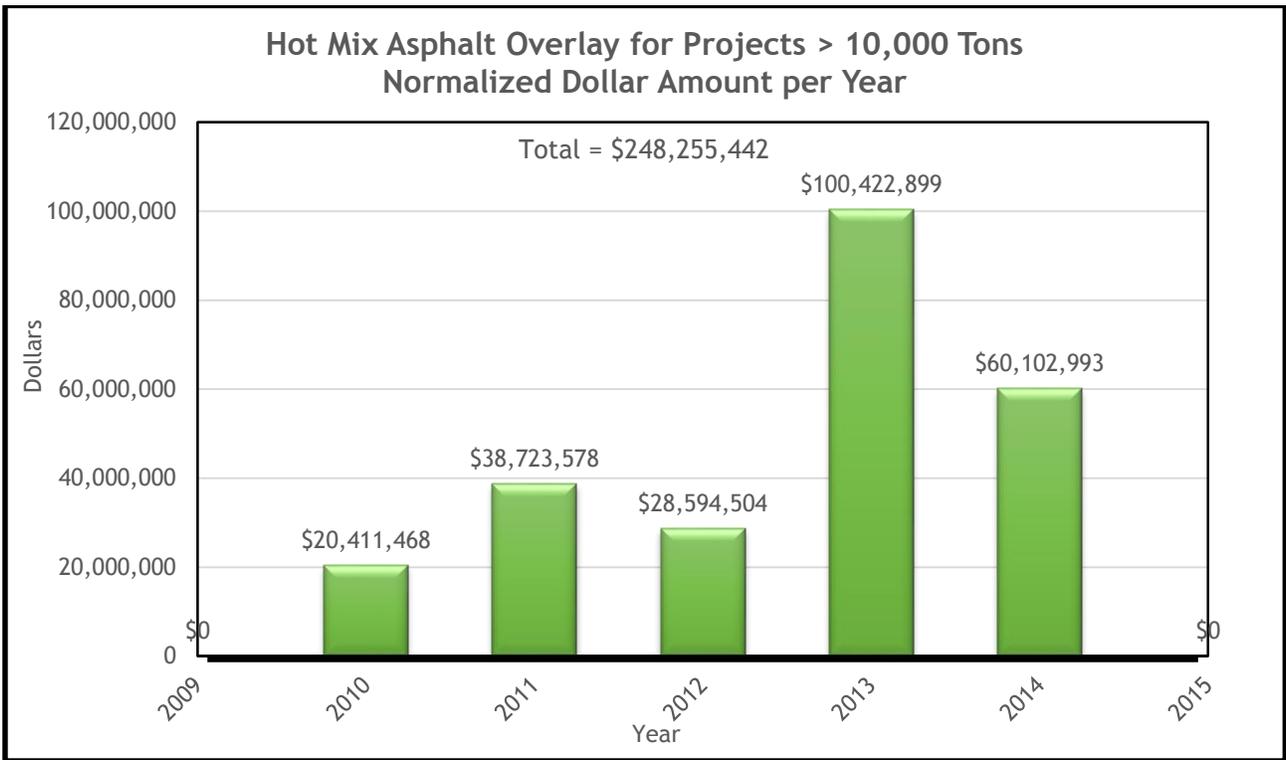


Figure 52 HMA Overlay Total Normalized Dollar Amount per Year for Projects Greater Than 10,000 Tons

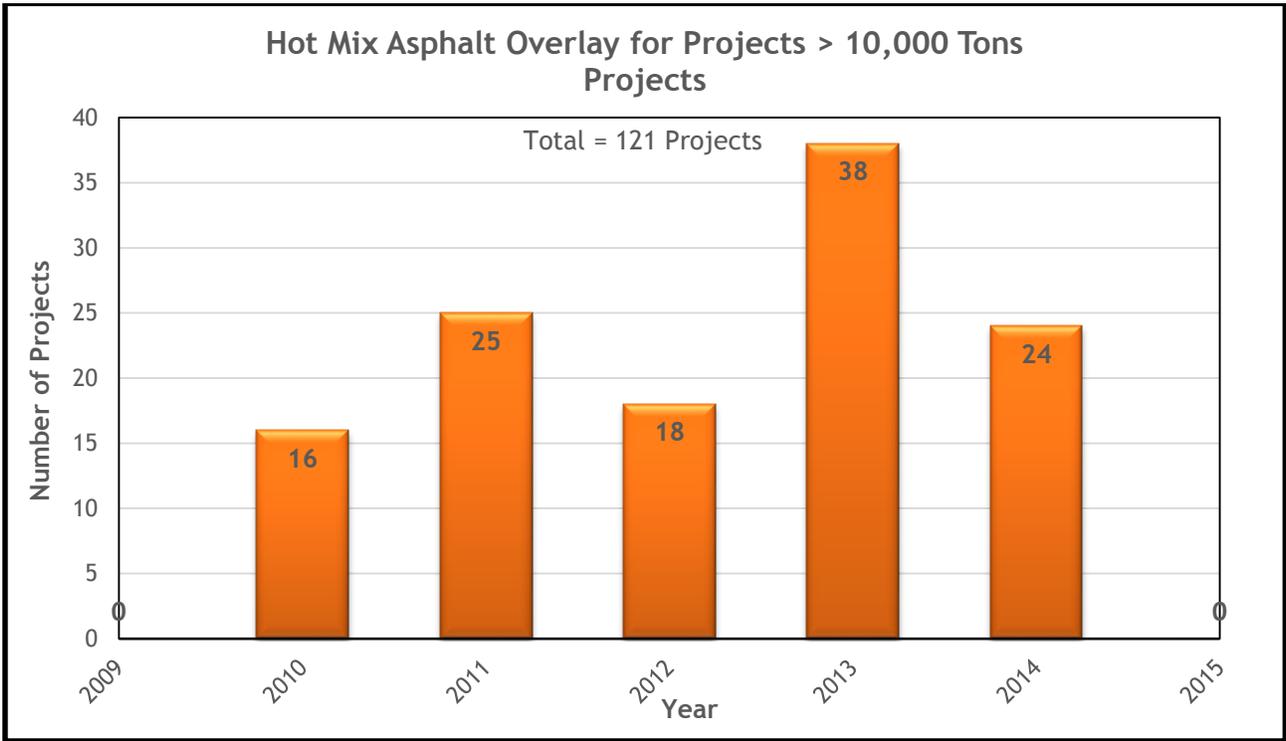


Figure 53 HMA Overlay Projects Greater Than 10,000 Tons per Year

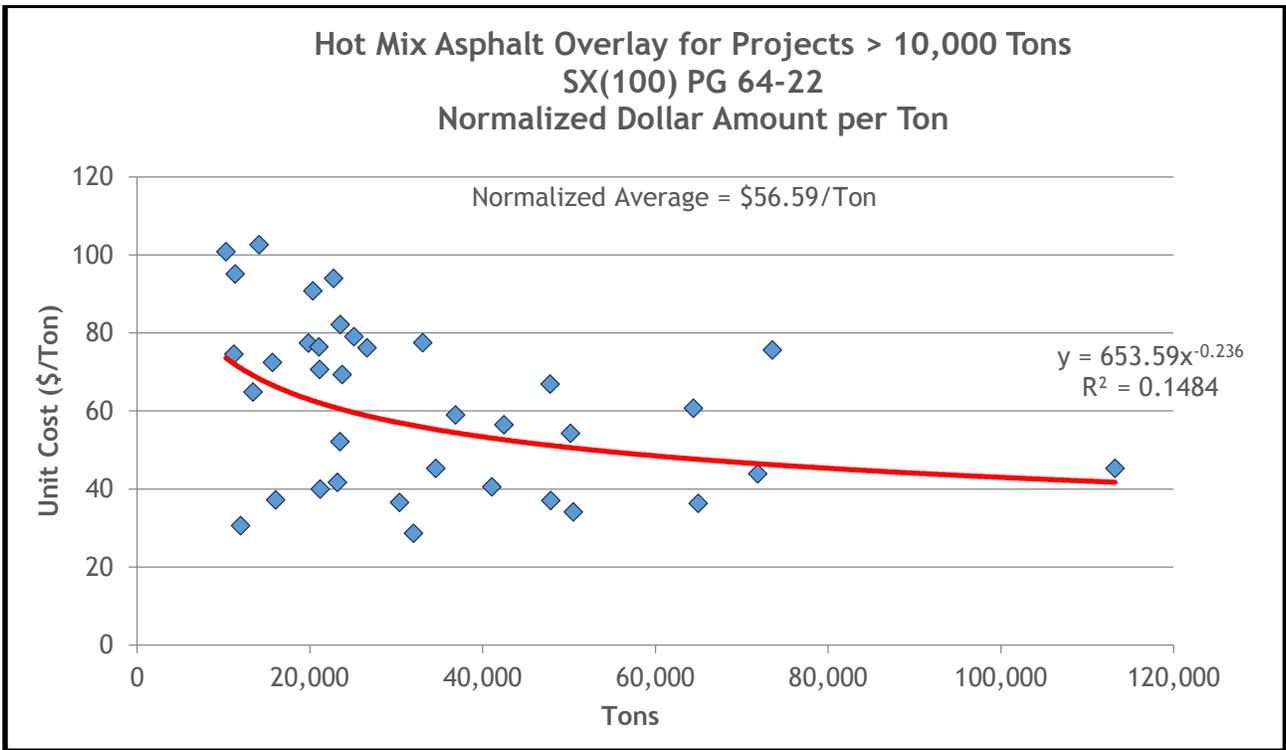


Figure 54 HMA Overlay Normalized Unit Costs for SX(100) PG 64-22 on Projects with Greater than 10,000 Tons

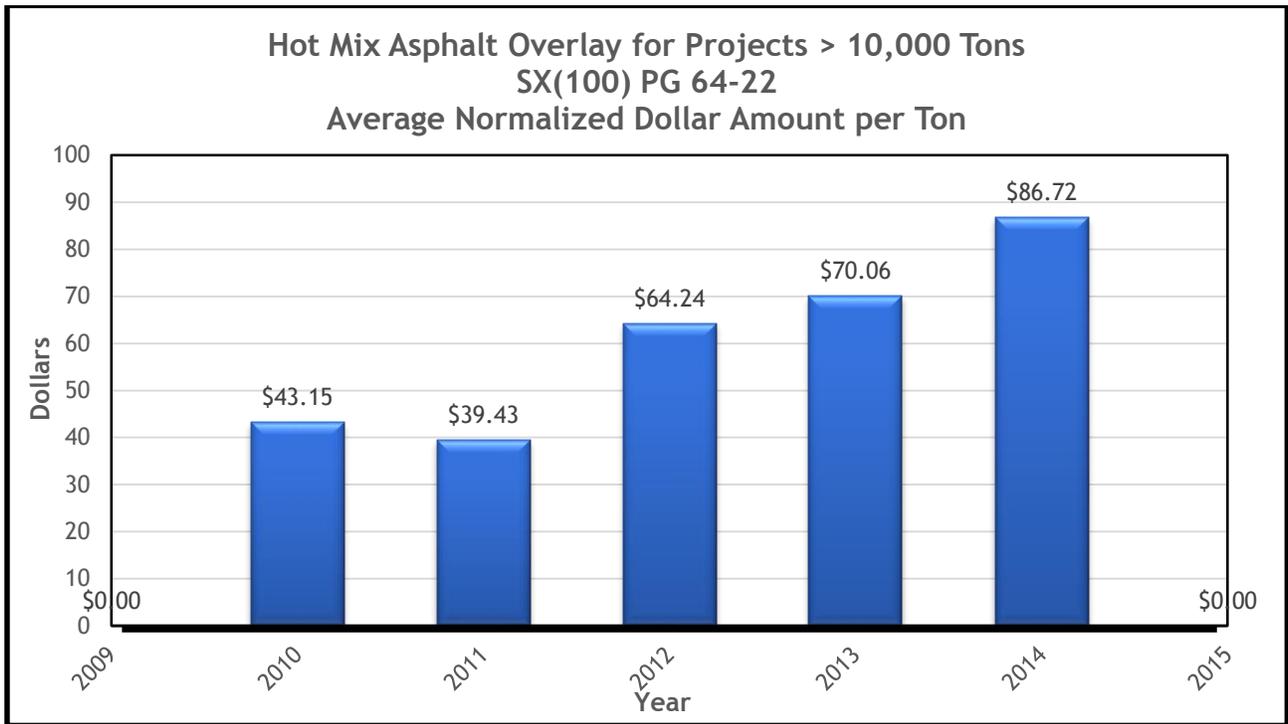


Figure 55 HMA Overlay Average Normalized Dollar Amount for SX(100) PG 64-22 per Year for Projects Greater Than 10,000 Tons

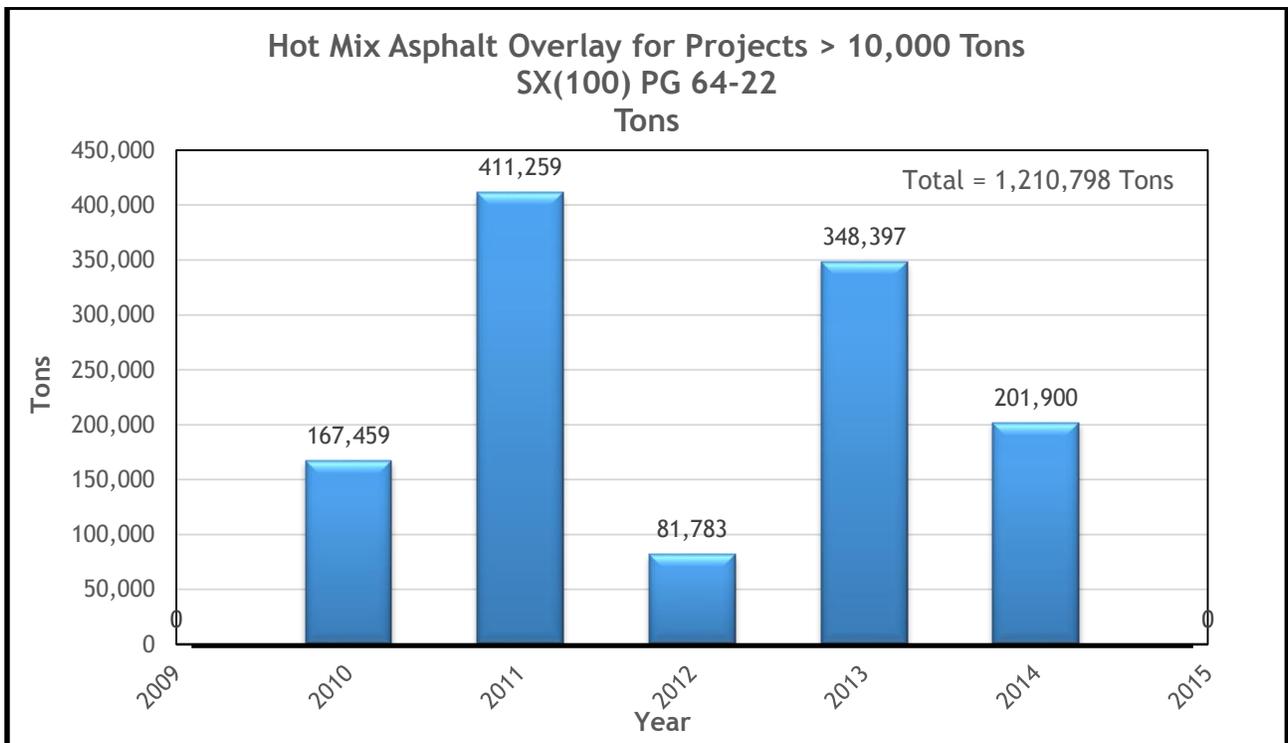


Figure 56 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 64-22 and Greater Than 10,000 Tons

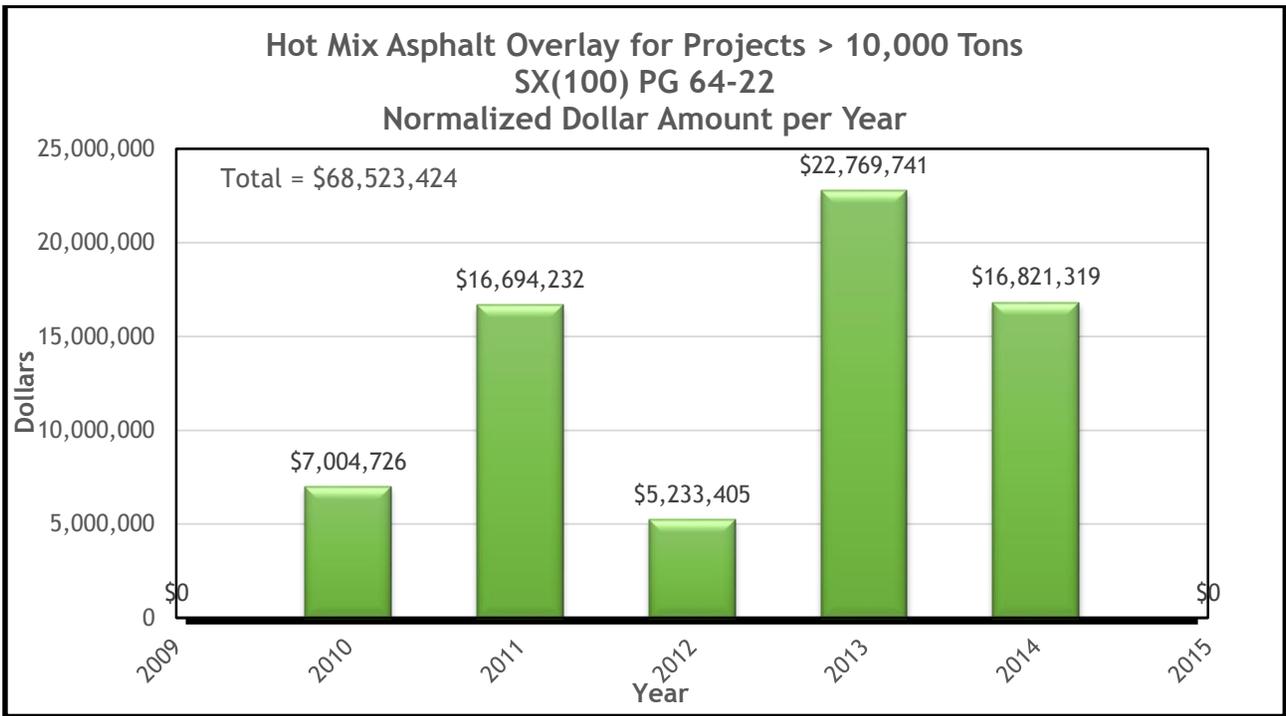


Figure 57 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 64-22 and Greater Than 10,000 Tons

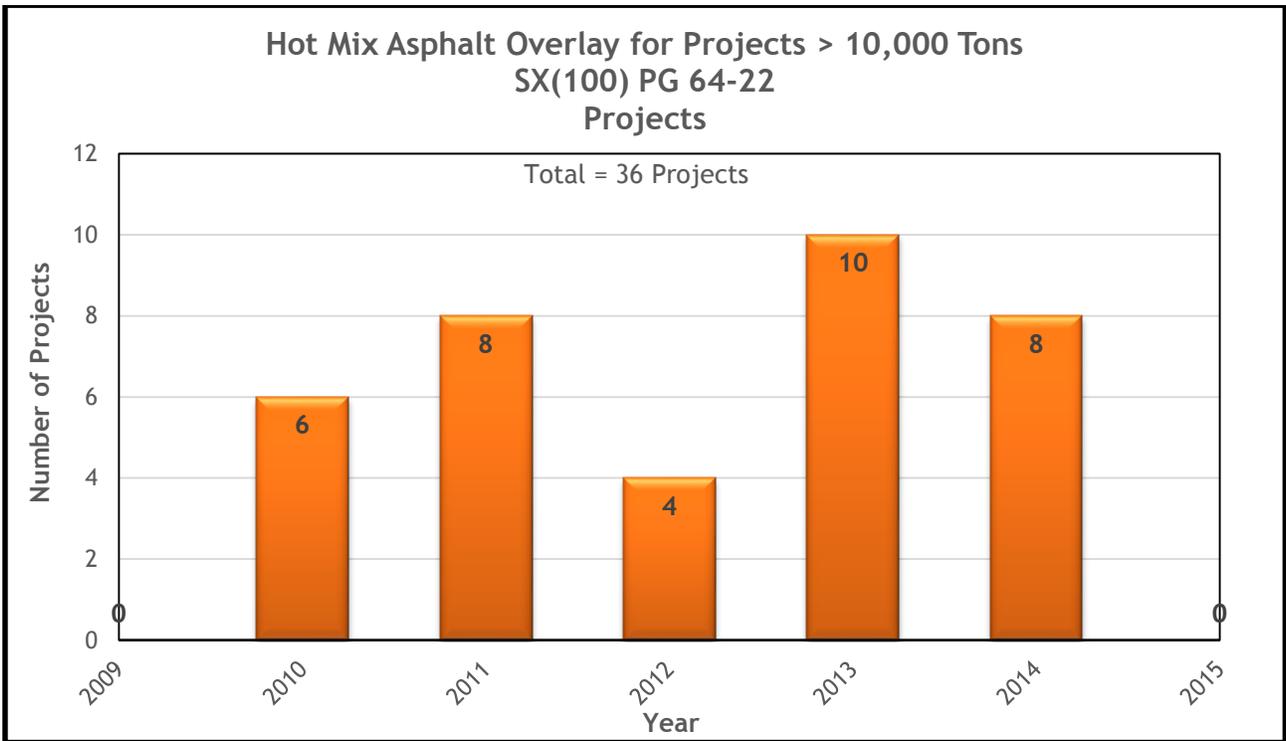


Figure 58 HMA Overlay Projects Using SX(100) PG 64-22 Greater Than 10,000 Tons per Year

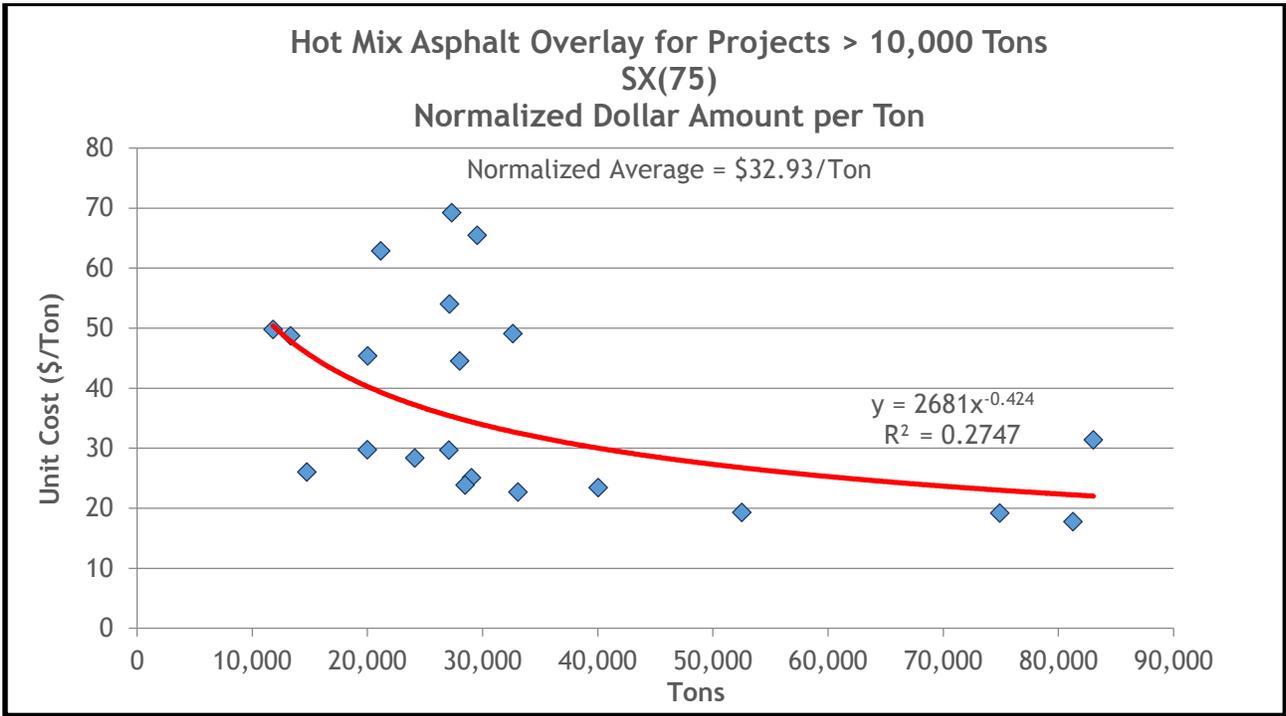


Figure 59 HMA Overlay Normalized Unit Costs for SX(75) on Projects with Greater than 10,000 Tons

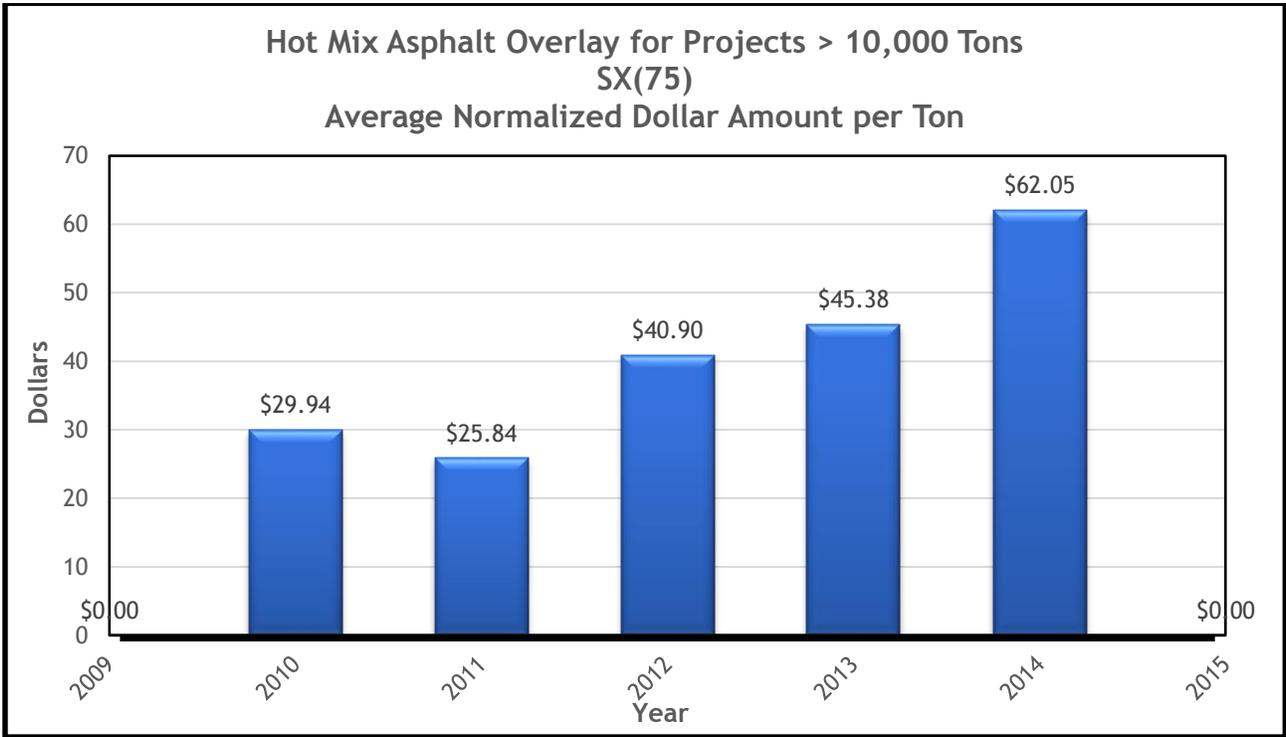


Figure 60 HMA Overlay Average Normalized Dollar Amount for SX(75) per Year for Projects Greater Than 10,000 Tons

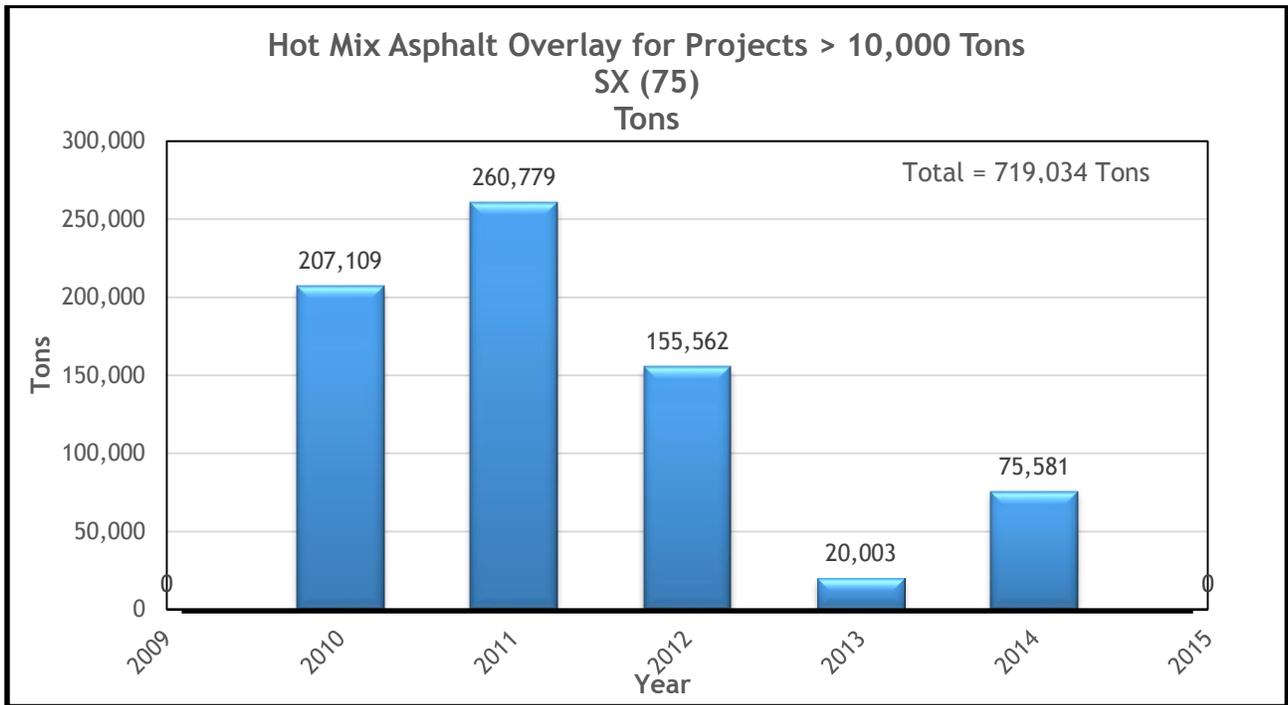


Figure 61 HMA Overlay Total Tons per Year for Projects Using SX(75) and Greater Than 10,000 Tons

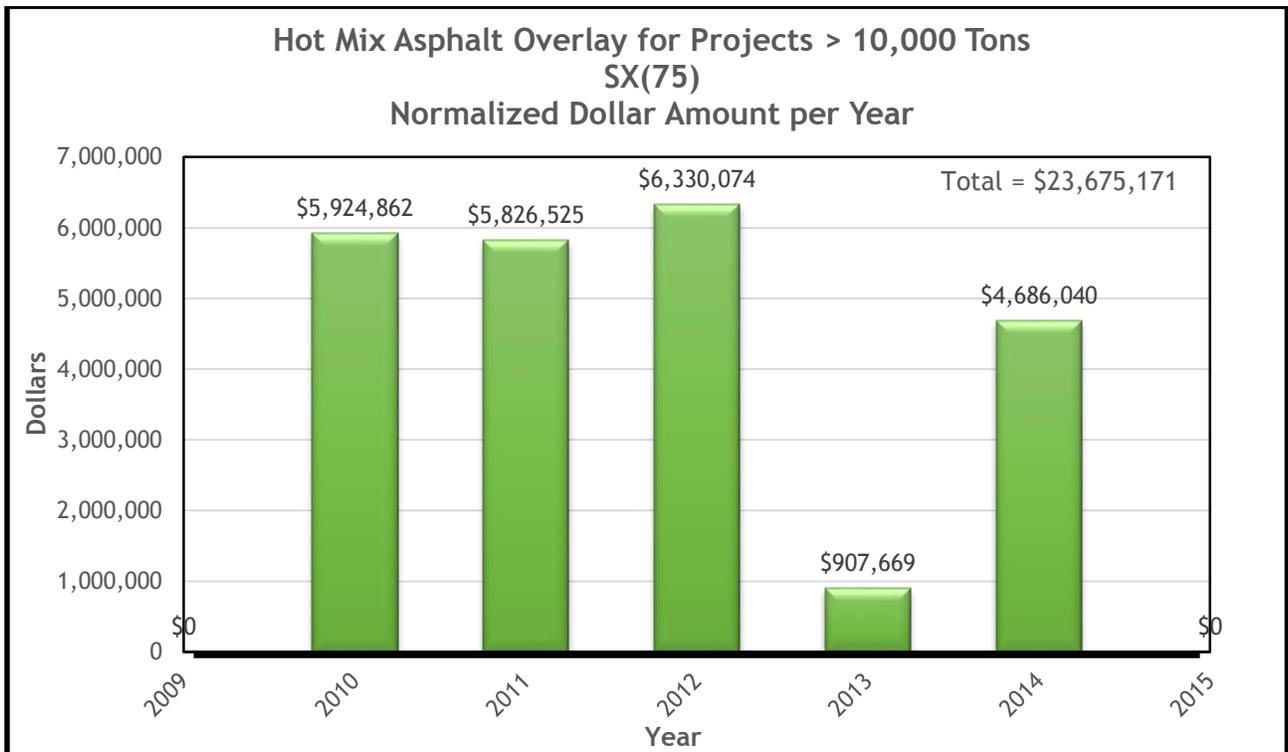


Figure 62 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(75) and Greater Than 10,000 Tons

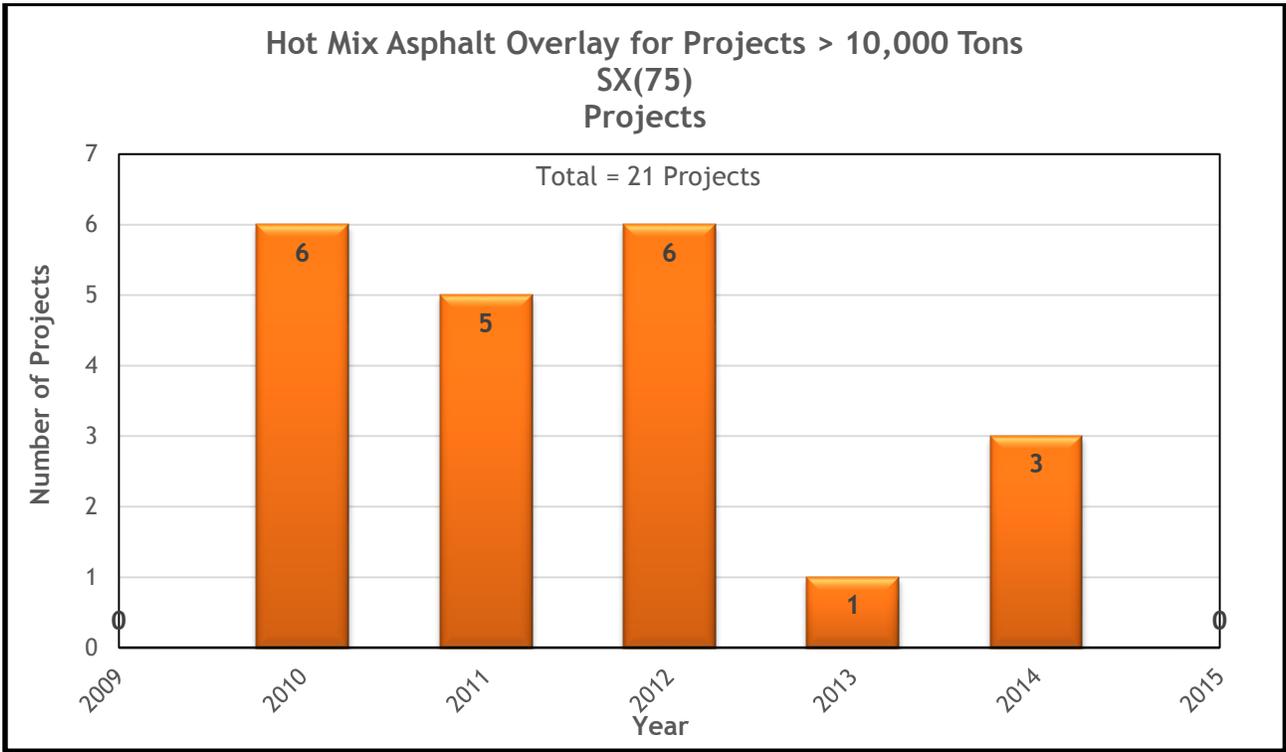


Figure 63 HMA Overlay Projects Using SX(75) Greater Than 10,000 Tons per Year

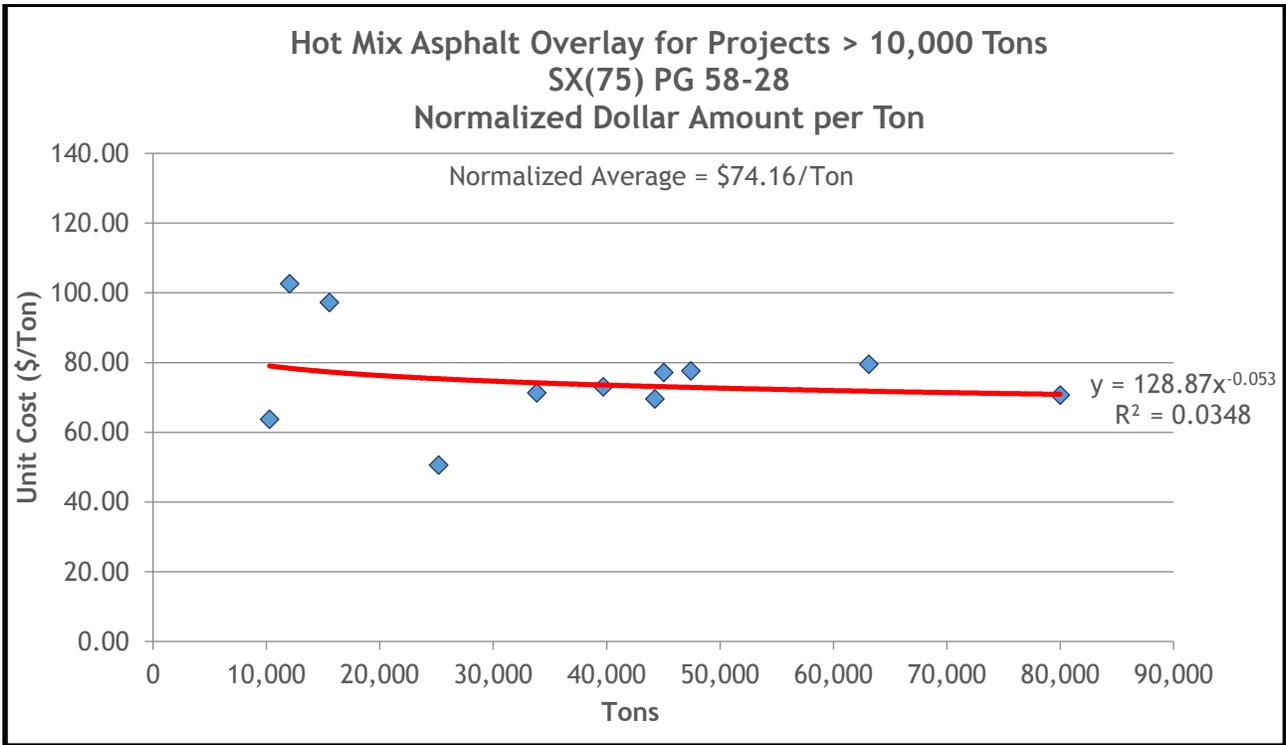


Figure 64 HMA Overlay Normalized Unit Costs for SX(75) PG 58-28 on Projects with Greater than 10,000 Tons

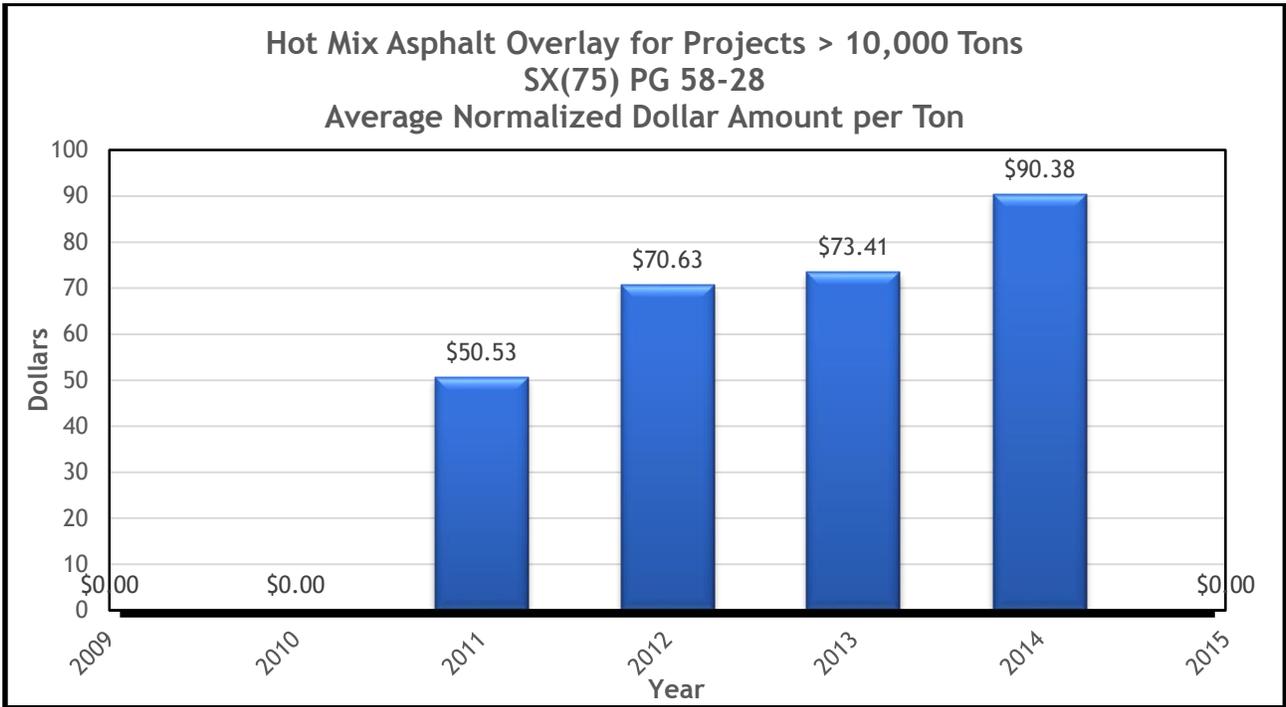


Figure 65 HMA Overlay Average Normalized Dollar Amount for SX(75) PG 58-28 per Year for Projects Greater Than 10,000 Tons

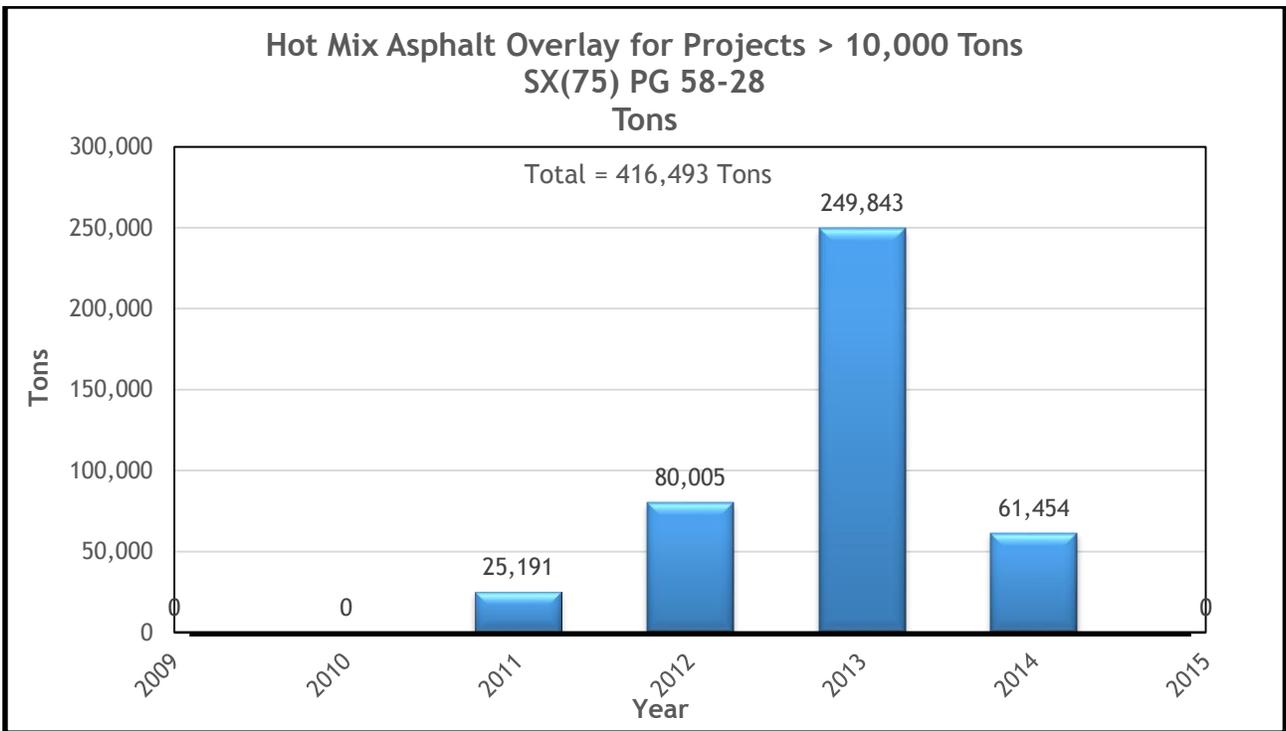


Figure 66 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 58-28 and Greater Than 10,000 Tons

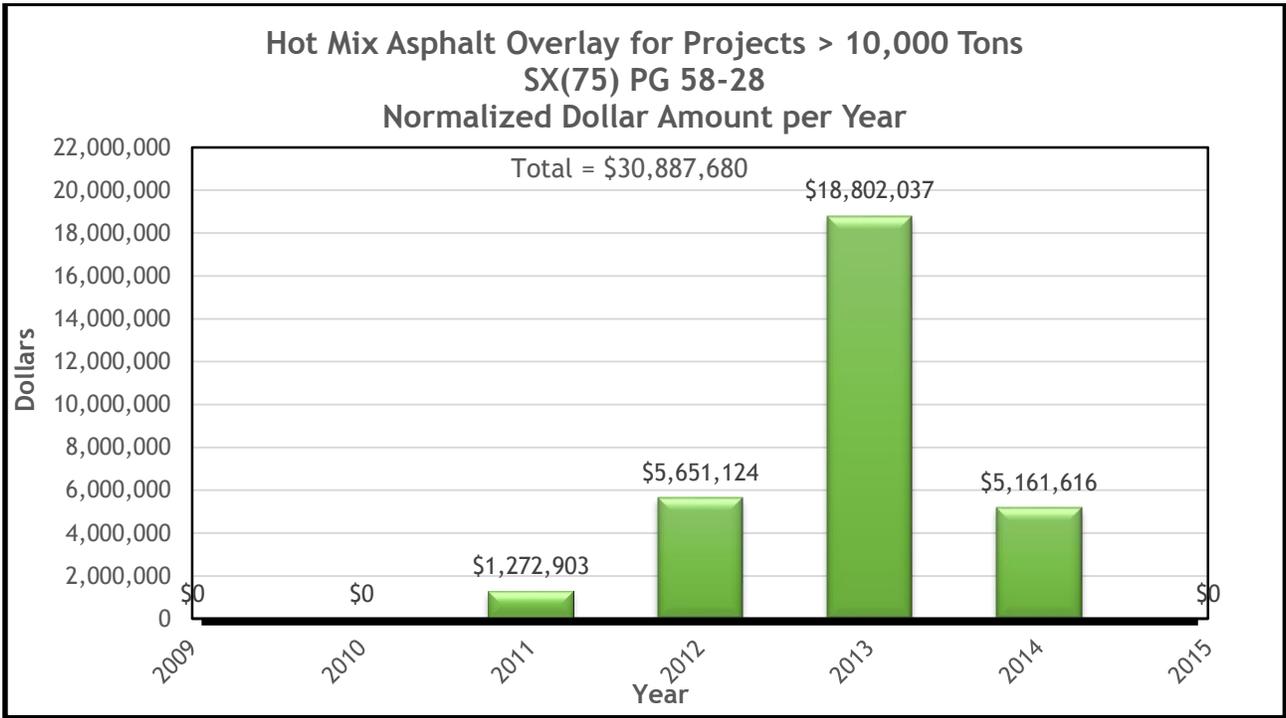


Figure 67 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(75) PG 58-28 and Less Than 10,000 Tons

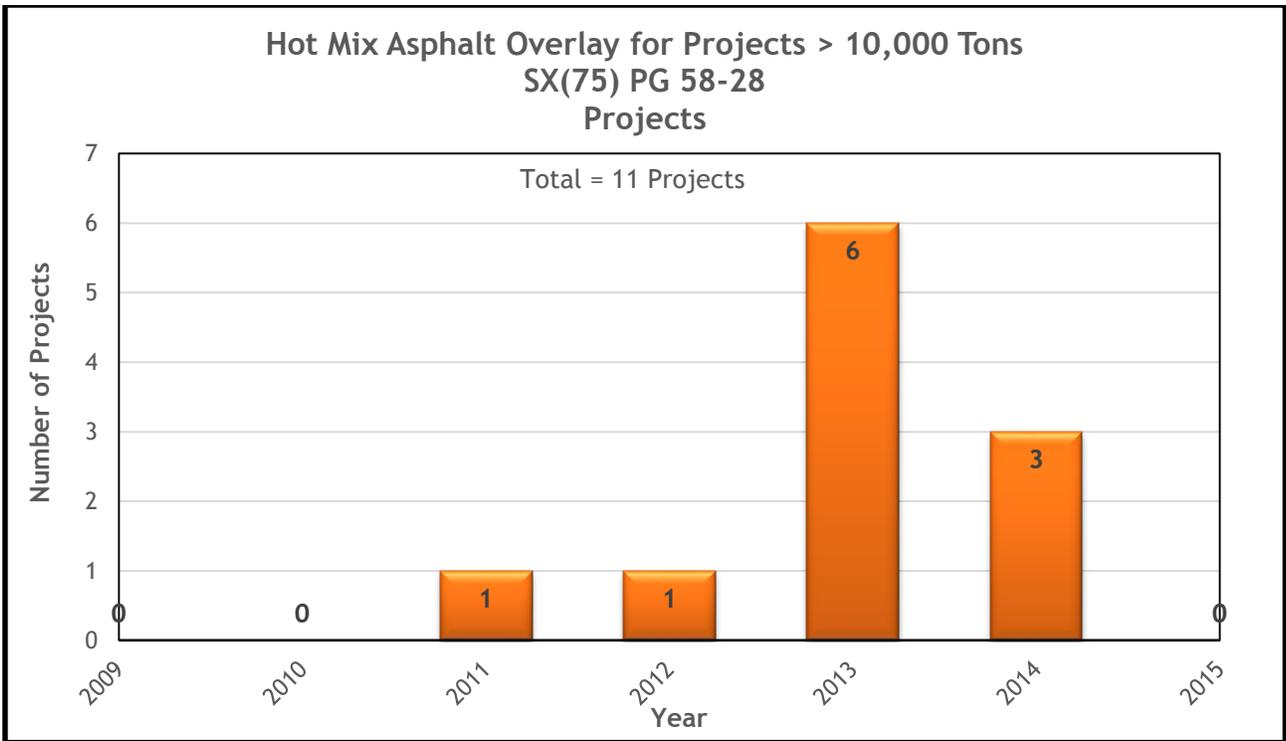


Figure 68 HMA Overlay Projects Using SX(75) PG 58-28 Greater Than 10,000 Tons per Year

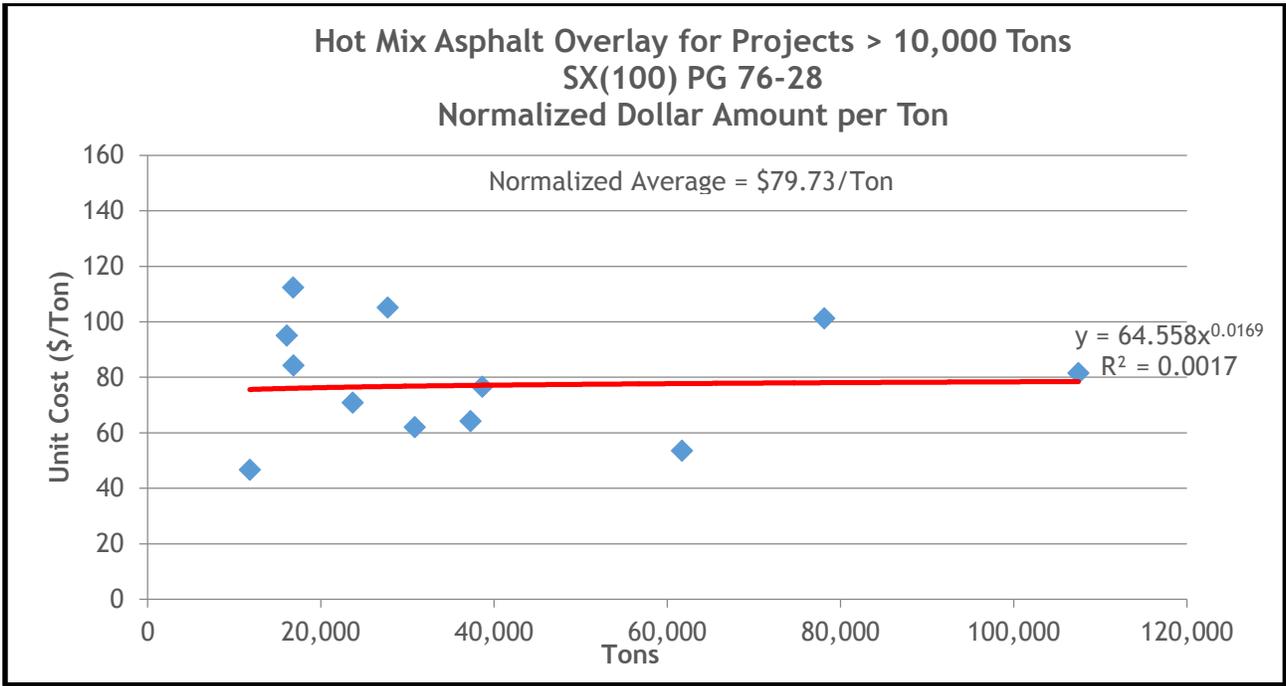


Figure 69 HMA Overlay Normalized Unit Costs for SX(100) PG 76-28 on Projects with Greater than 10,000 Tons

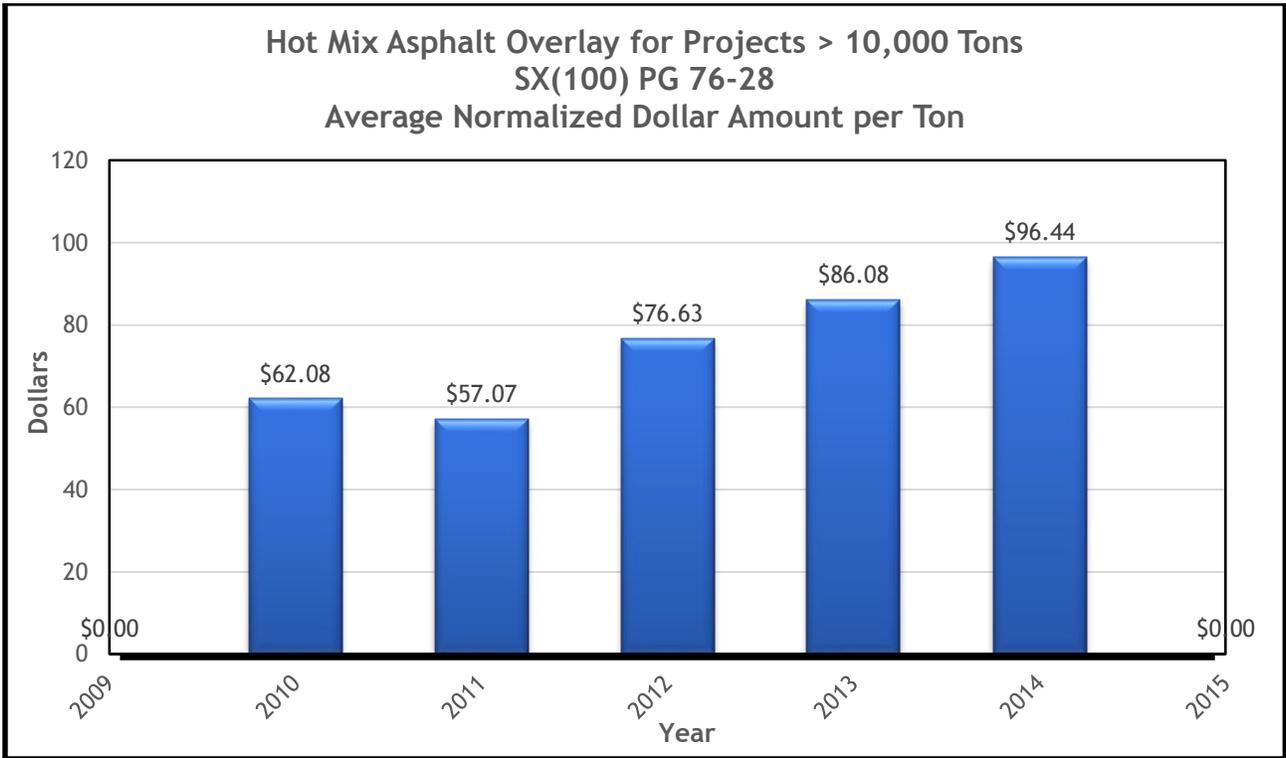


Figure 70 HMA Overlay Average Normalized Dollar Amount for Projects Using SX(100) PG 76-28 and Greater Than 10,000 Tons per Year

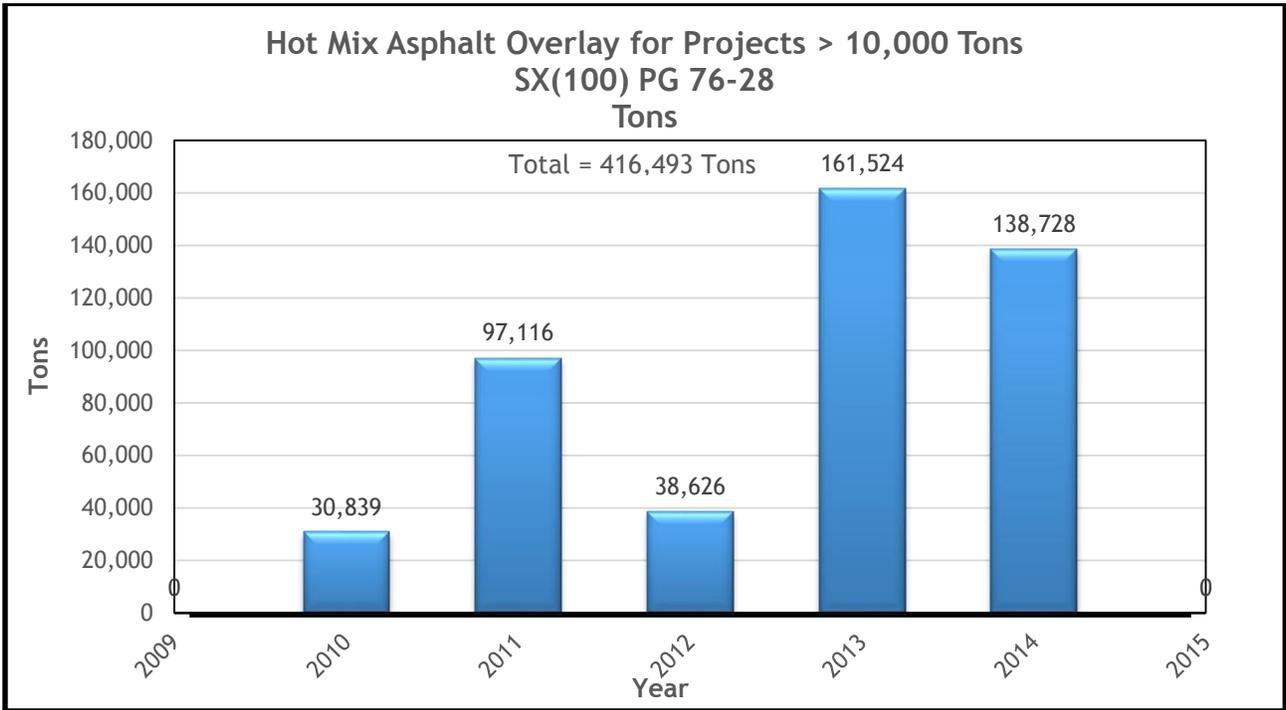


Figure 71 HMA Overlay Total Tons per Year for Projects Using SX(100) PG 76-28 and Greater Than 10,000 Tons

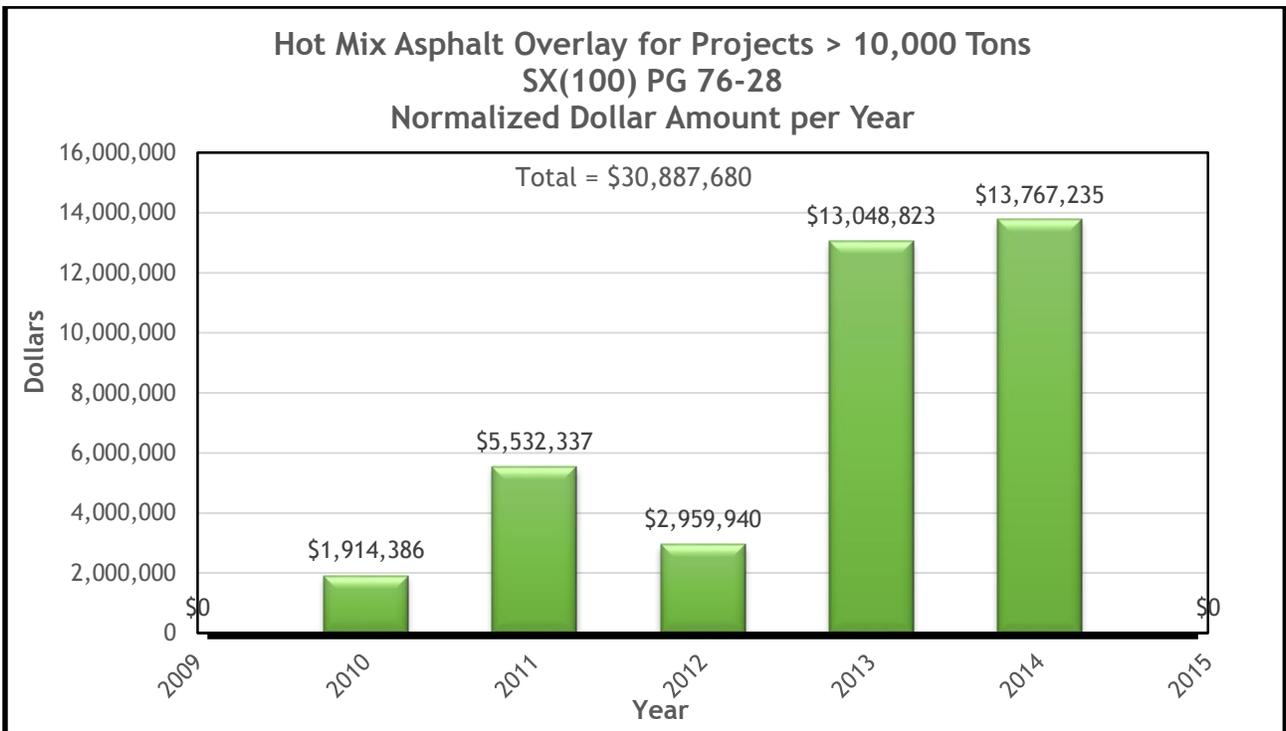


Figure 72 HMA Overlay Total Normalized Dollar Amount per Year for Projects Using SX(100) PG 76-28 and Less Than 10,000 Tons

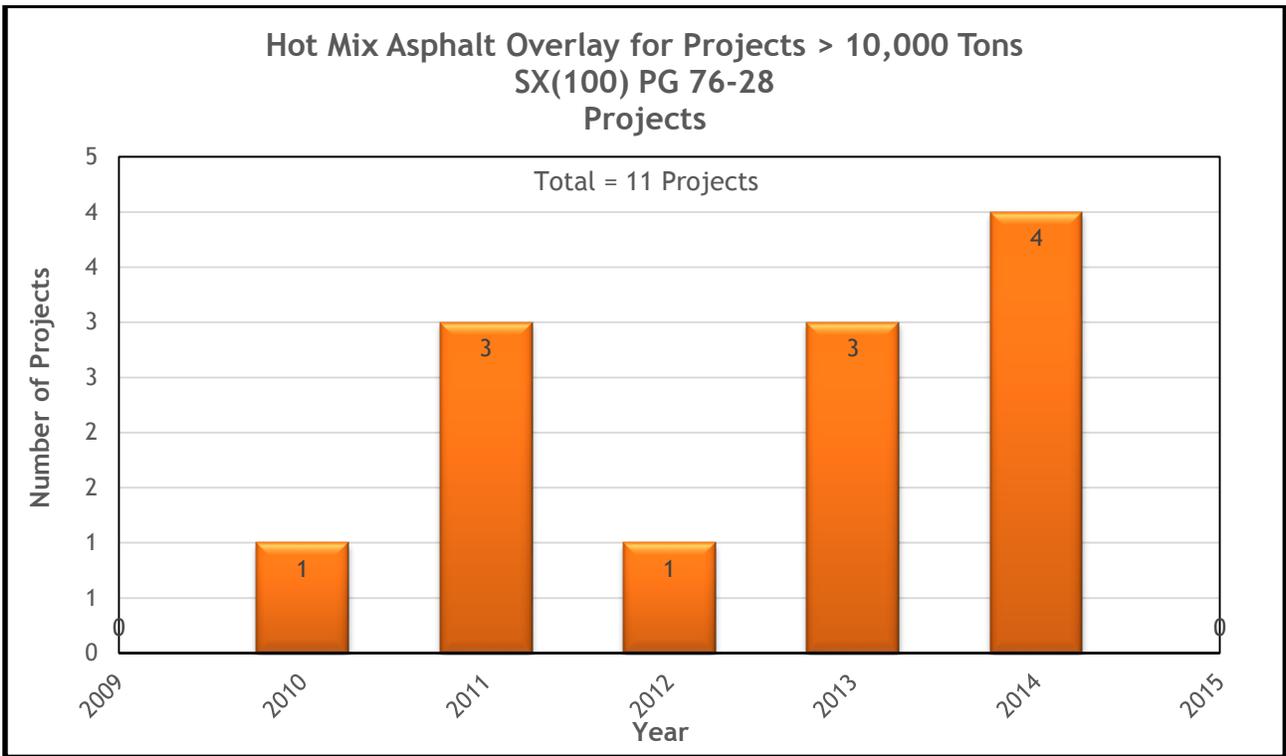


Figure 73 HMA Overlay Normalized Unit Costs for Projects Using SX(100) PG 64-22 and Greater than 10,000 Tons

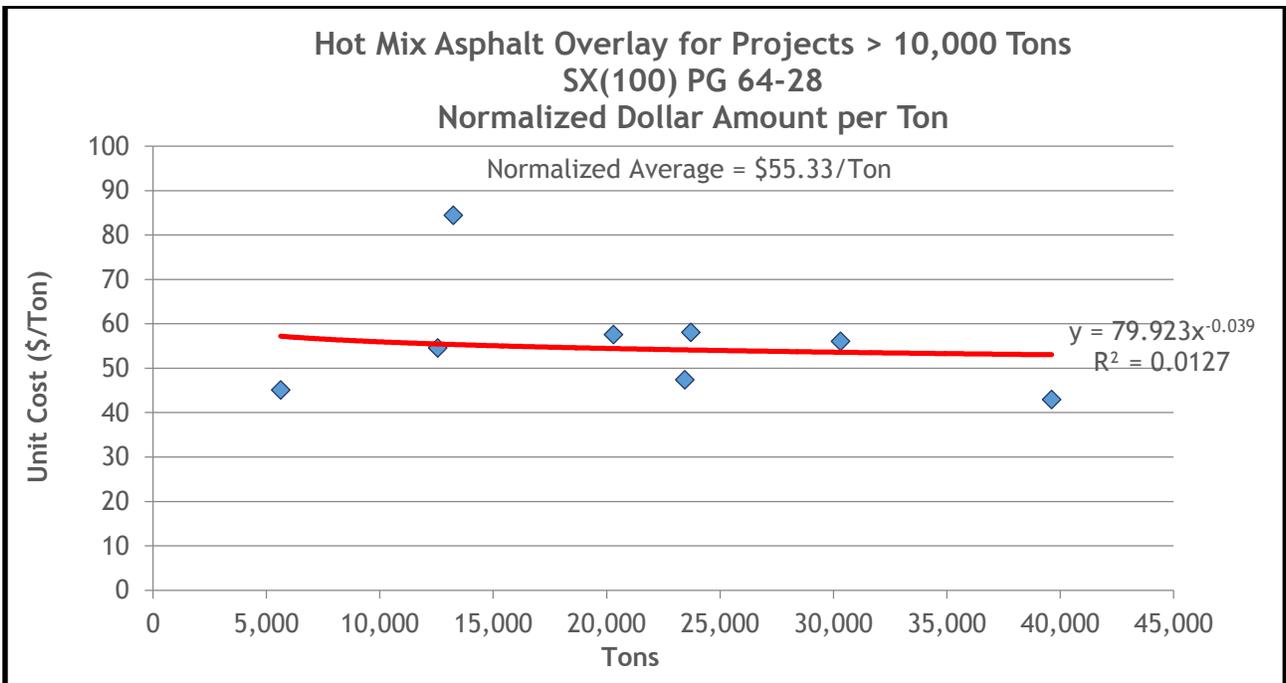


Figure 74 HMA Overlay Normalized Unit Costs for SX(100) PG 64-28 on Projects with Greater than 10,000 Tons

Appendix D
HMA Mill and Fill

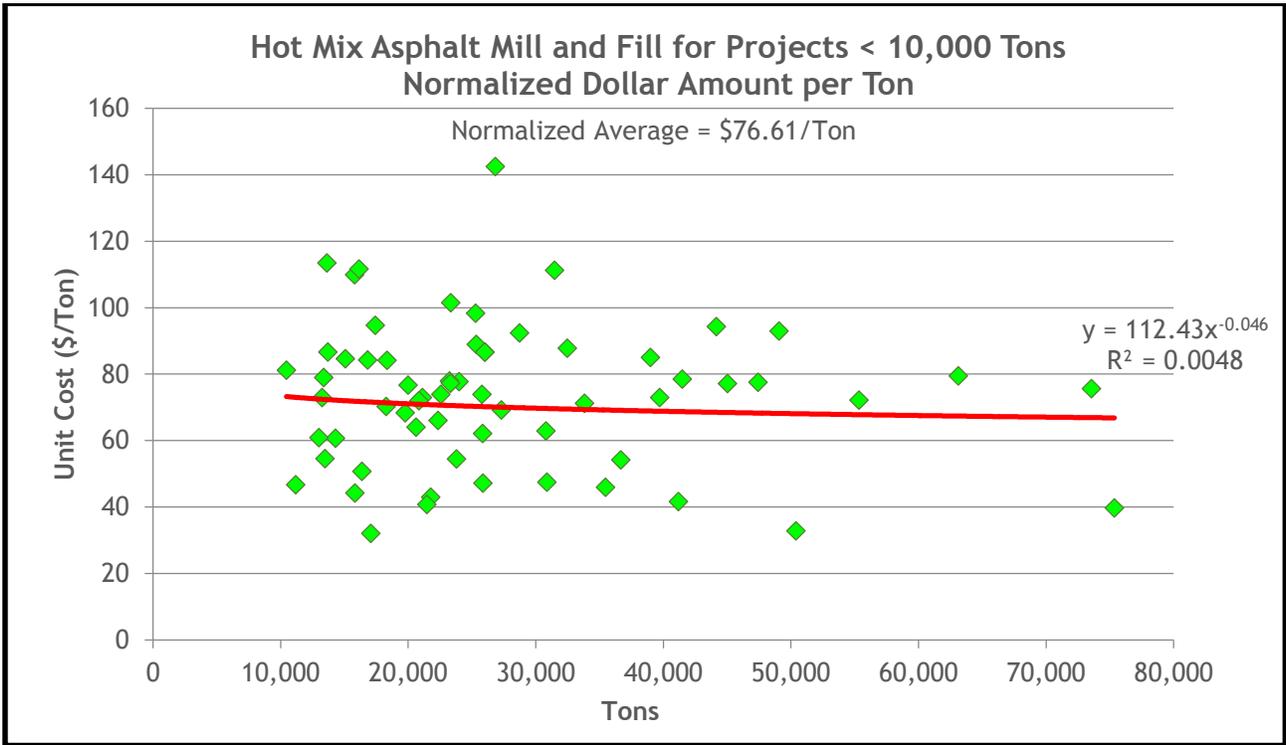


Figure 75 HMA Mill and Fill Normalized Unit Costs for Projects with Less than 10,000 Tons

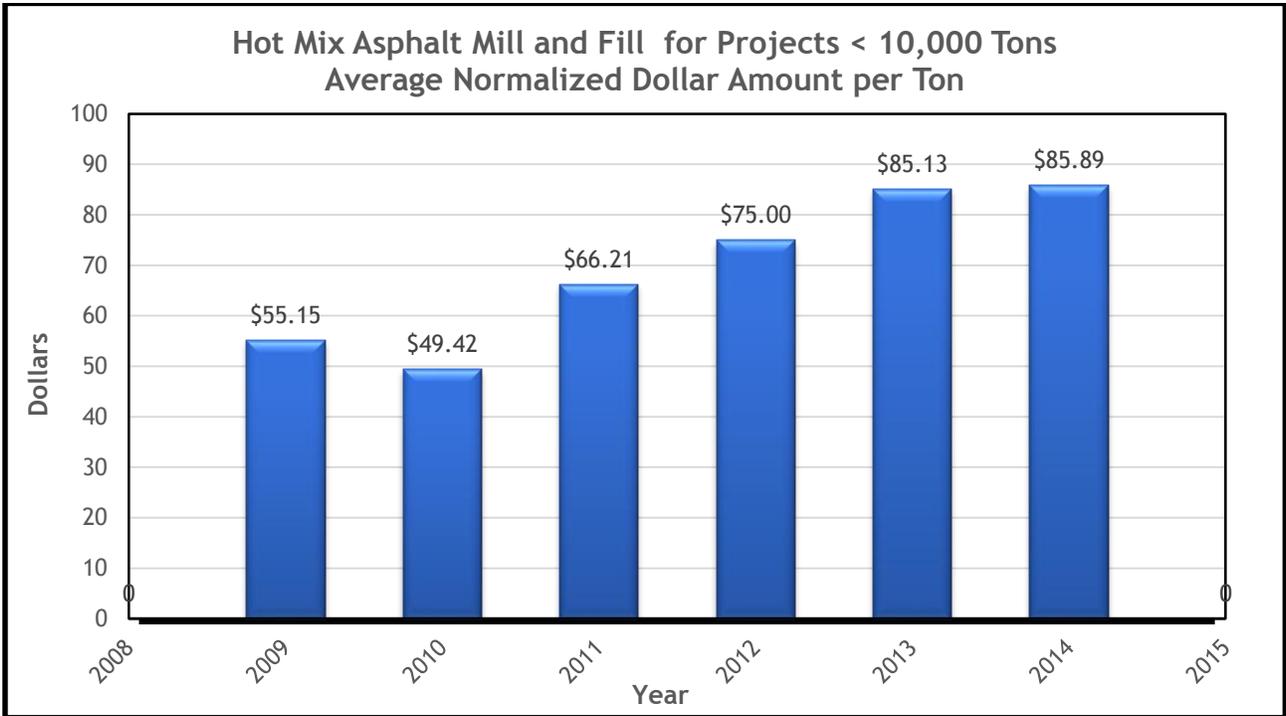


Figure 76 HMA Overlay Average Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons

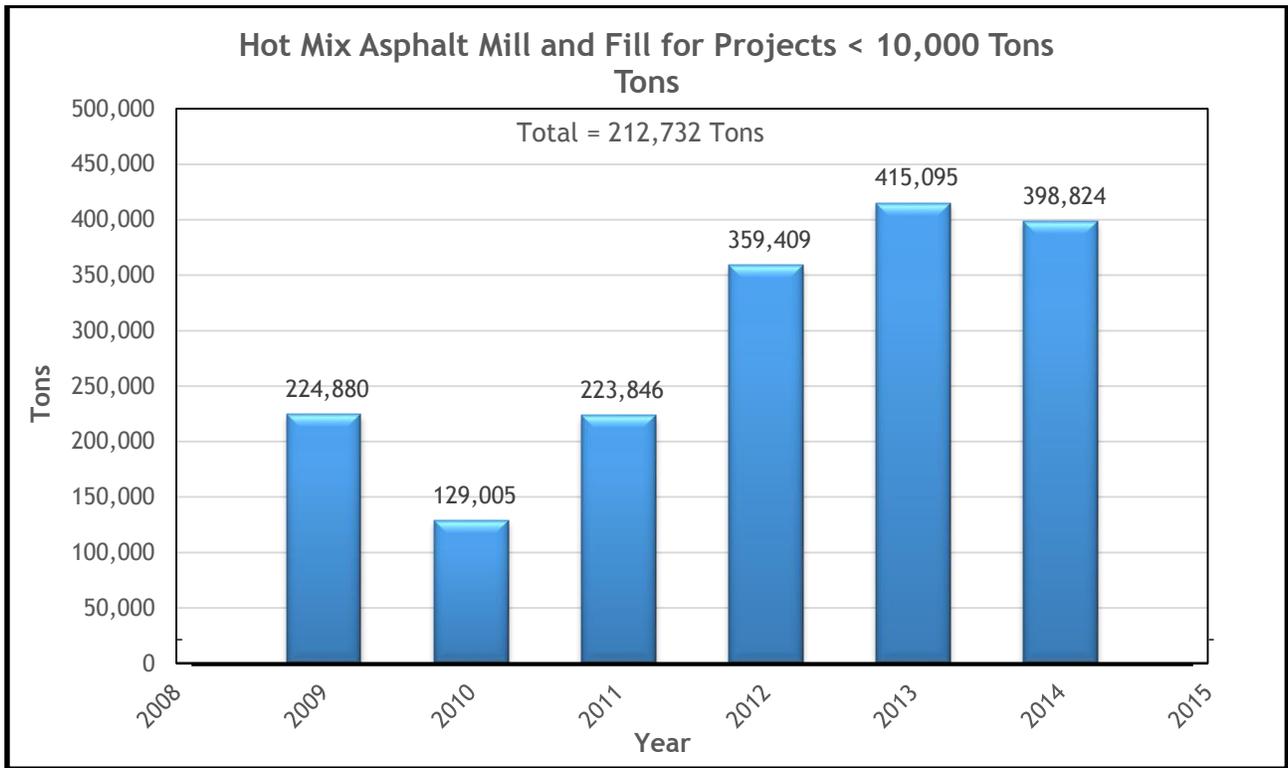


Figure 77 HMA Overlay Total Tons per Year for Projects Less Than 10,000 Tons

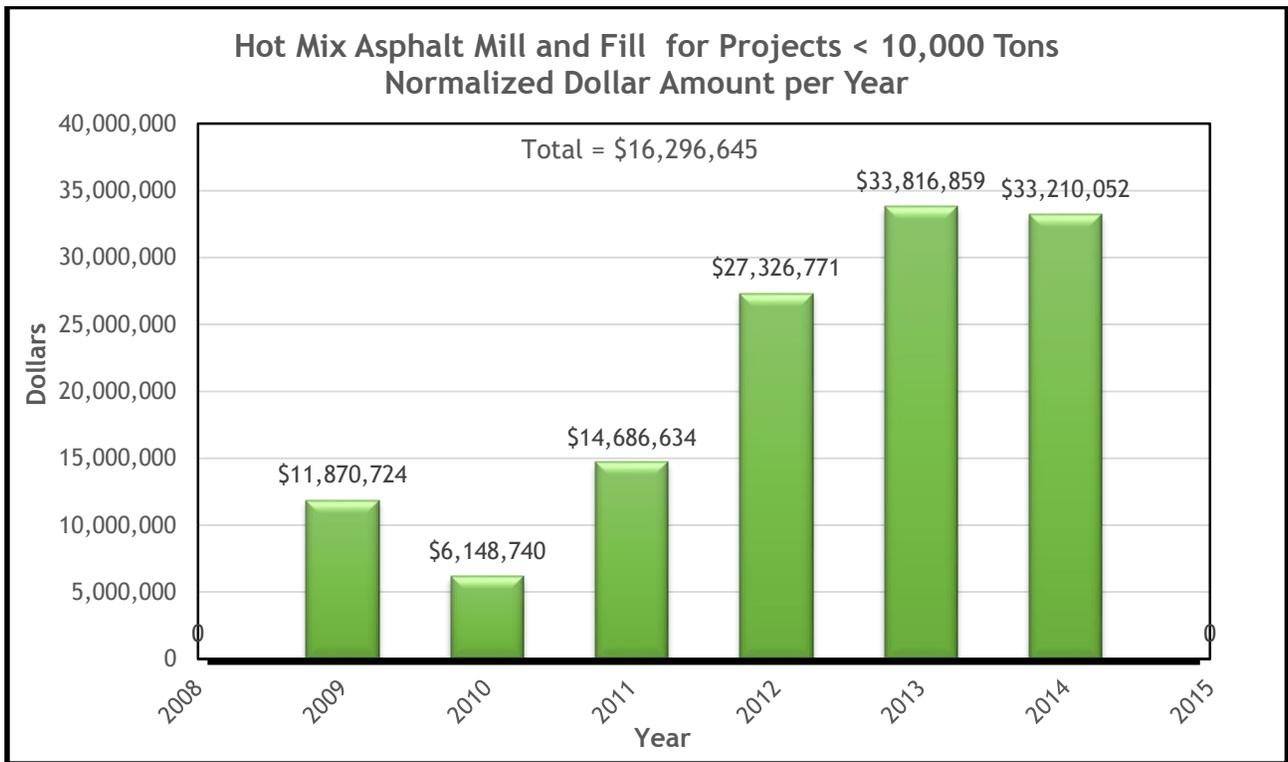


Figure 78 HMA Overlay Total Normalized Dollar Amount per Year for Projects Less Than 10,000 Tons

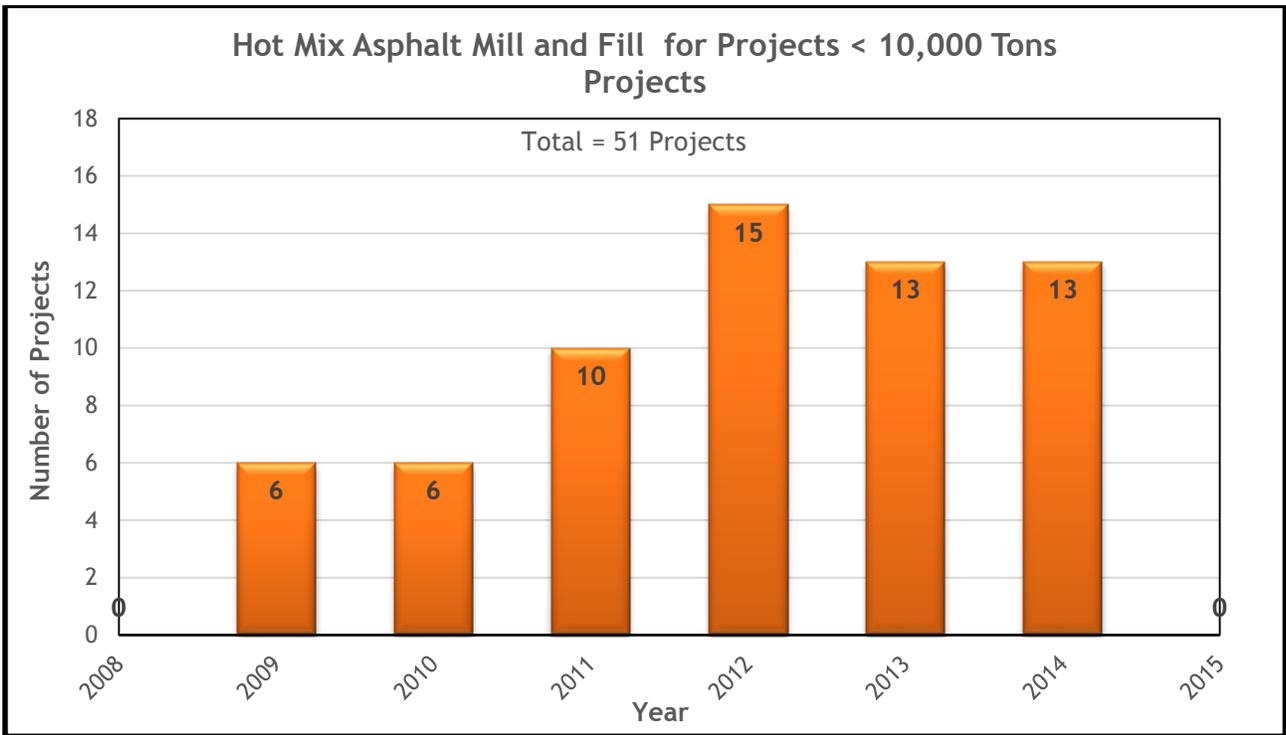


Figure 79 HMA Mill and Fill Normalized Unit Costs for Projects Less Than 10,000 Tons

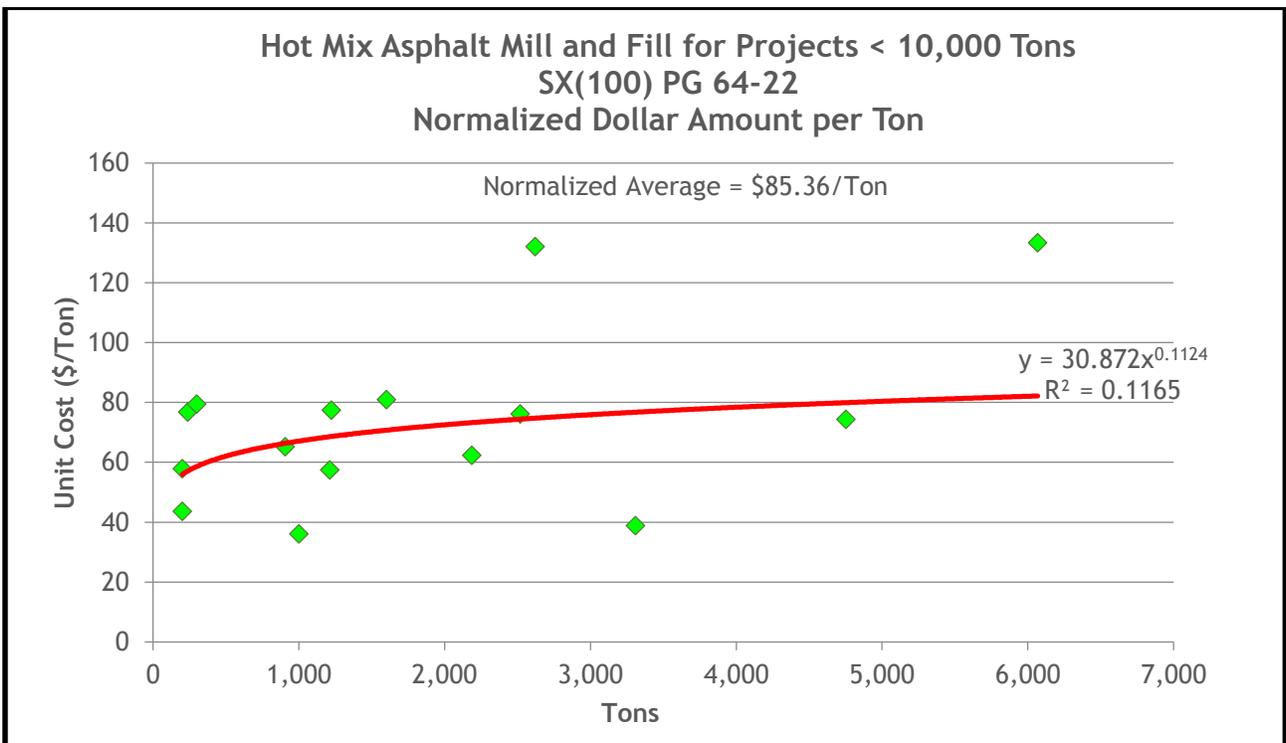


Figure 80 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 64-22 and Less than 10,000 Tons

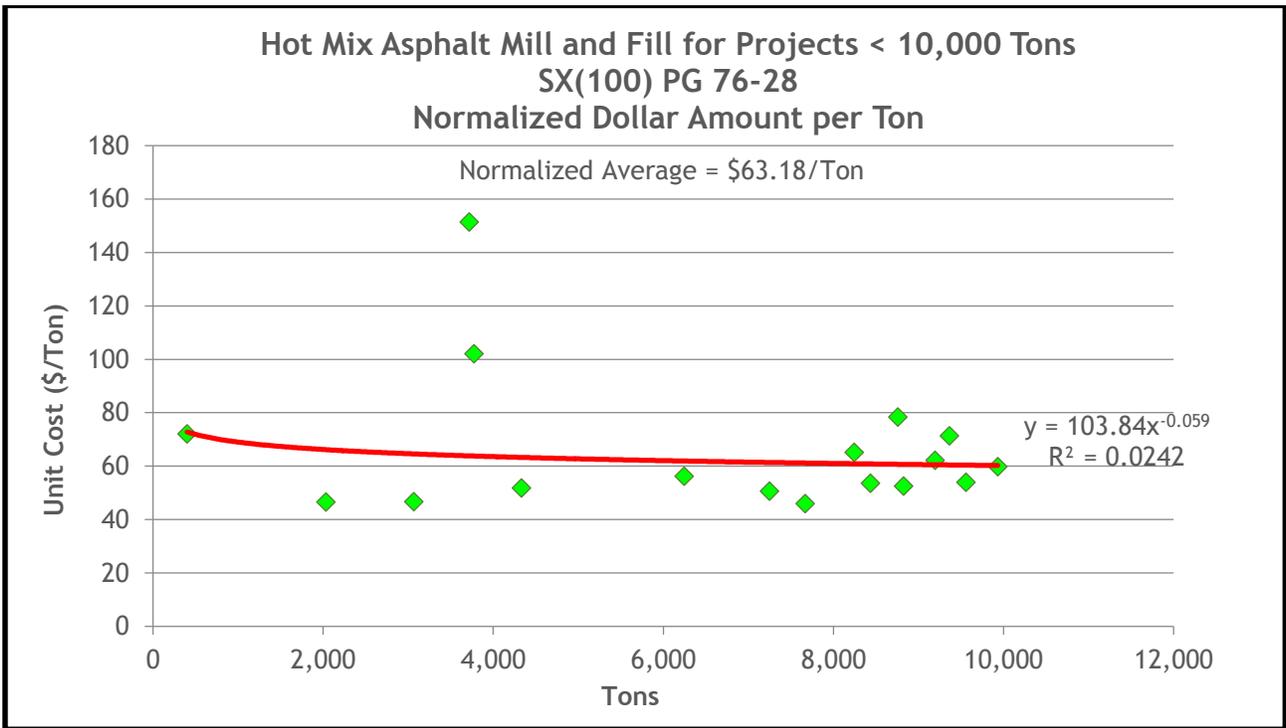


Figure 81 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 76-28 and Less than 10,000 Tons

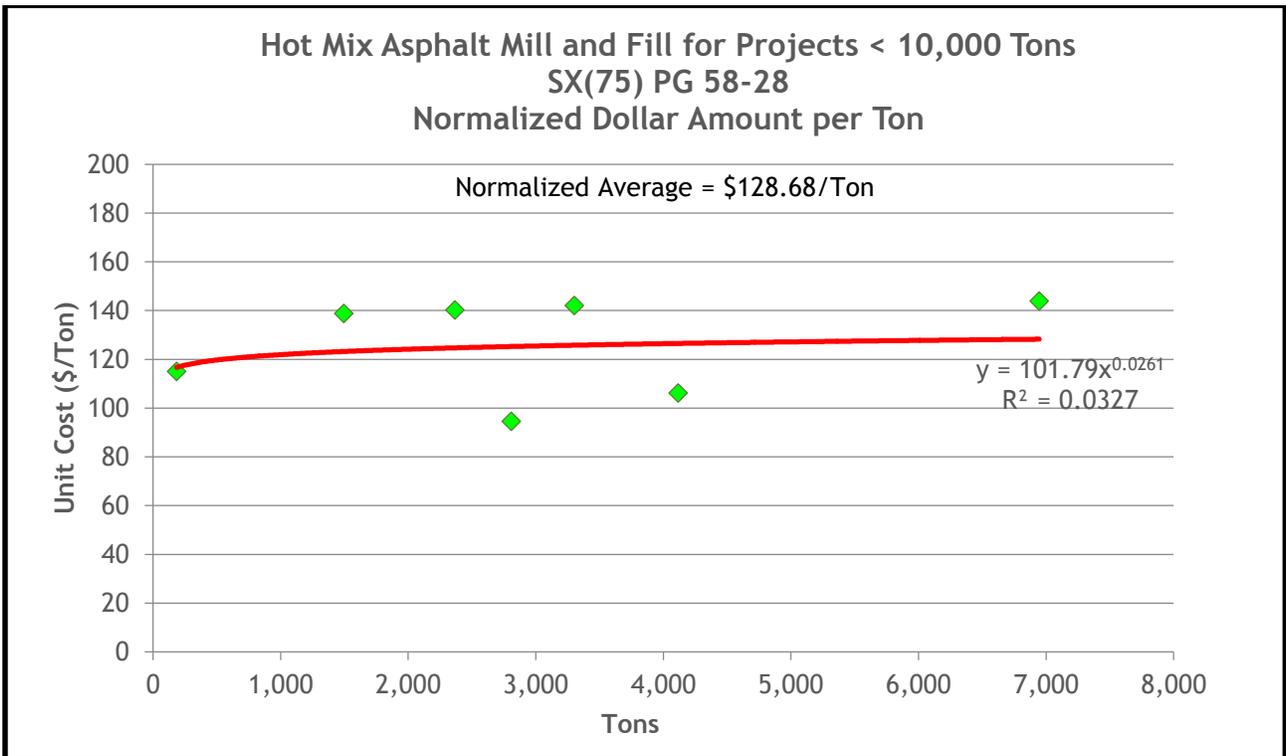


Figure 82 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 58-28 and Less than 10,000 Tons

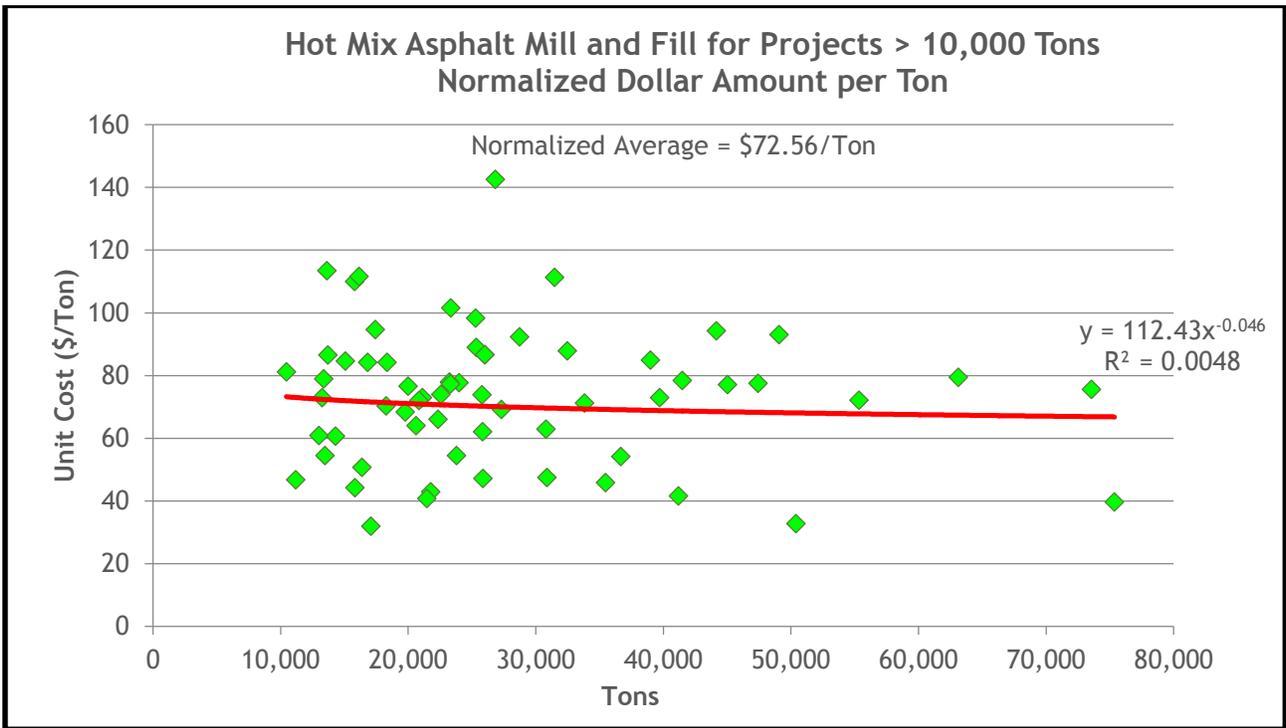


Figure 83 HMA Mill and Fill Normalized Unit Costs for Projects Greater than 10,000 Tons

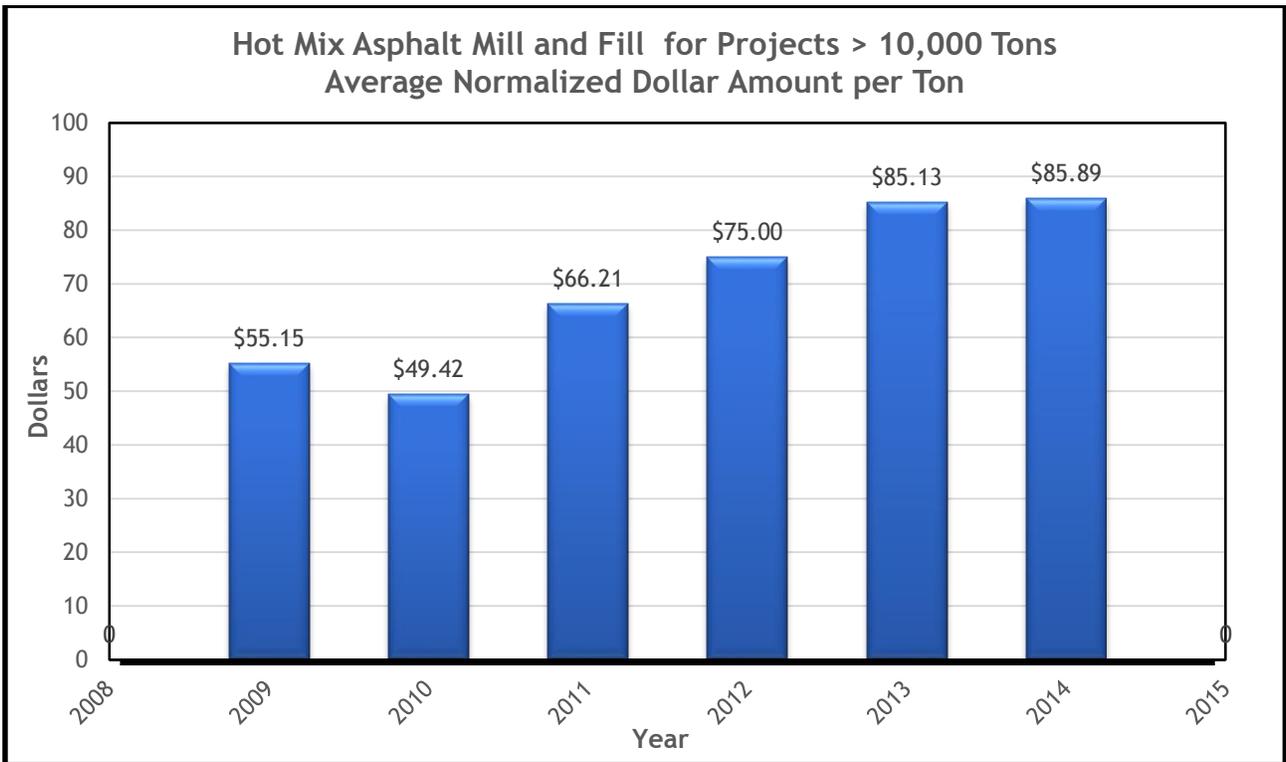


Figure 84 HMA Overlay Average Normalized Dollar Amount for Projects Greater Than 10,000 Tons

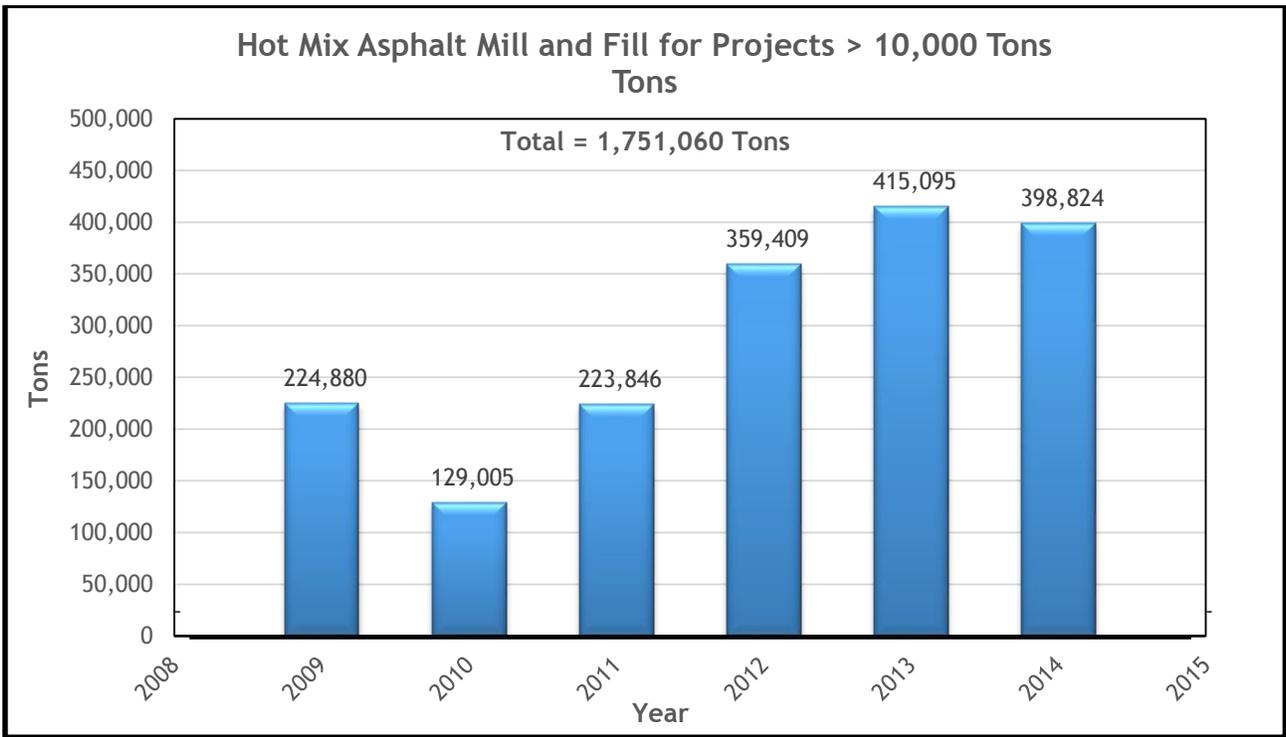


Figure 85 HMA Overlay Total Tons per Year for Projects Greater Than 10,000 Tons

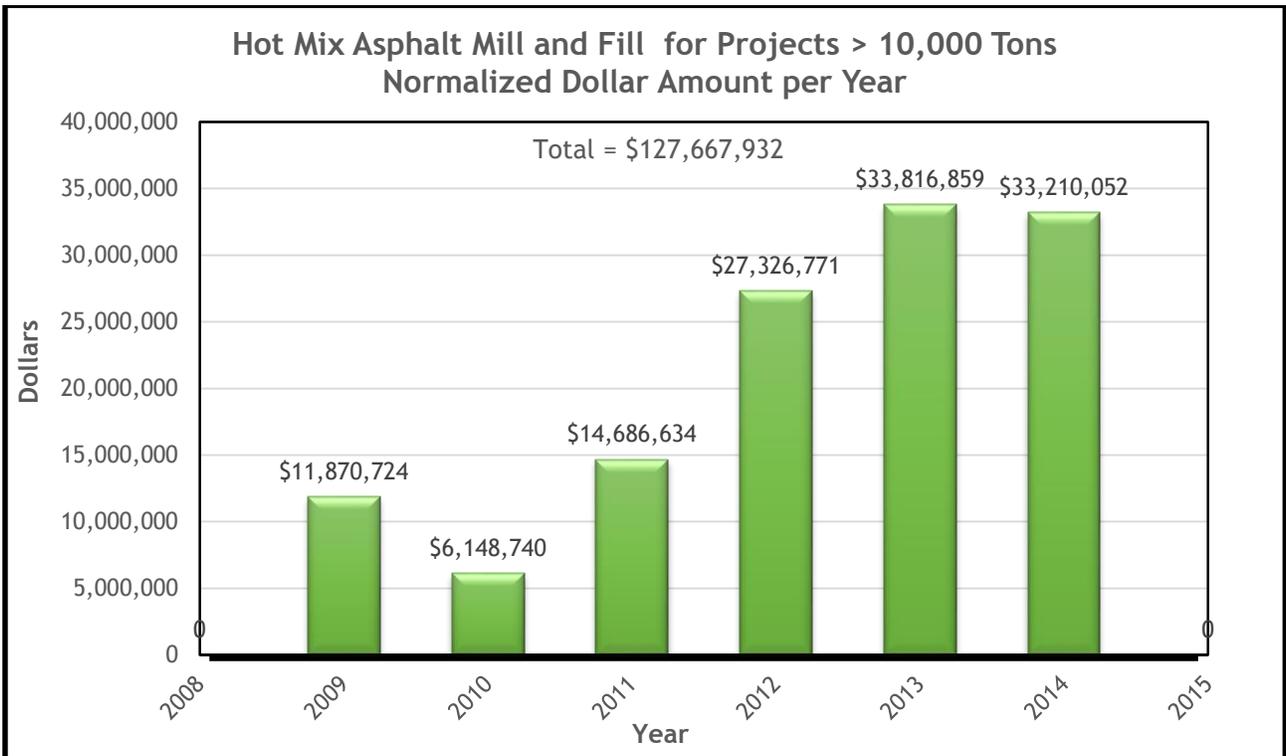


Figure 86 HMA Overlay Total Normalized Dollar Amount per Year for Projects Greater Than 10,000 Tons

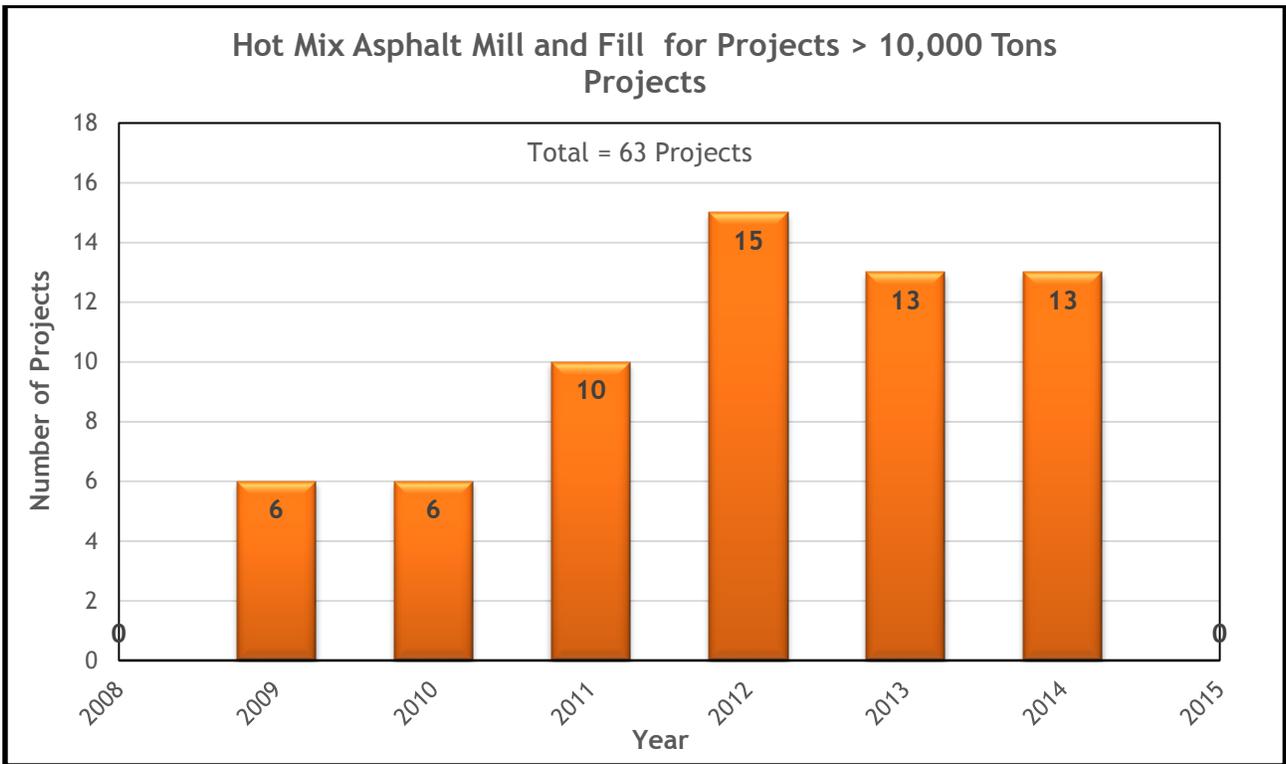


Figure 87 HMA Mill and Fill Normalized Unit Costs for Projects Greater Than 10,000 Tons

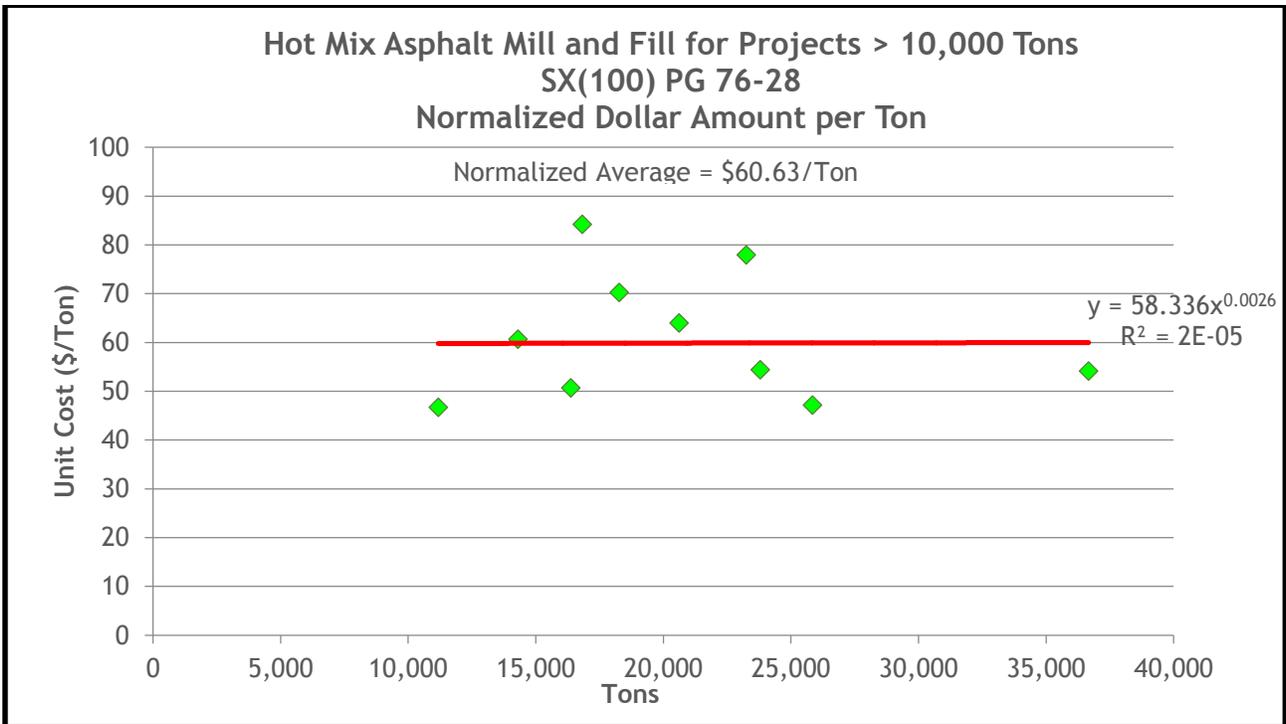


Figure 88 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 76-28 and Greater than 10,000 Tons

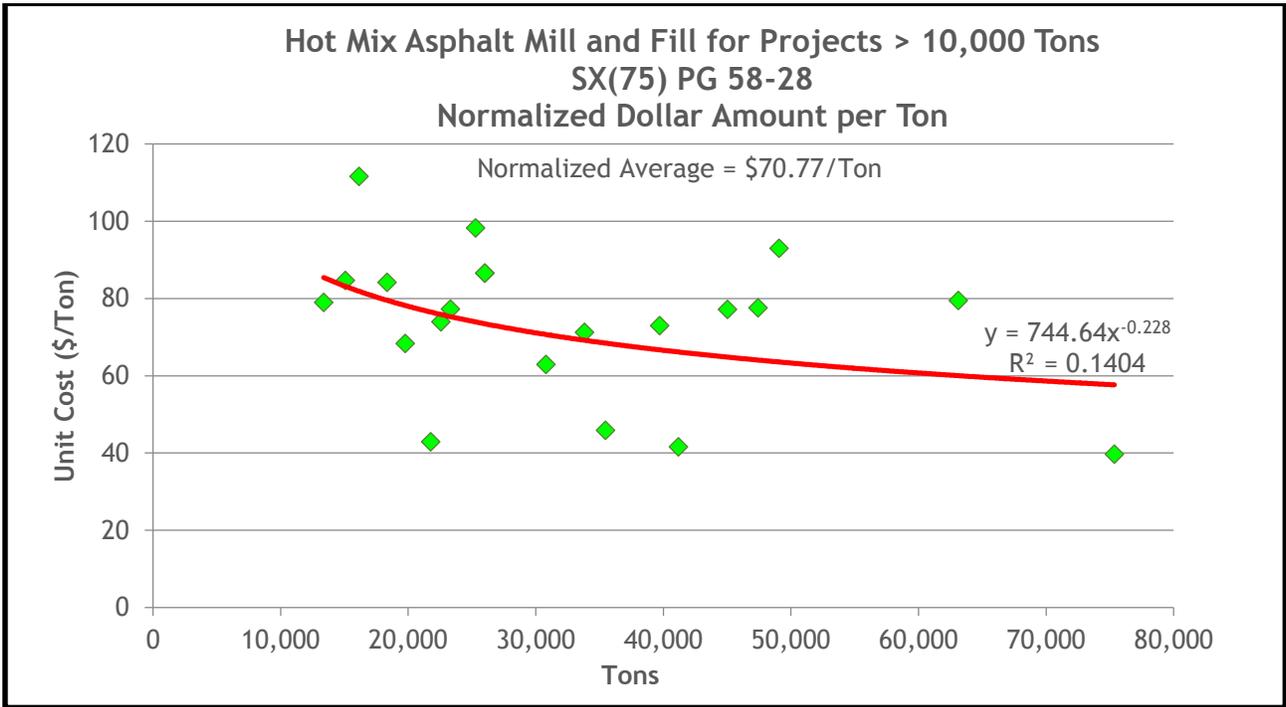


Figure 89 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 58-28 and Greater than 10,000 Tons

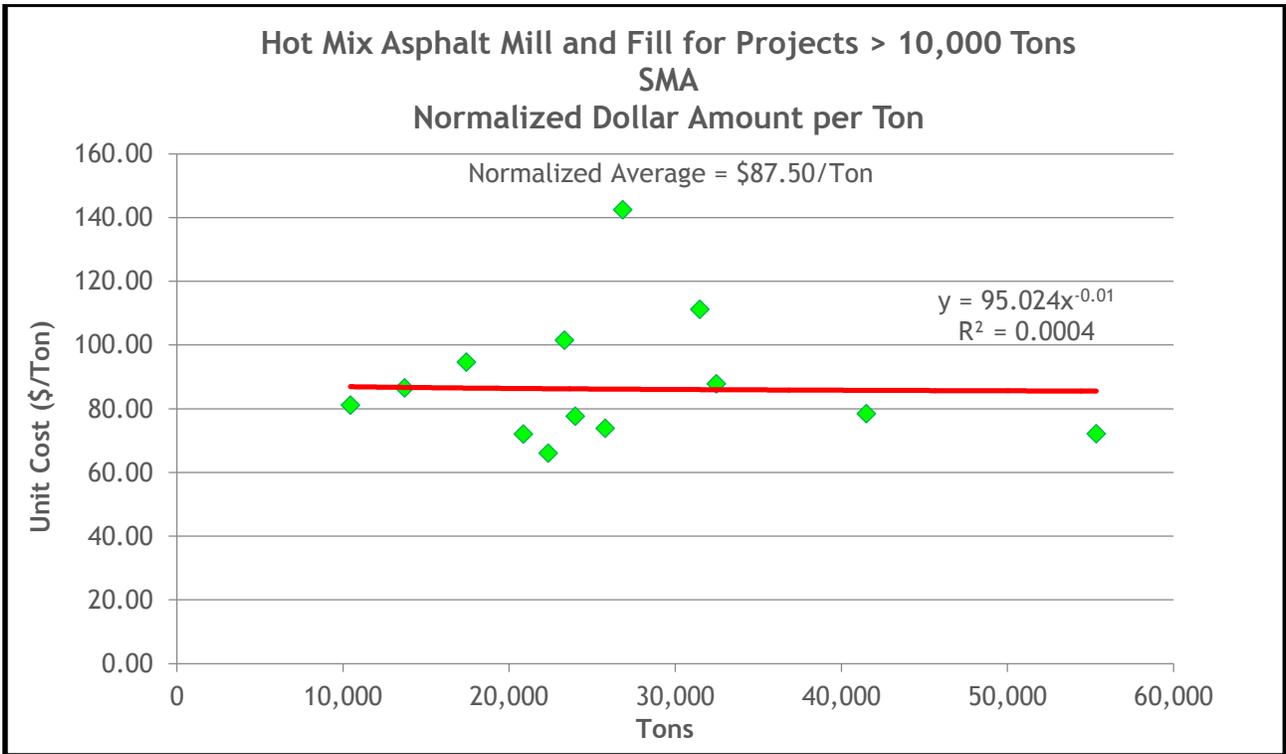


Figure 90 HMA Mill and Fill Normalized Unit Costs for Projects Using SMA and Greater than 10,000 Tons

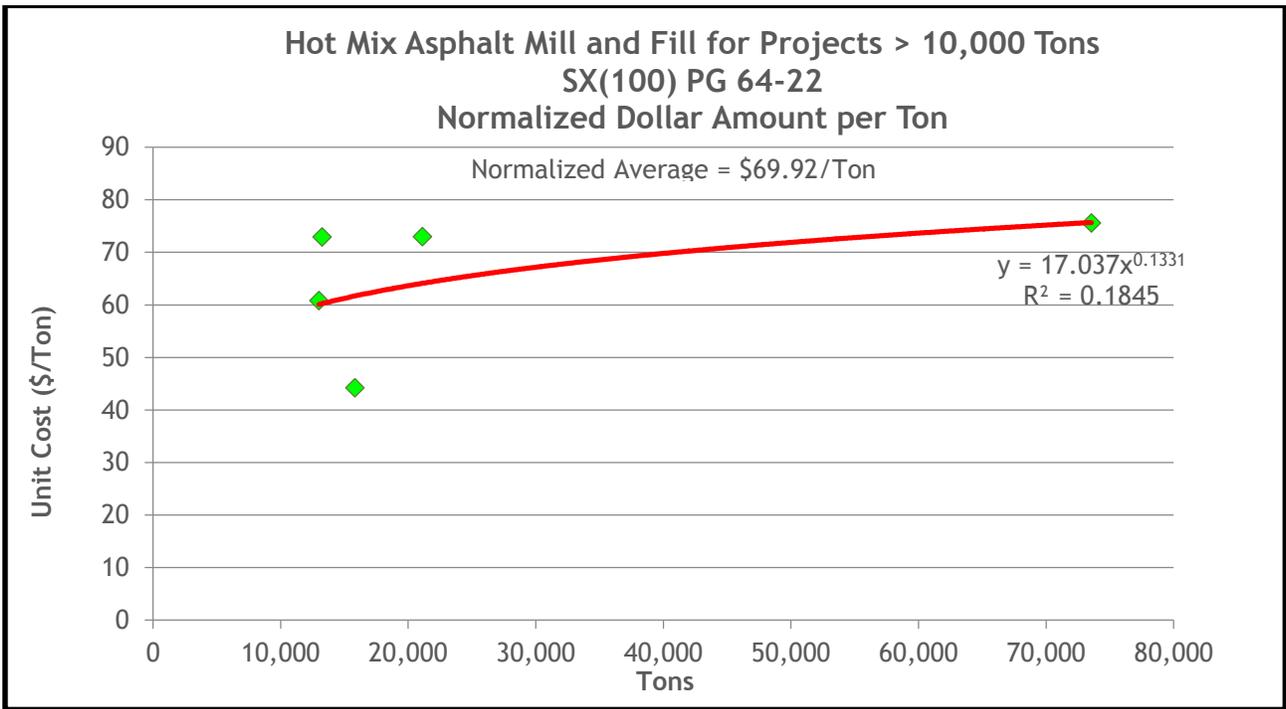


Figure 91 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 64-22 and Greater than 10,000 Tons

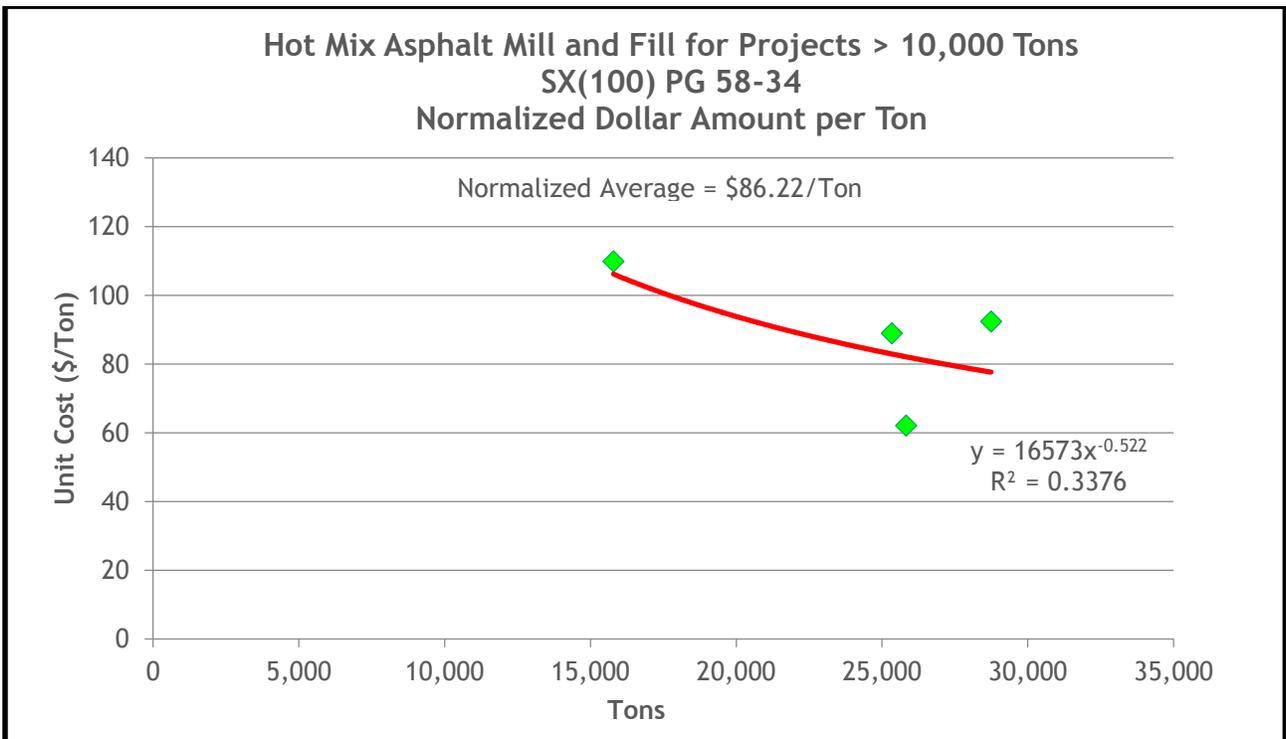


Figure 92 HMA Mill and Fill Normalized Unit Costs for Projects Using SX(100) PG 58-34 and Greater than 10,000 Tons

Appendix E
Cold In-Place Recycling

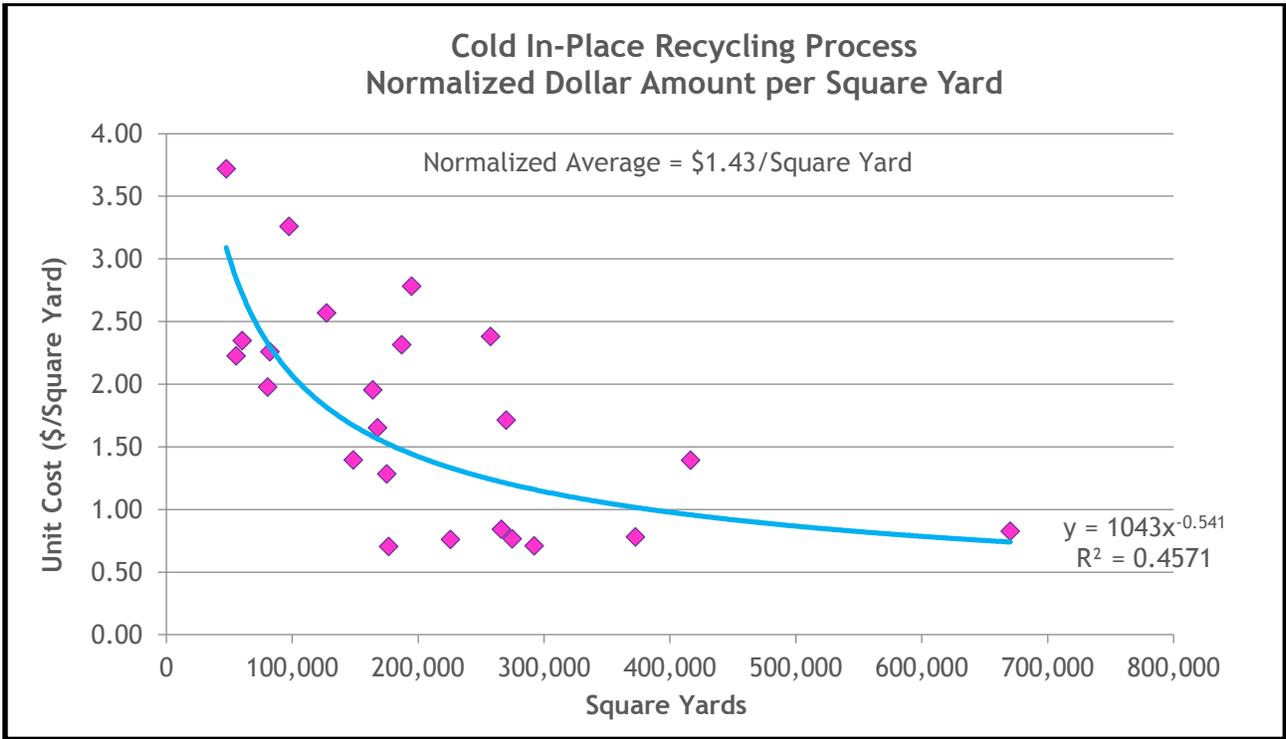


Figure 93 Cold In-Place Recycling Normalized Dollar Amount per Square Yard

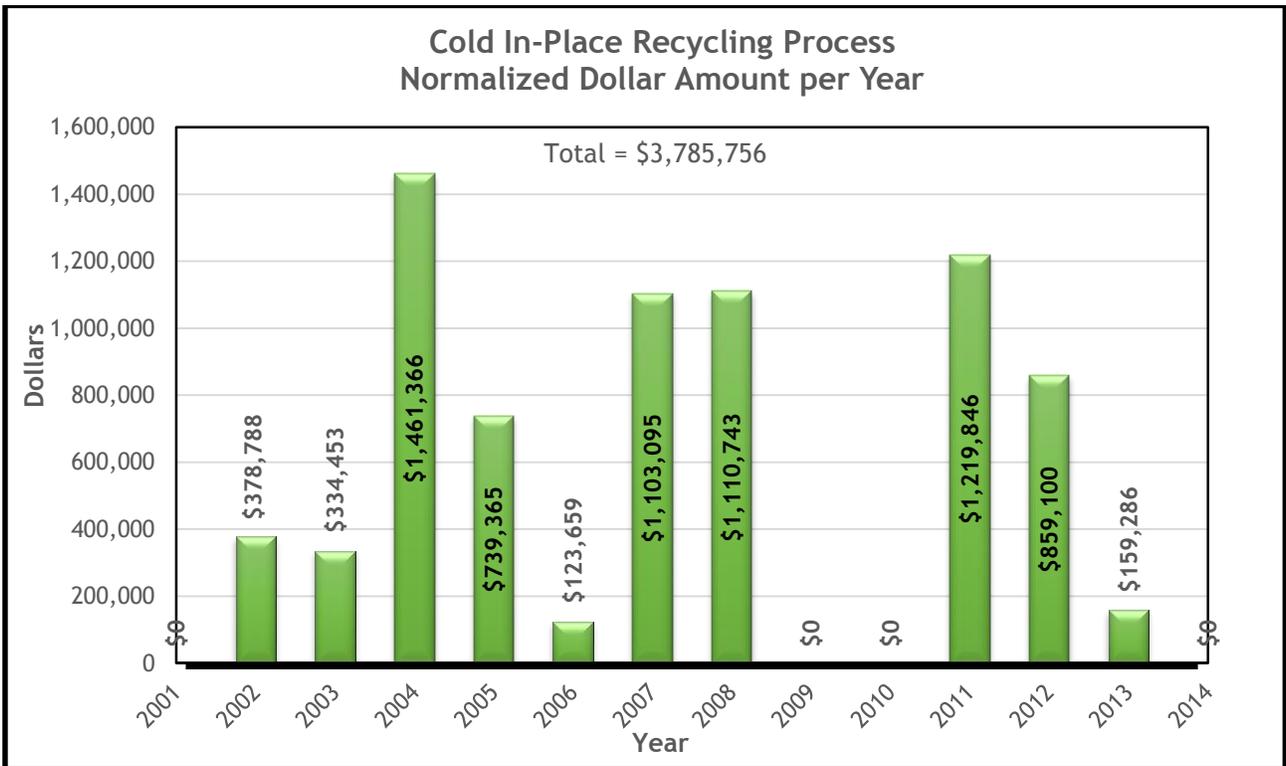


Figure 94 Cold In-Place Recycling Normalized Dollar Amount per Year

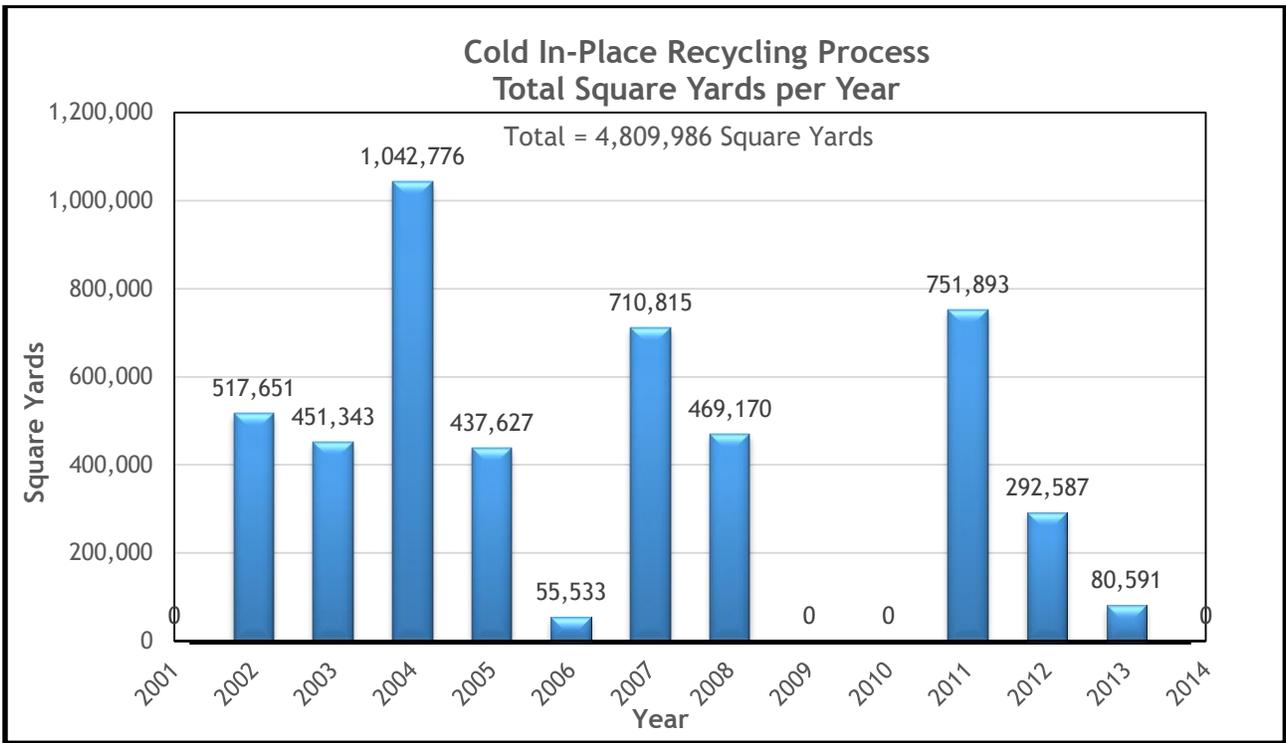


Figure 95 Cold In-Place Recycling Projects Total Square Yards per Year

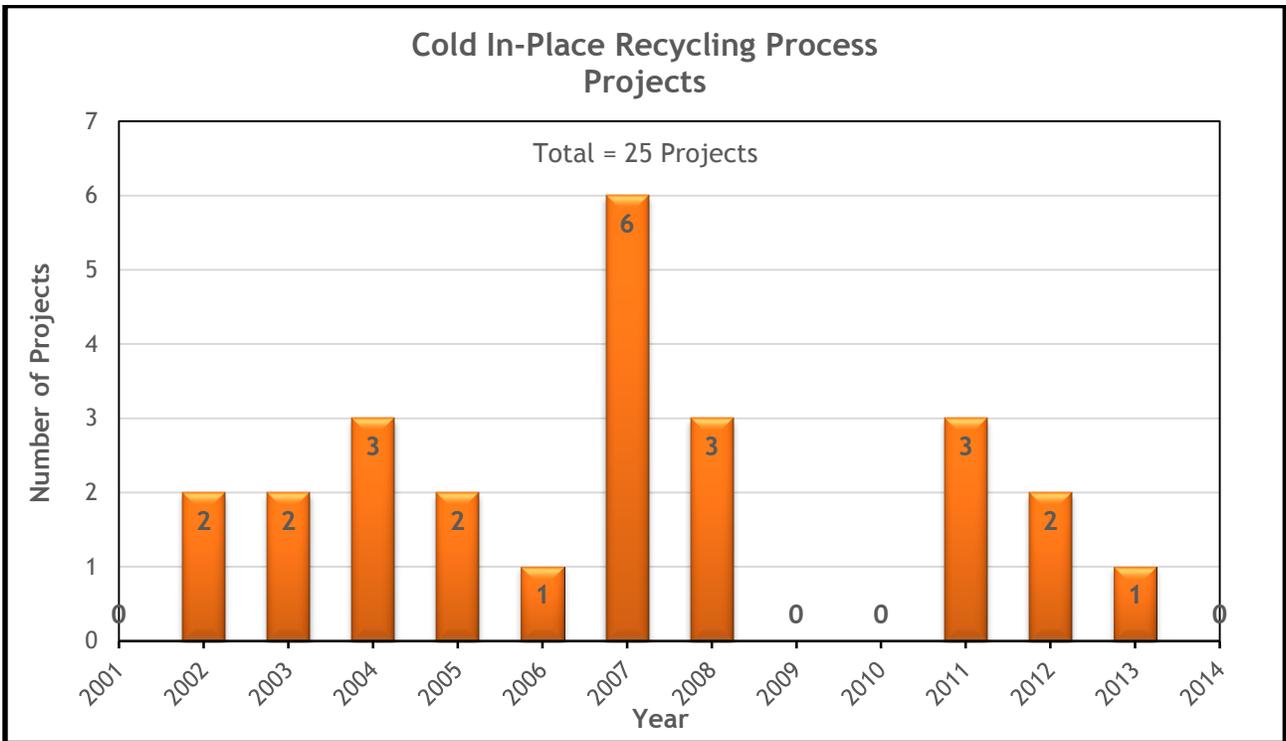


Figure 96 Cold In-Place Recycling Projects per Year

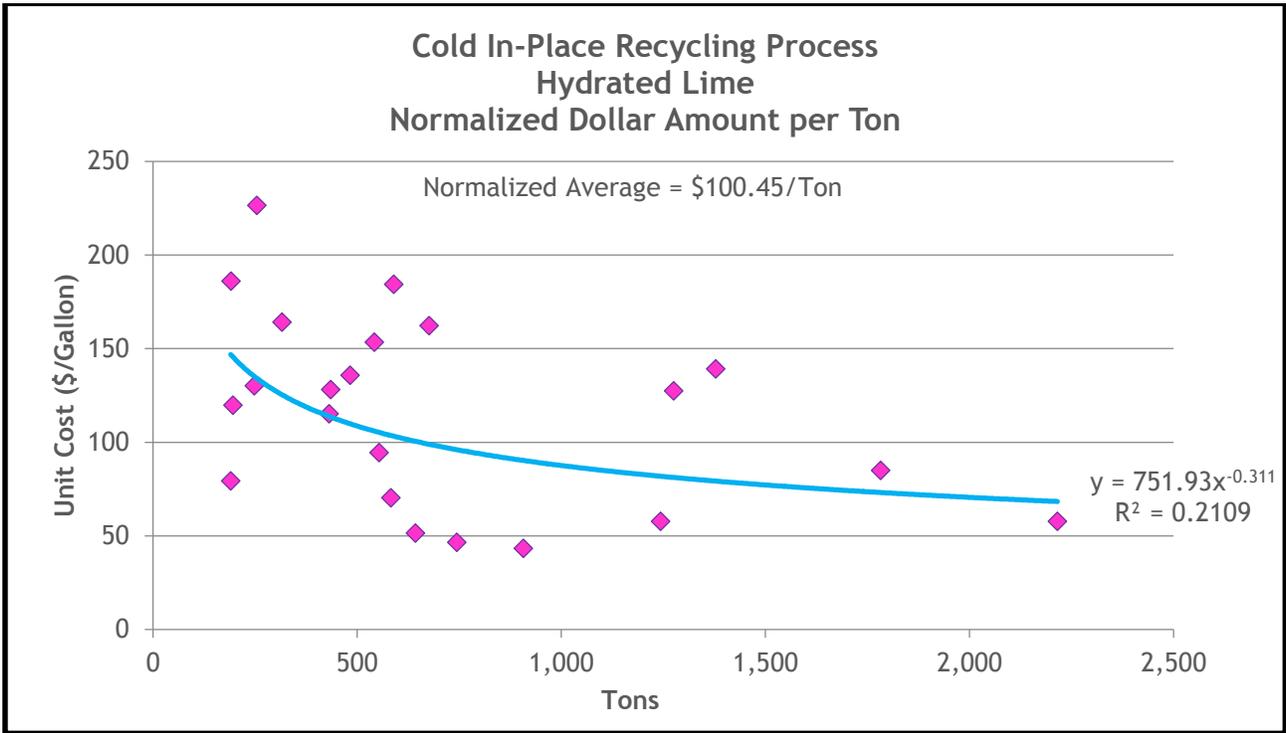


Figure 97 Cold In-Place Recycling Hydrated Lime Normalized Dollar Amount per Ton

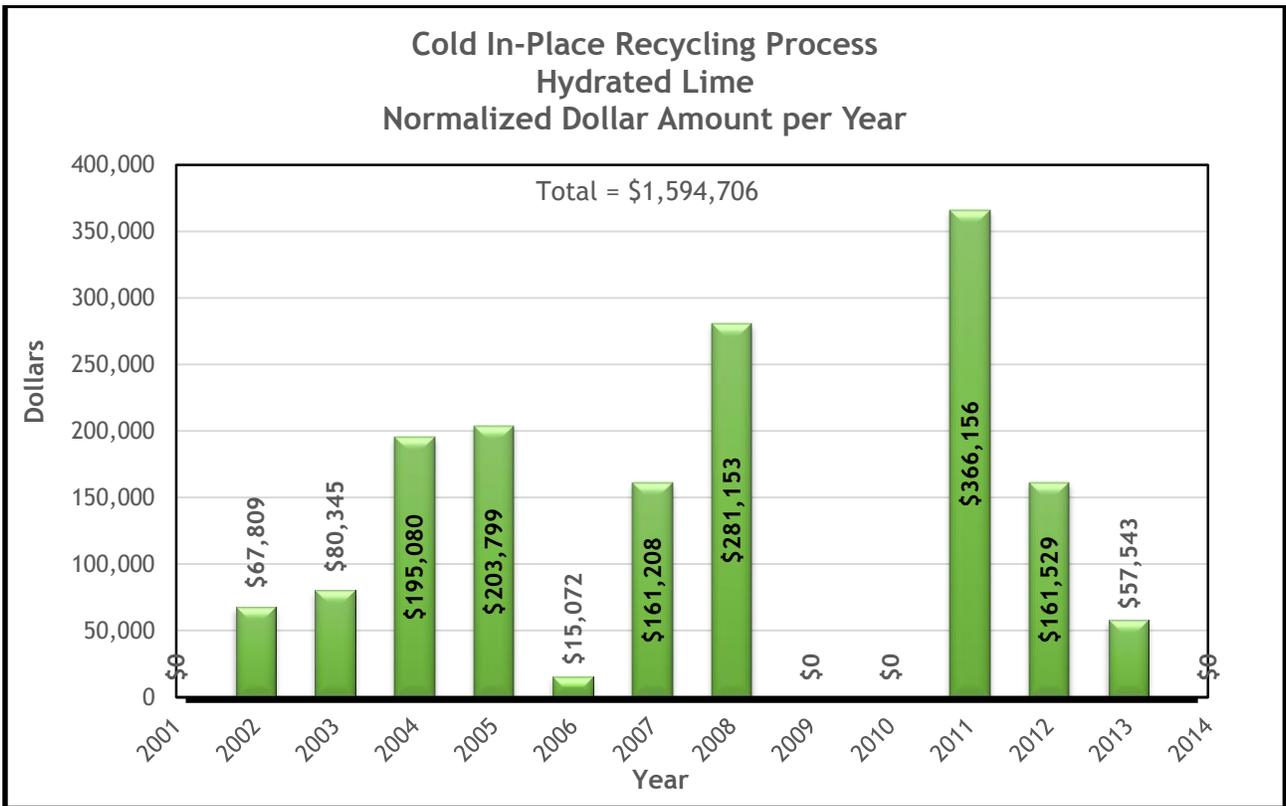


Figure 98 Cold In-Place Recycling Normalized Dollar Amount for Hydrated Lime per Year

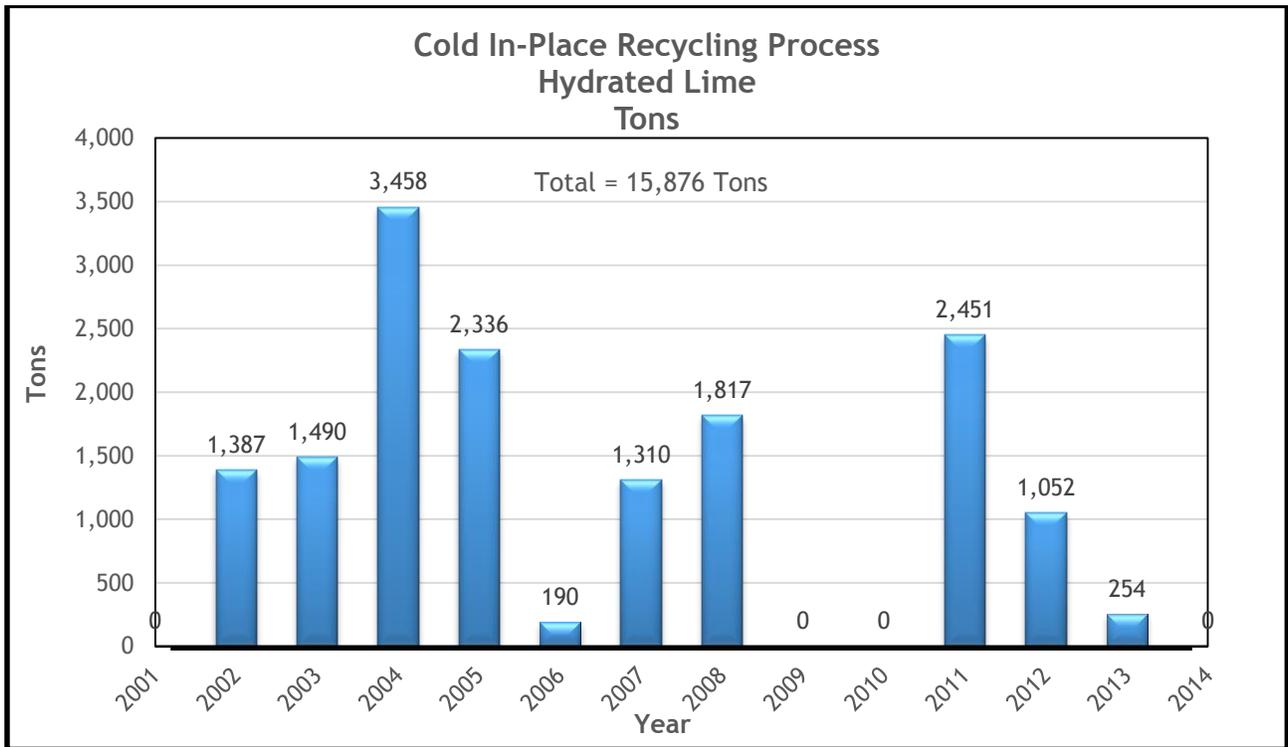


Figure 99 Cold In-Place Recycling Gallons of Hydrated Lime per Year

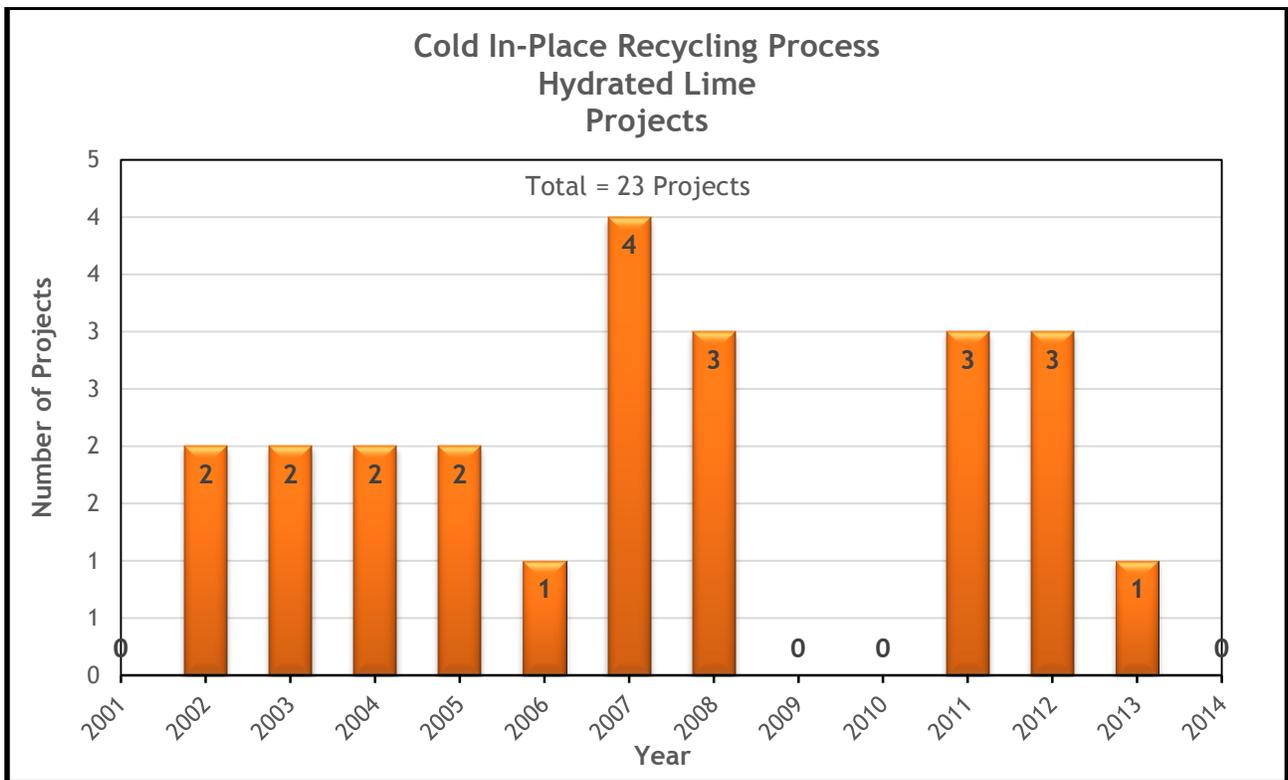


Figure 100 Cold In-Place Recycling Projects with Hydrated Lime per Year

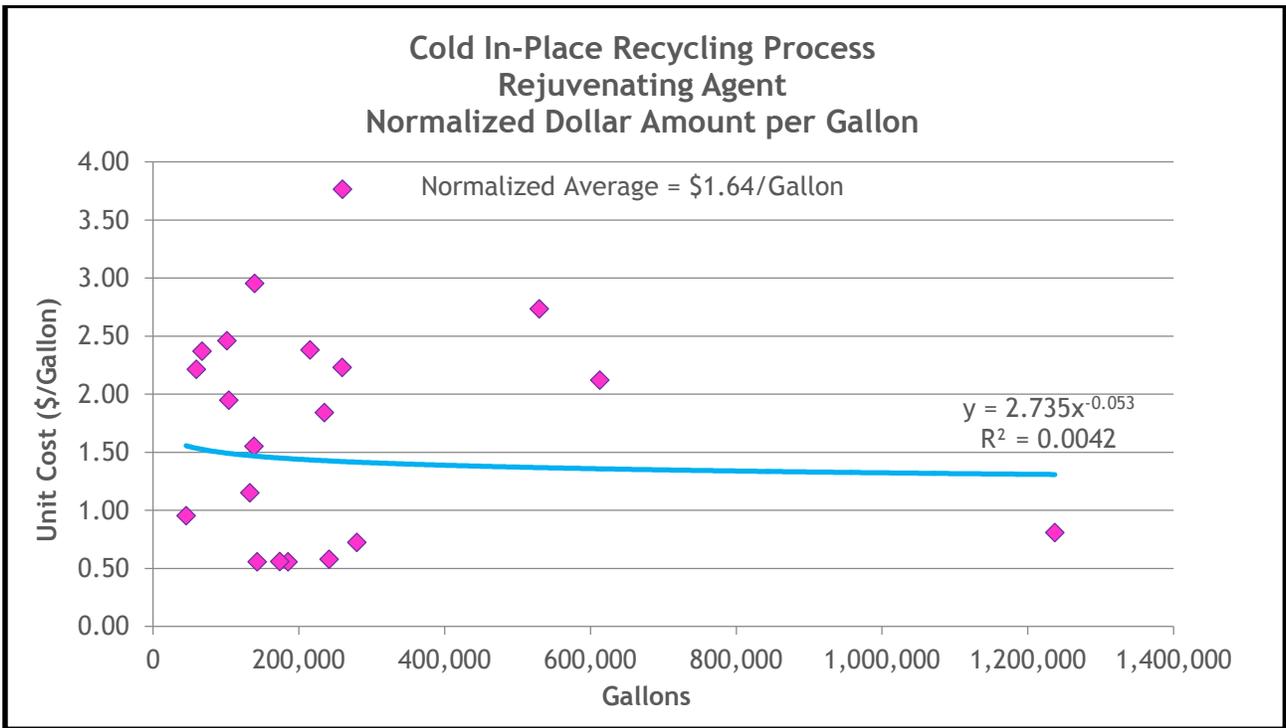


Figure 101 Cold In-Place Recycling Rejuvenating Agent Normalized Dollar Amount per Gallon

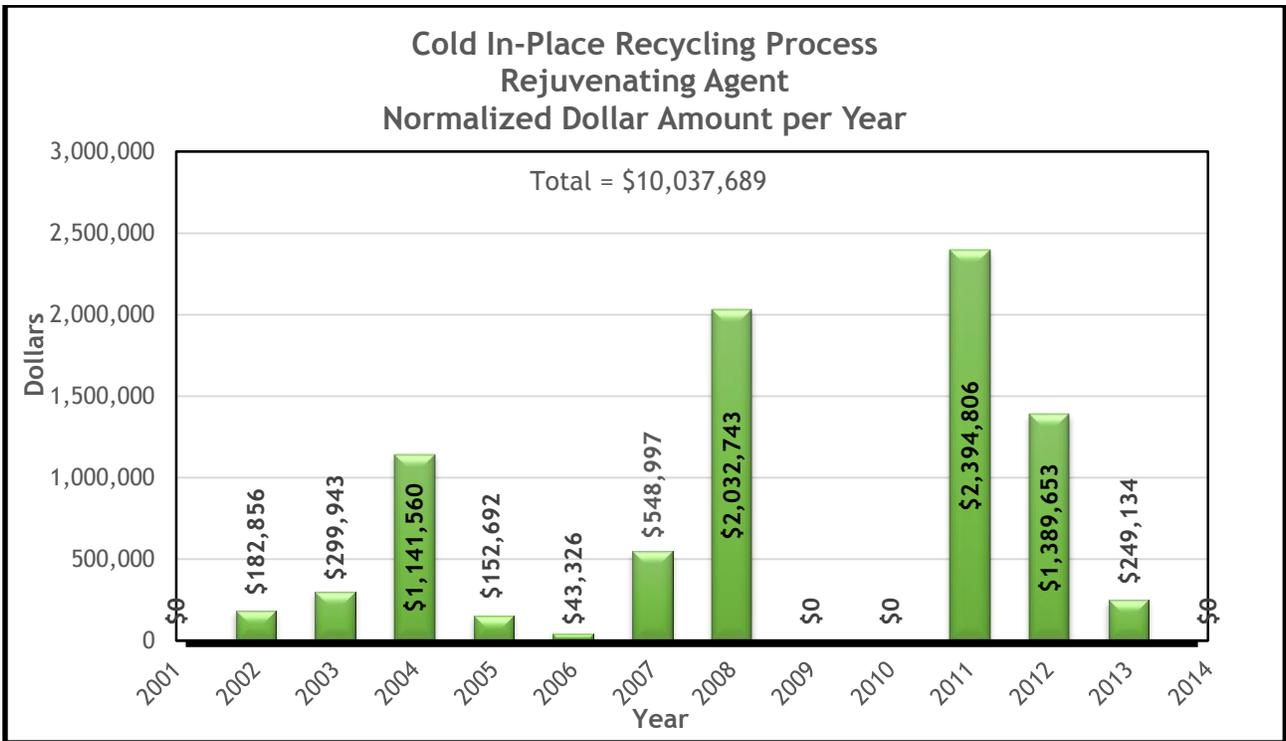


Figure 102 Cold In-Place Recycling Normalized Dollar Amount for Rejuvenating Agent per Year

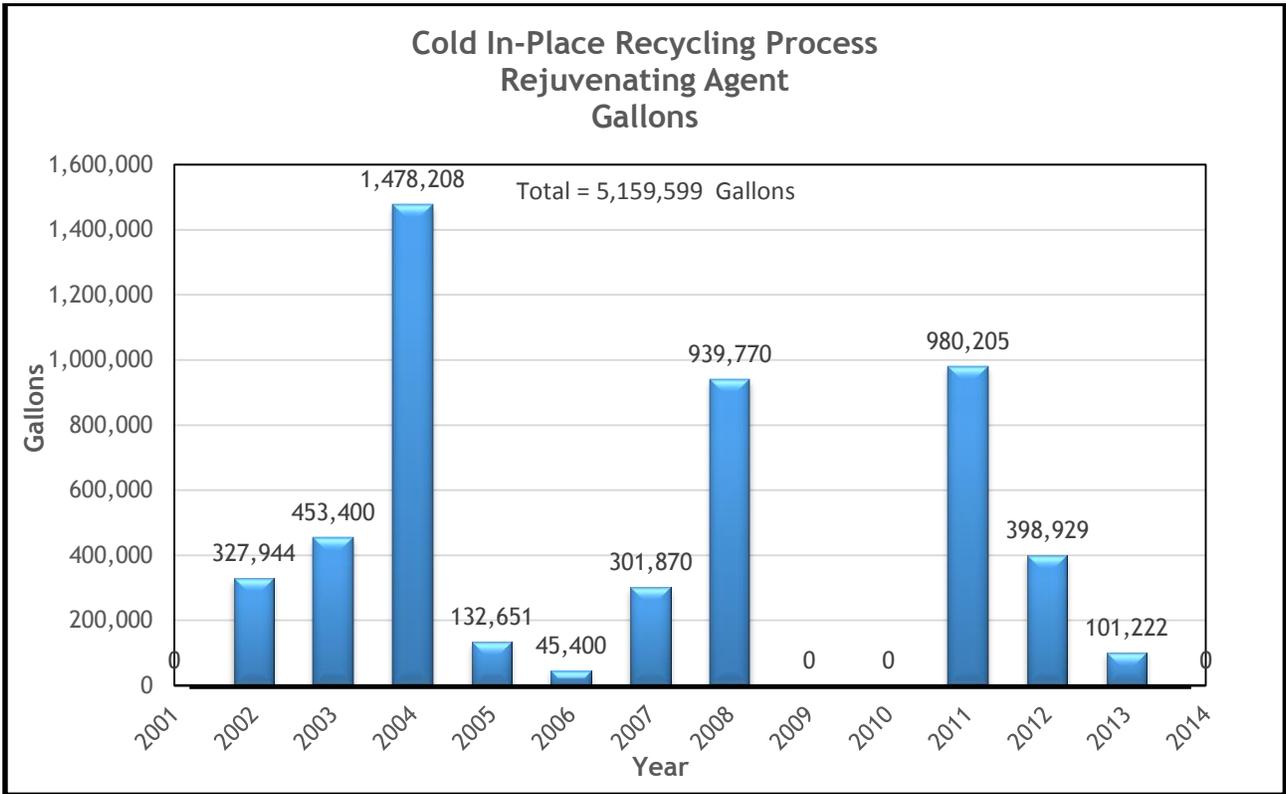


Figure 103 Cold In-Place Recycling Gallons of Rejuvenating Agent per Year

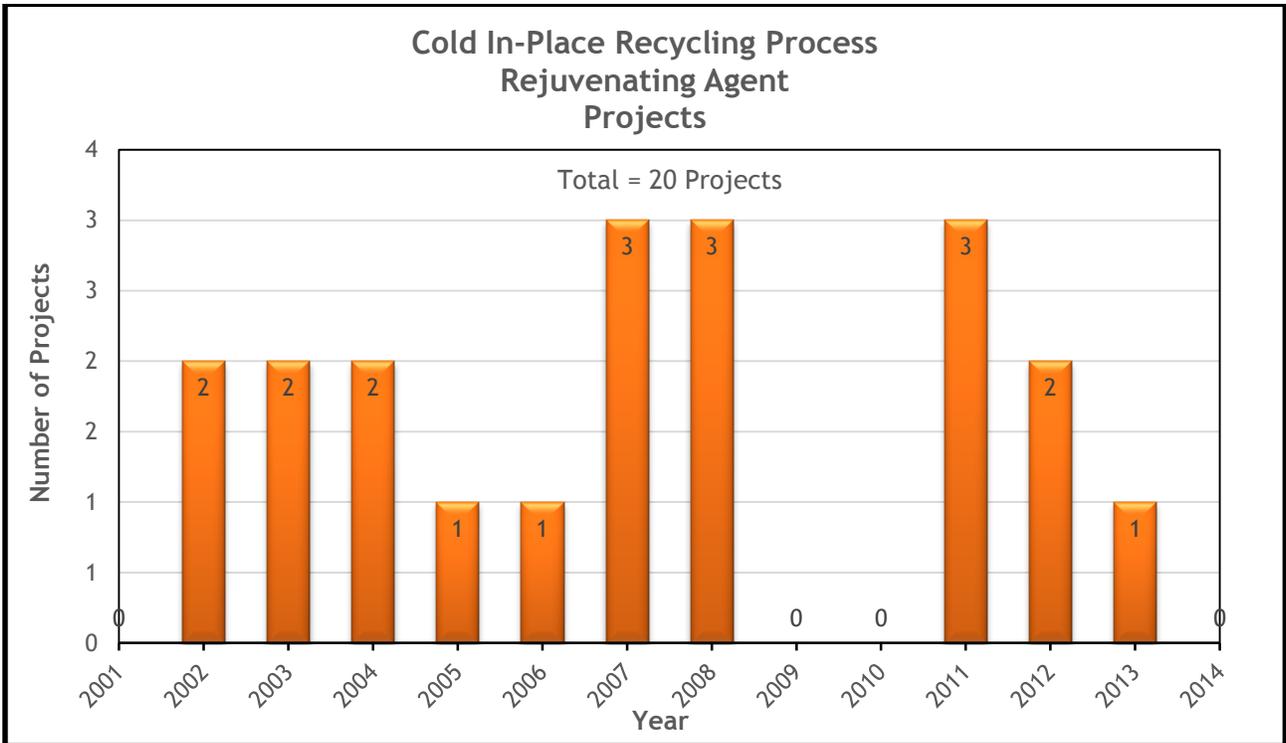


Figure 104 Cold In-Place Recycling Projects with Rejuvenating Agent per Year

Appendix F
Full Depth Reclamation

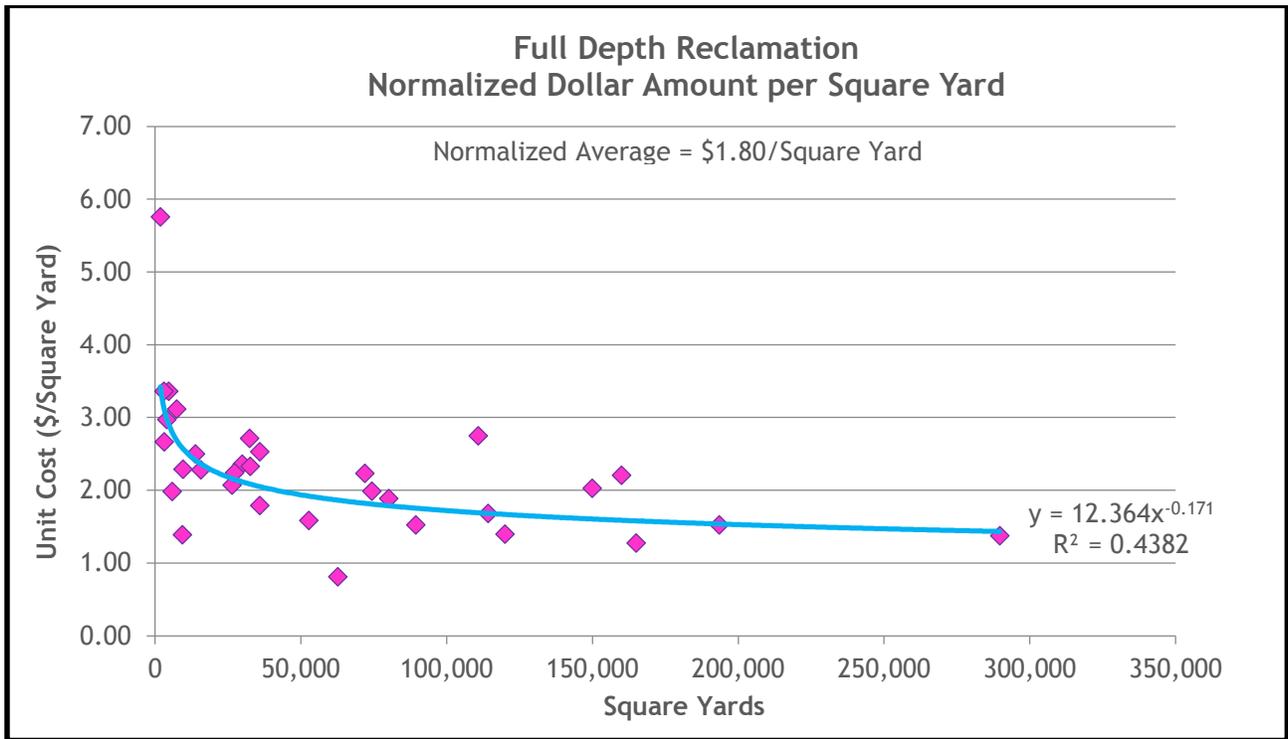


Figure 105 Full Depth Reclamation Normalized Dollar Amount per Square Yard

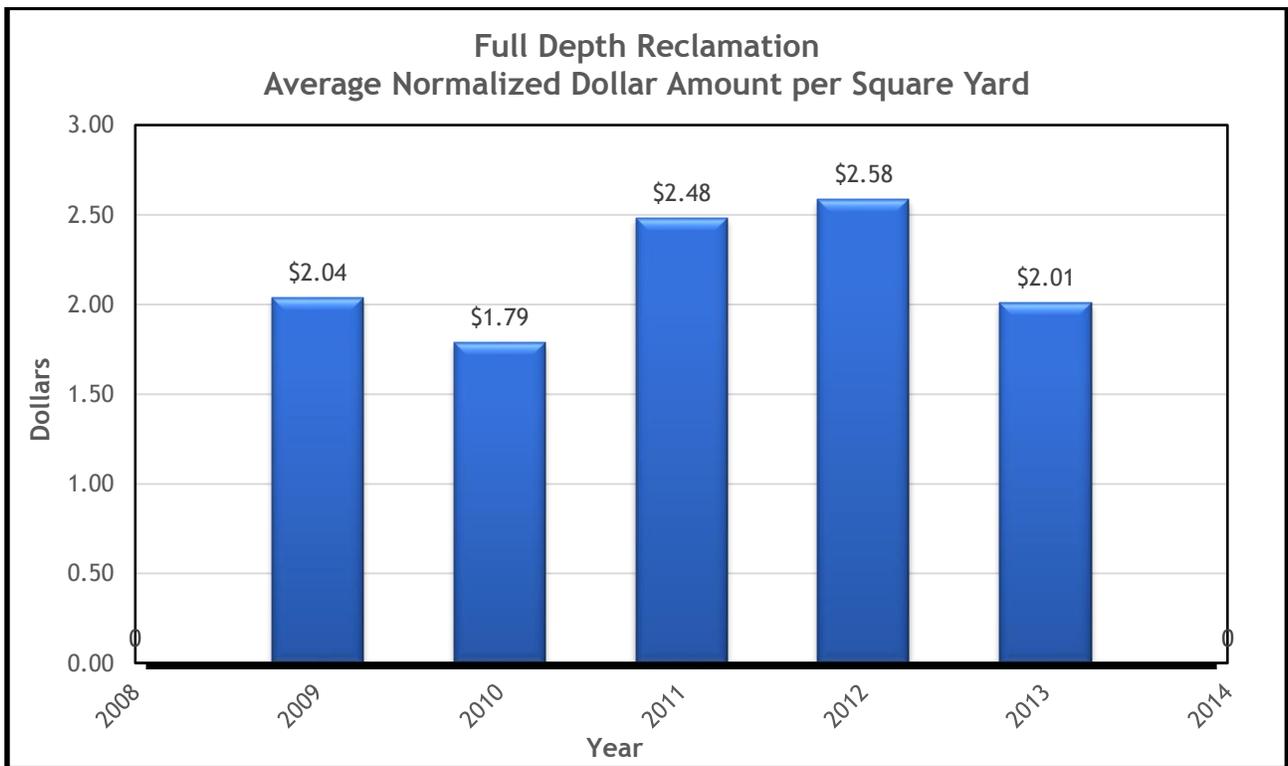


Figure 106 Full Depth Reclamation Average Normalized Dollar Amount per Square Yard per Year

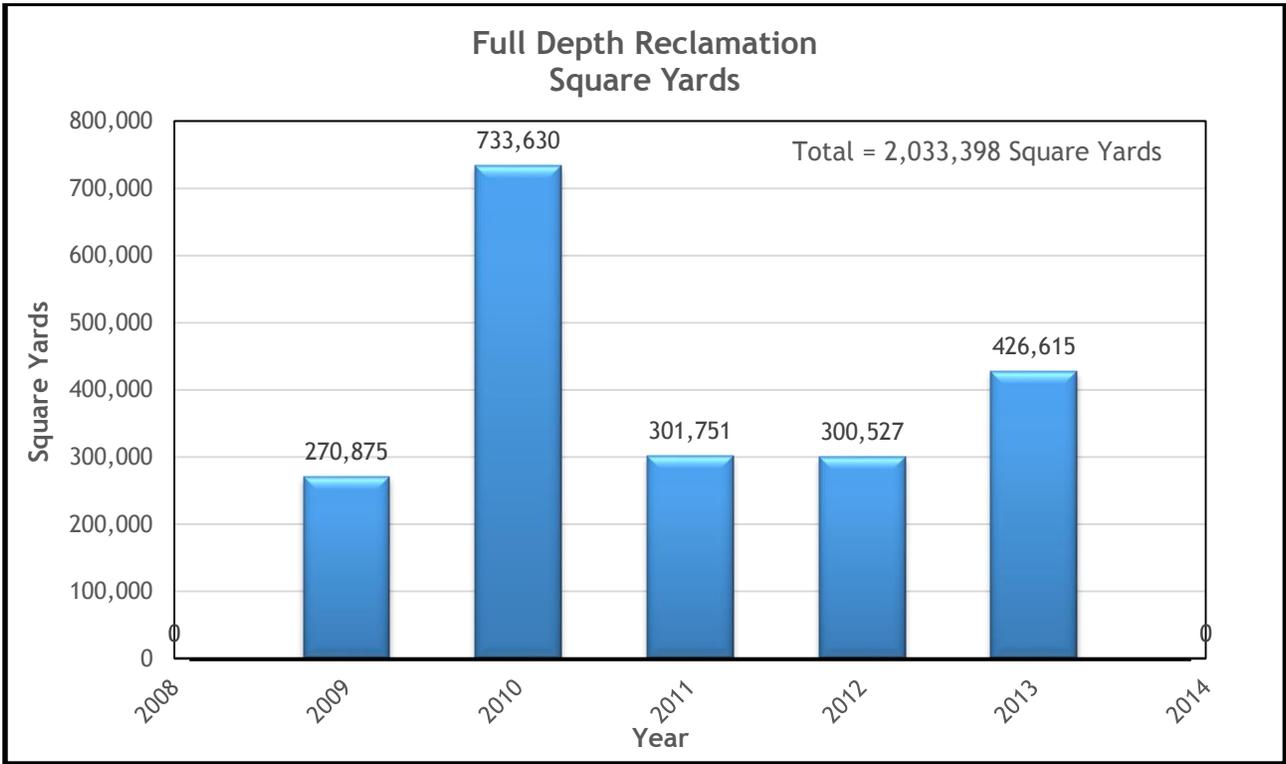


Figure 107 Full Depth Reclamation Total Square Yards per Year

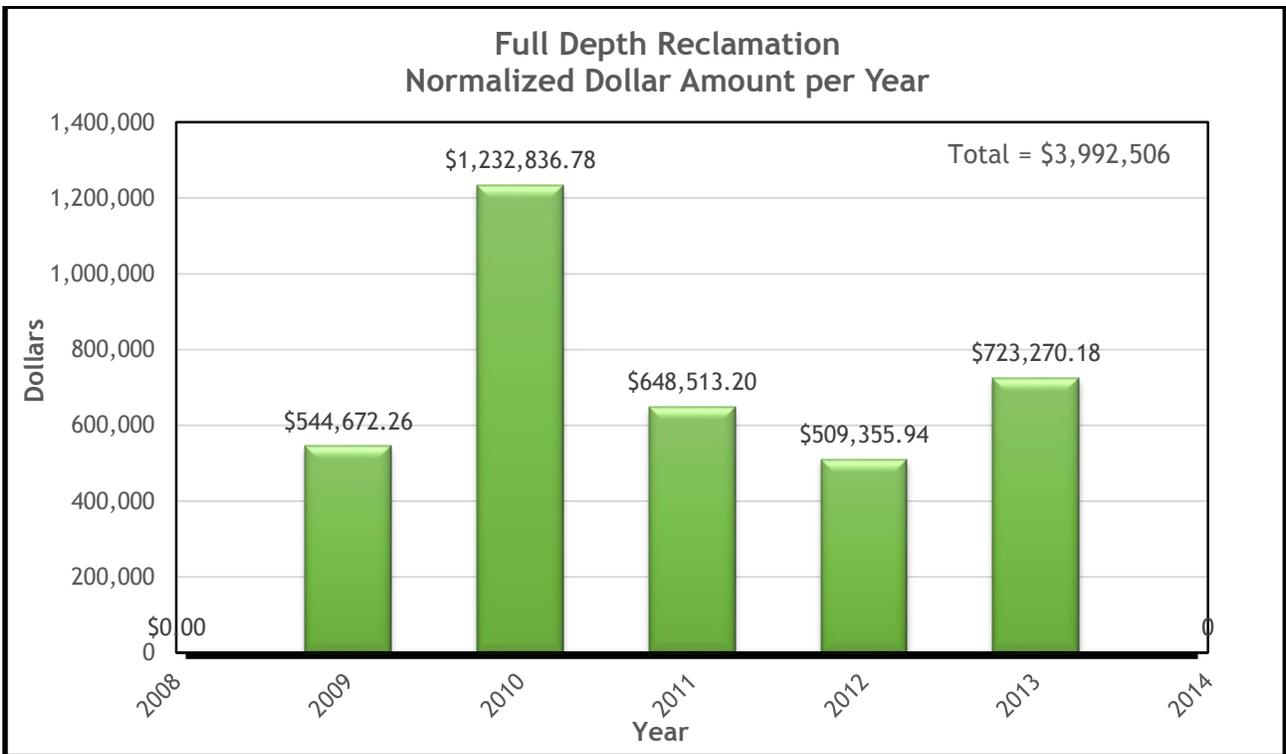


Figure 108 Full Depth Reclamation Normalized Dollar Amount per Year

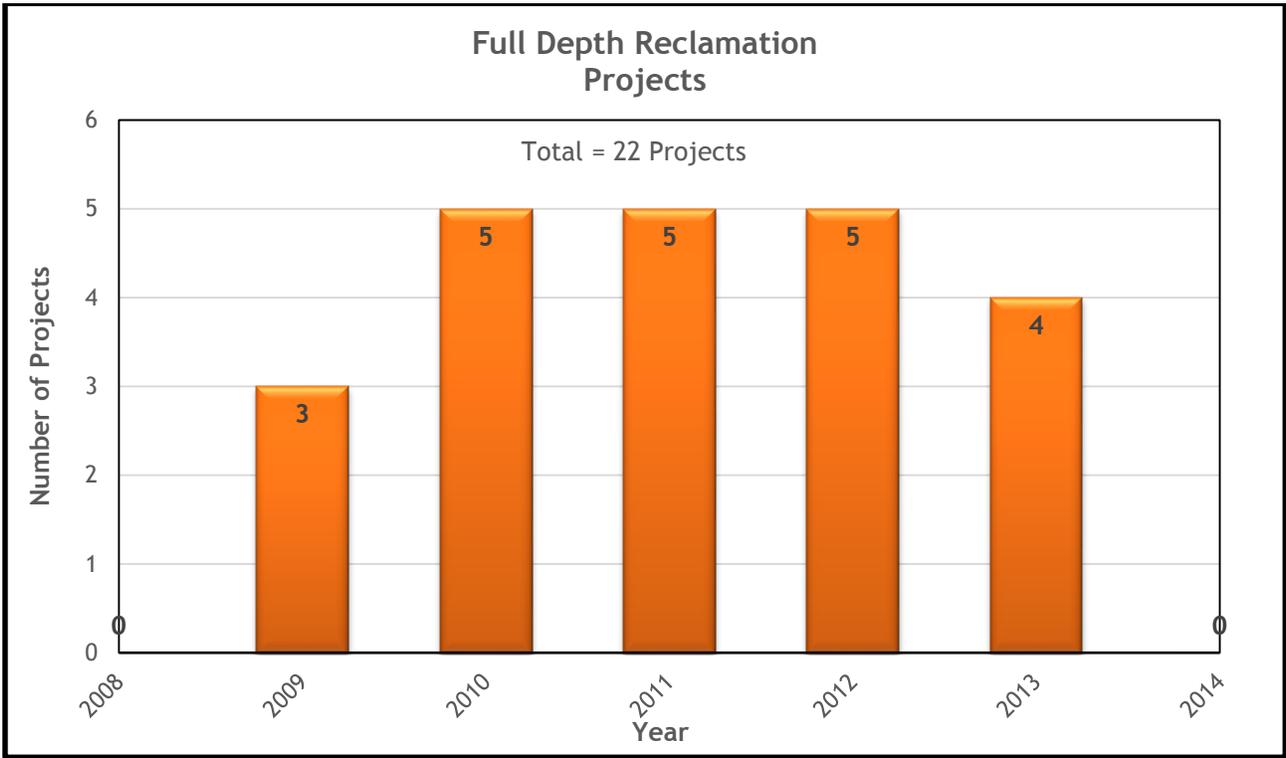


Figure 109 Full Depth Reclamation Projects per Year

Appendix G
Heater Remixing

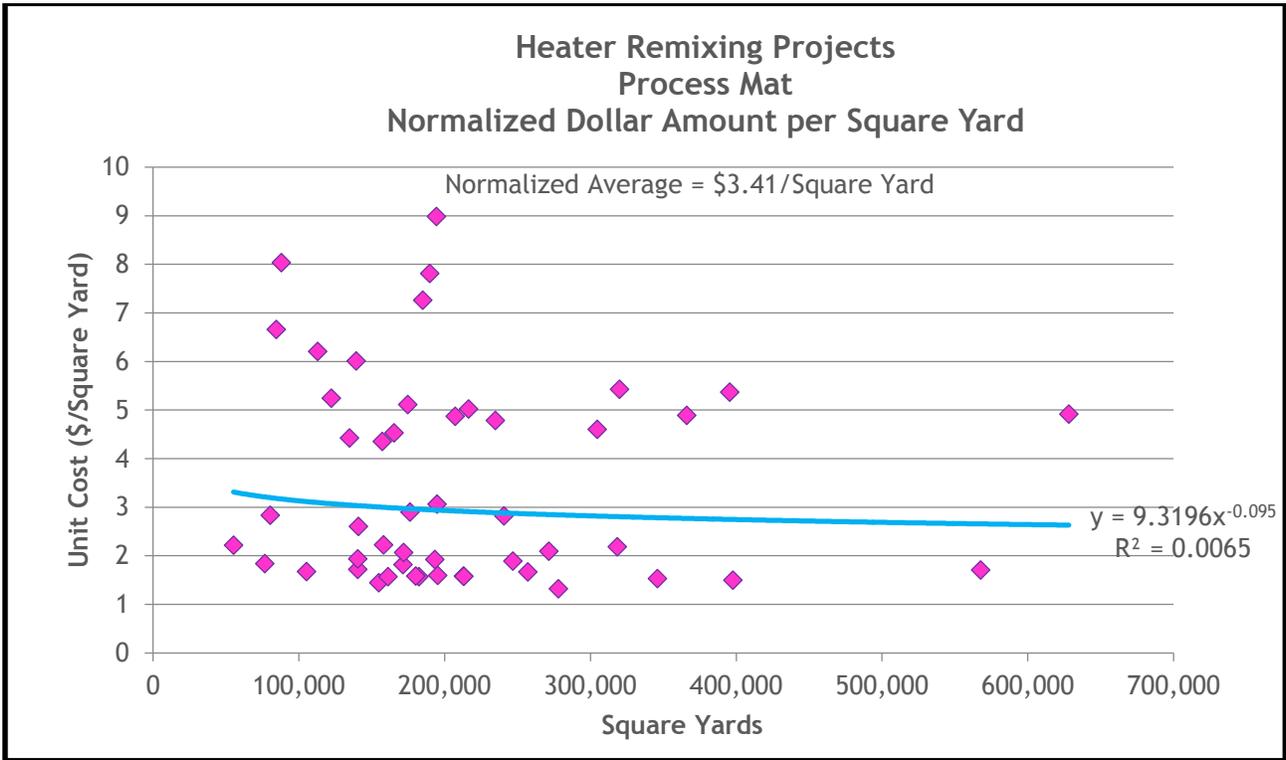


Figure 110 Heater Remixing Process Mat Normalized Dollar Amount per Square Yard

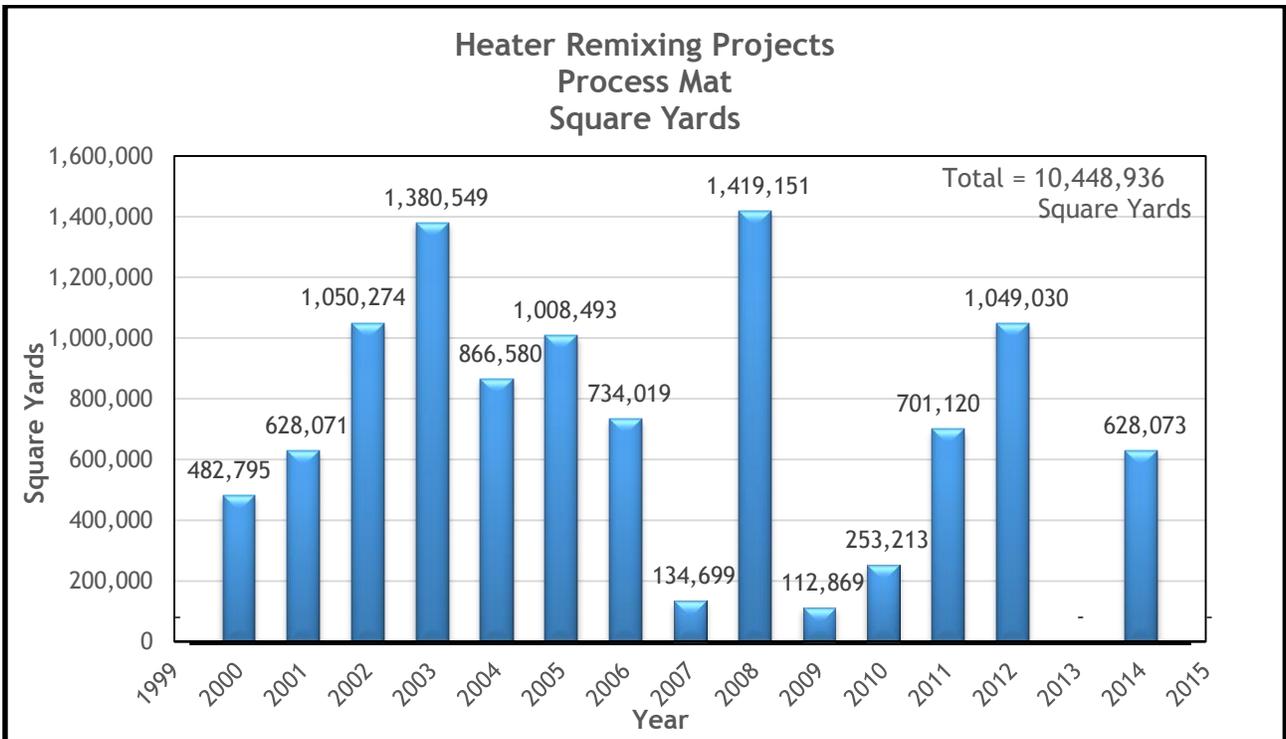


Figure 111 Heater Remixing Process Mat Total Square Yards per Year

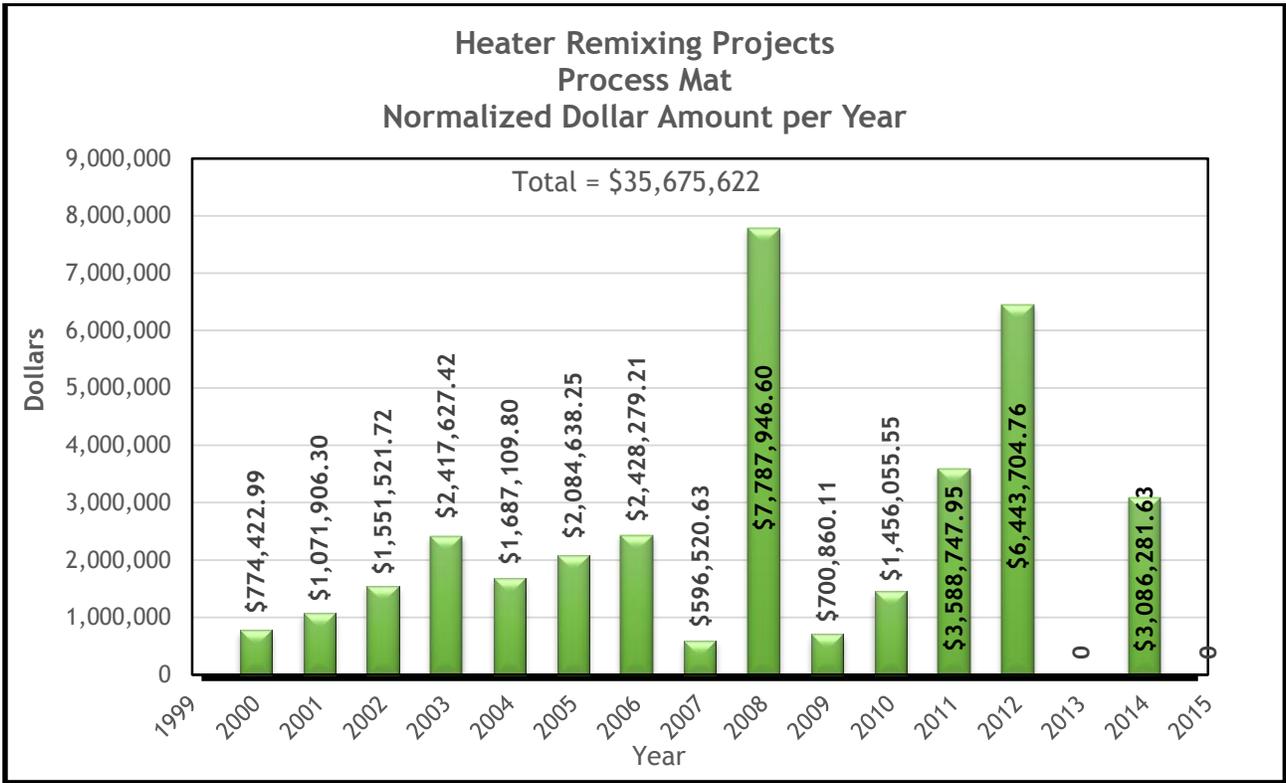


Figure 112 Heater Remixing Process Mat Normalized Dollar Amount per Year

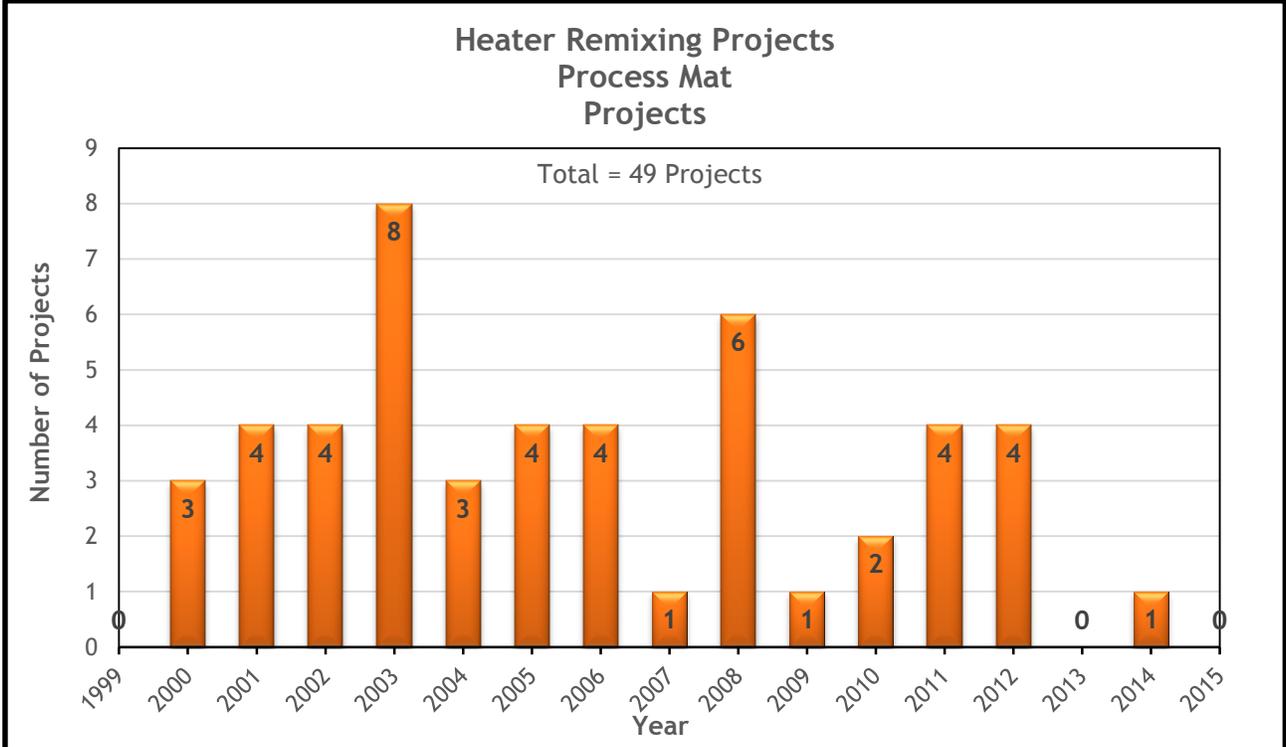


Figure 113 Heater Remixing Process Mat Projects per Year

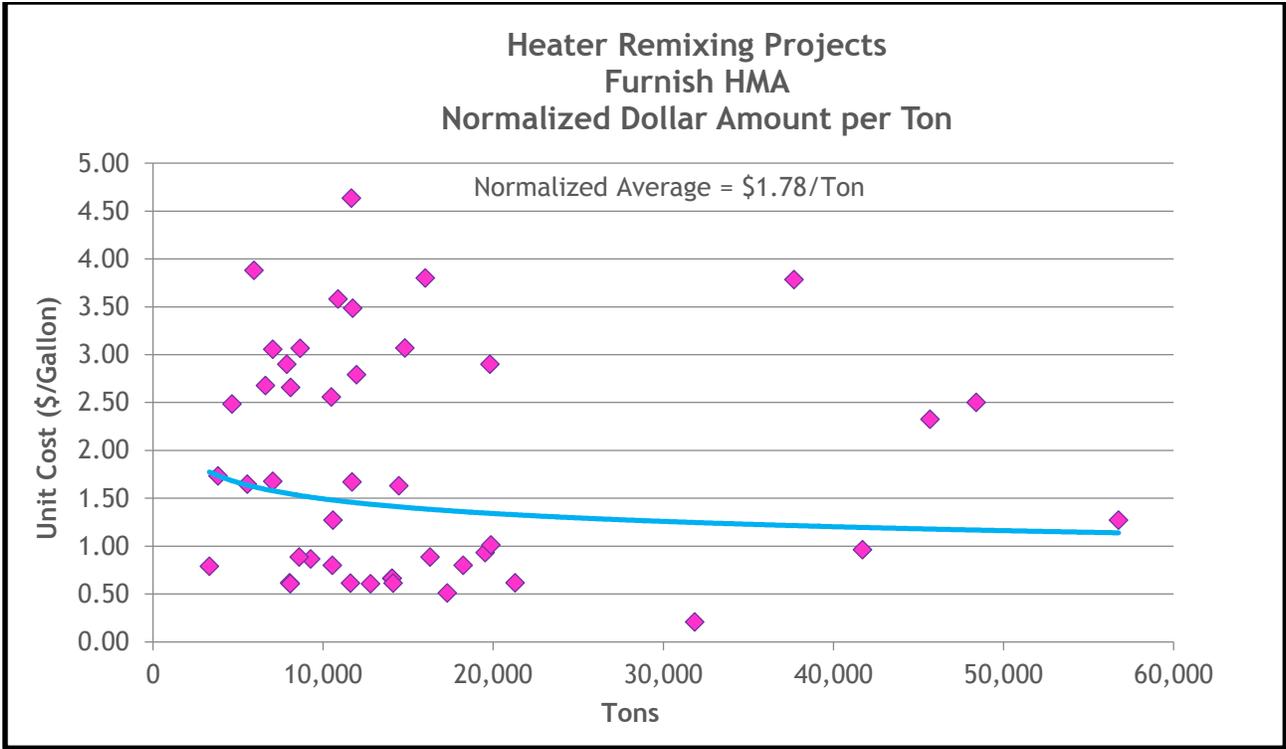


Figure 114 Heater Remixing Furnish HMA Normalized Dollar Amount per Ton

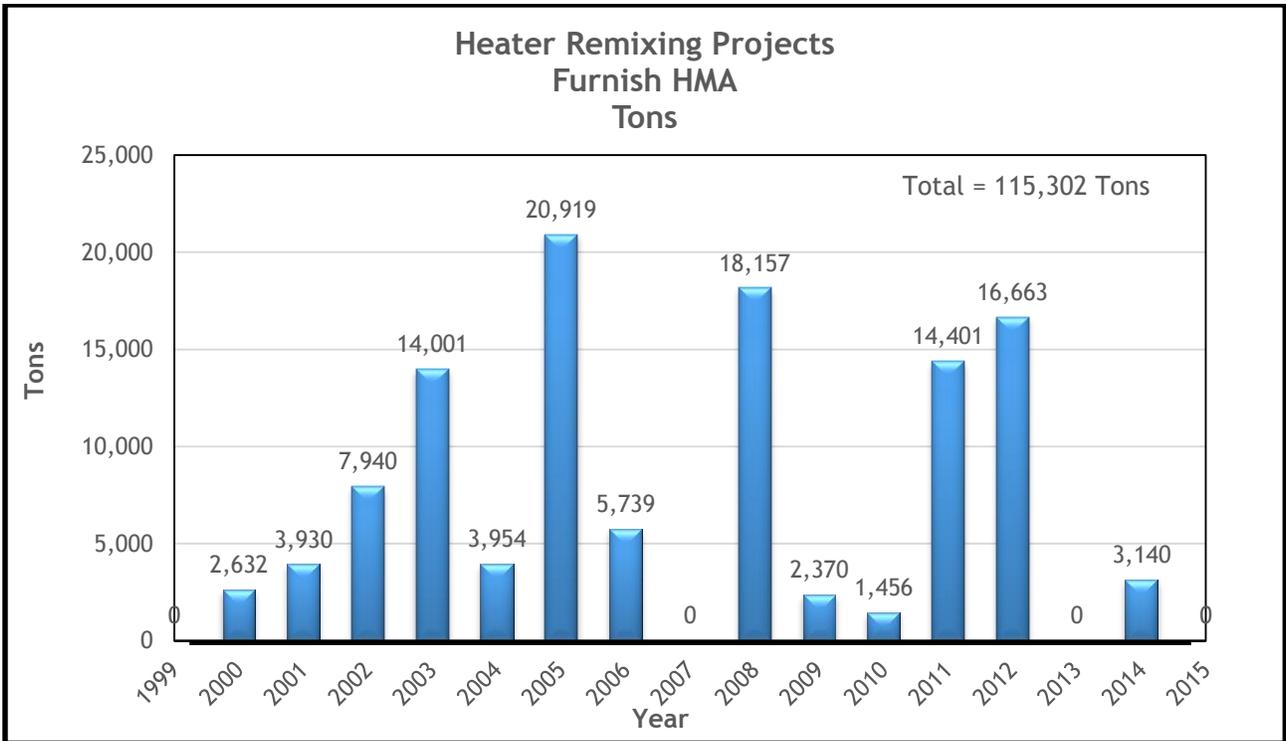


Figure 115 Heater Remixing Furnish HMA Total Tons per Year

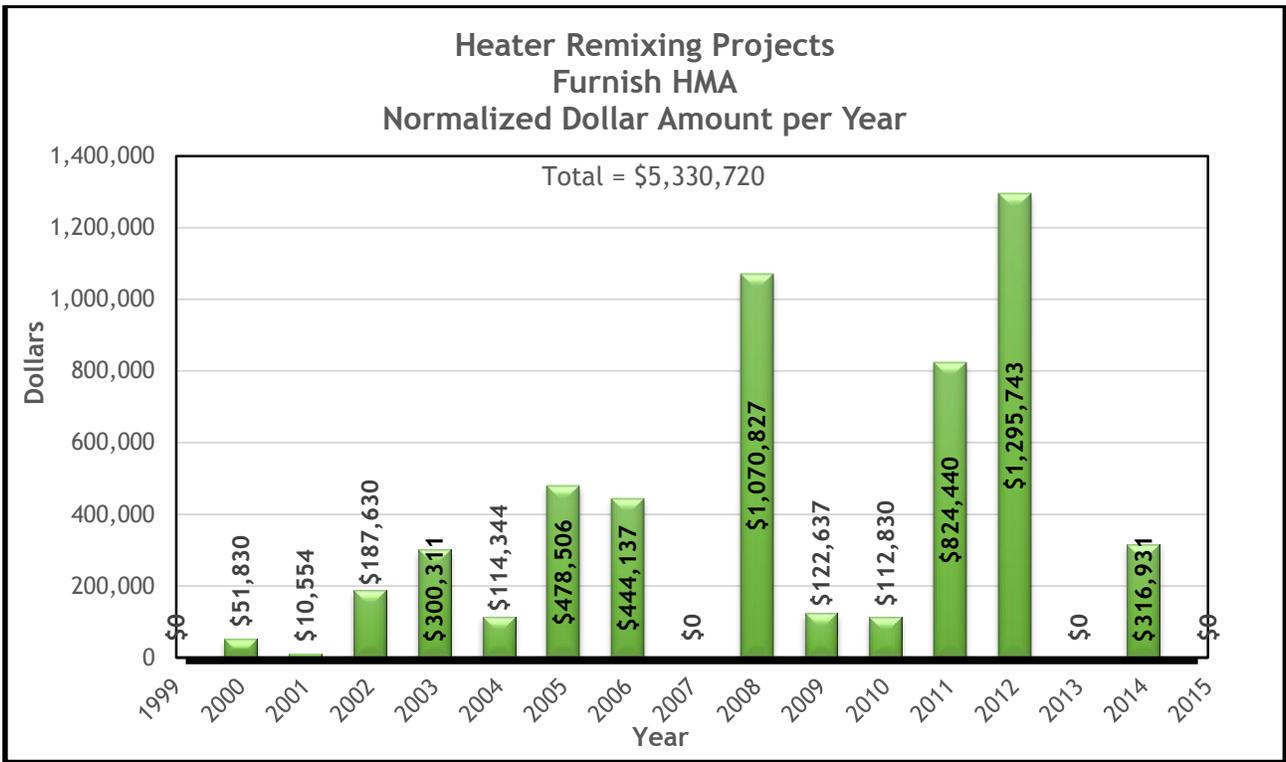


Figure 116 Heater Remixing Furnish HMA Normalized Dollar Amount per Year

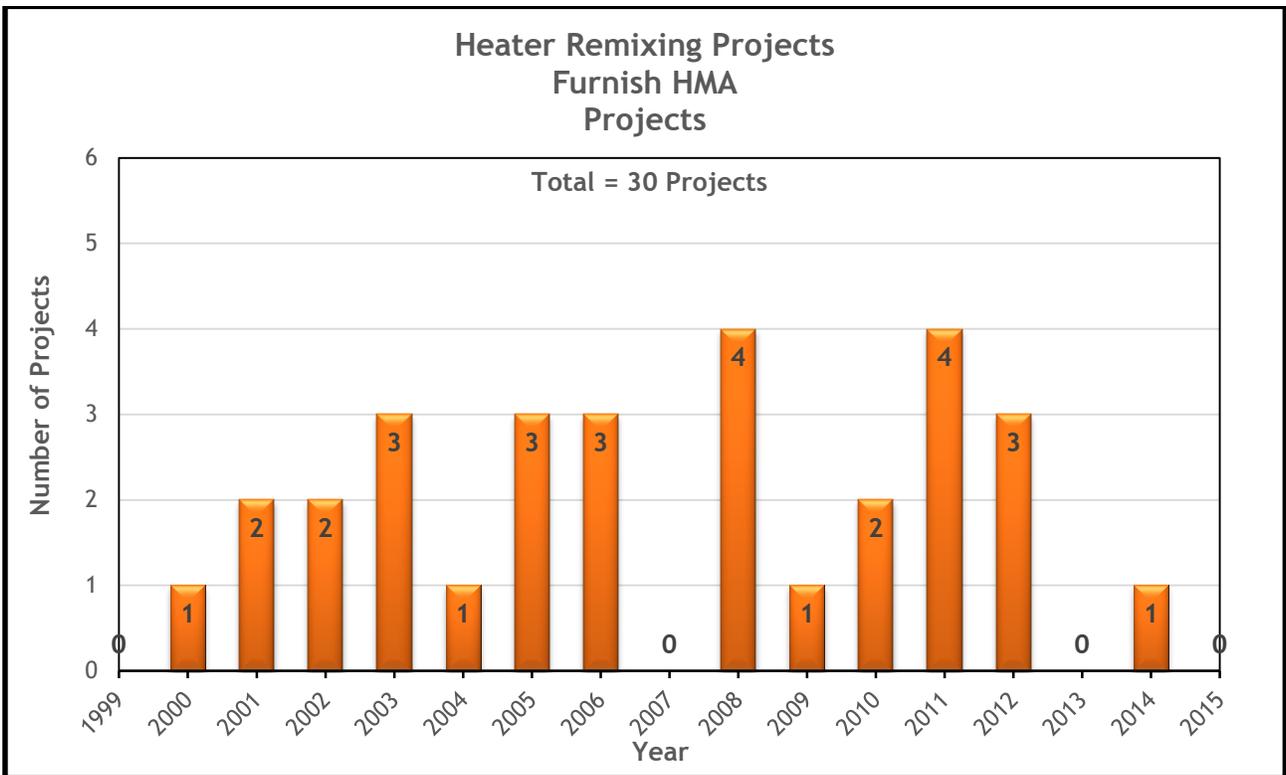


Figure 117 Heater Remixing Furnish HMA Projects per Year

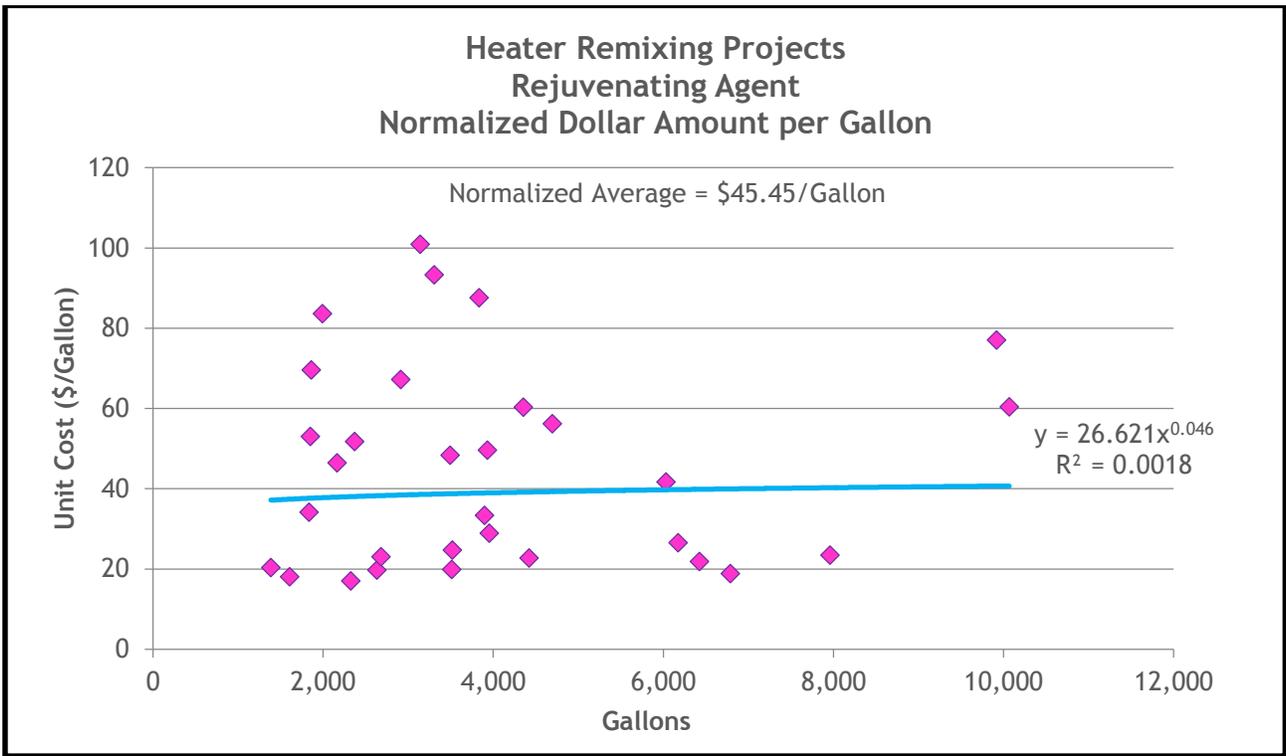


Figure 118 Heater Remixing Rejuvenating Agent Normalized Dollar Amount per Gallon

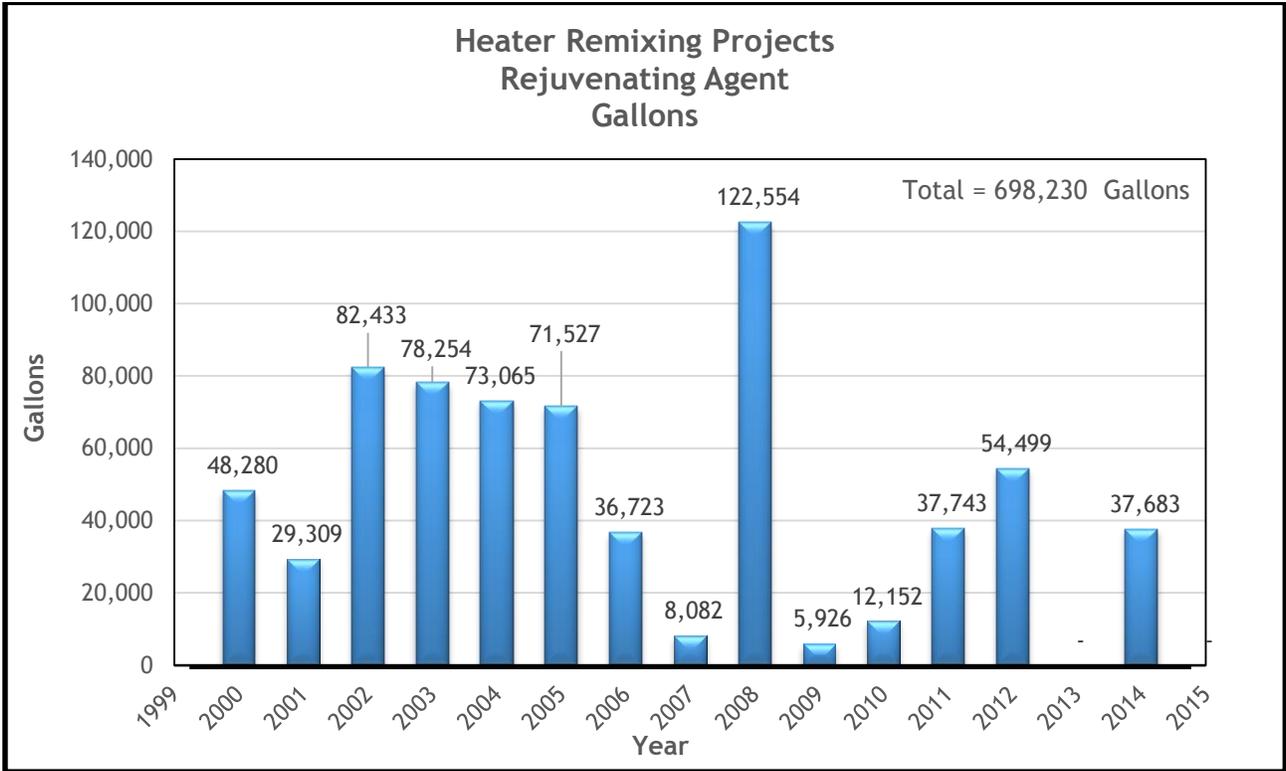


Figure 119 Heater Remixing Rejuvenating Agent Total Gallons per Year

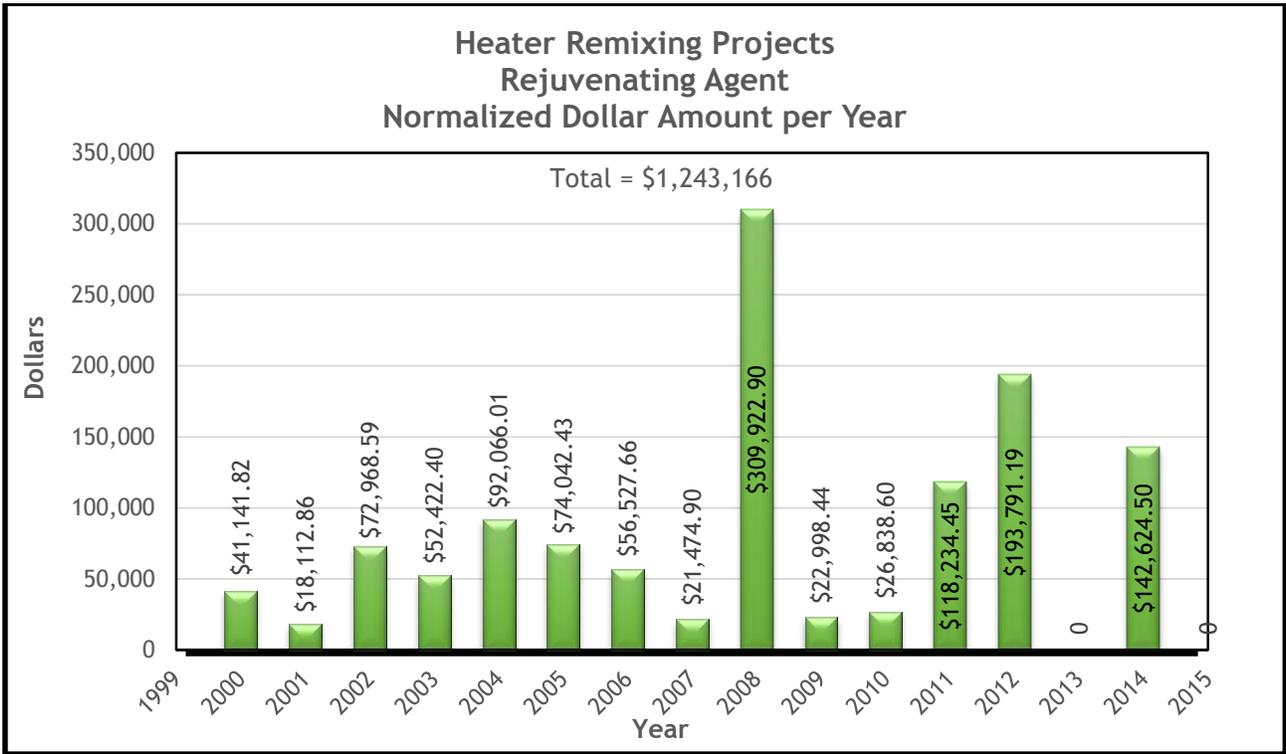


Figure 120 Heater Remixing Rejuvenating Agent Normalized Dollar Amount per Year

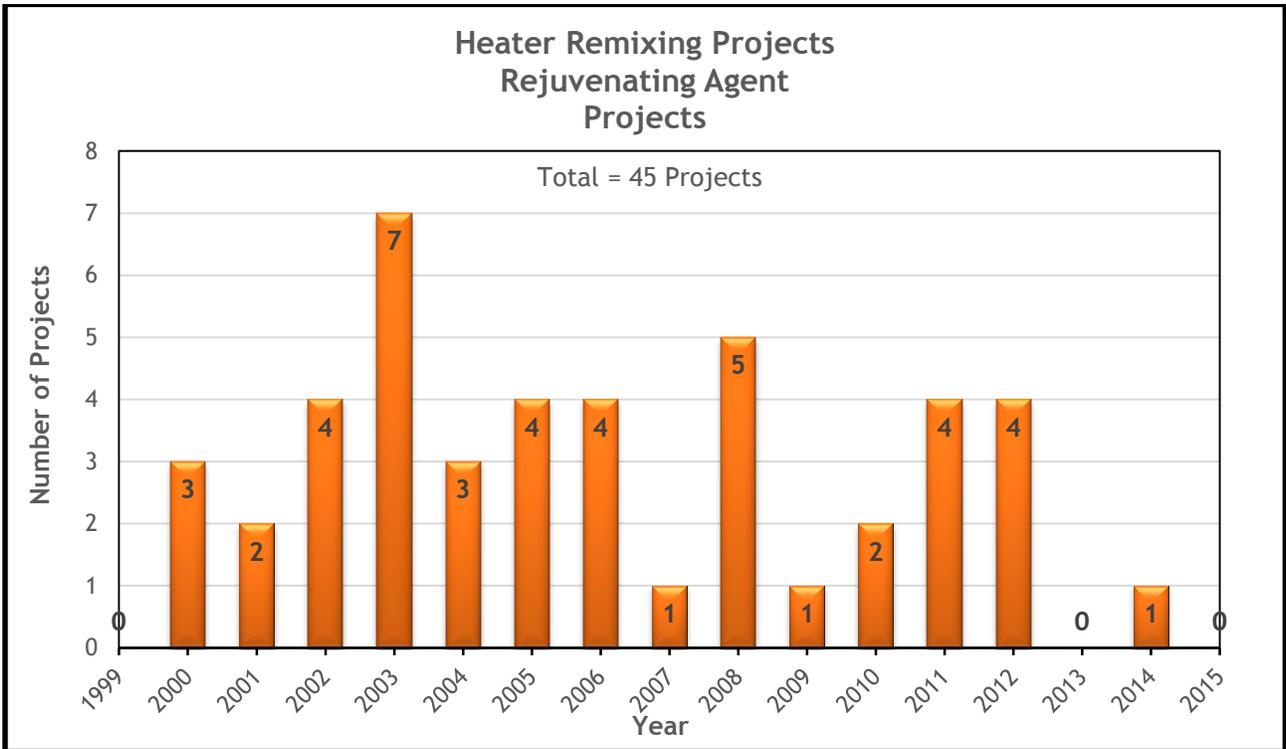


Figure 121 Heater Remixing Rejuvenating Agent Projects per Year

Appendix H
Heater Scarifying

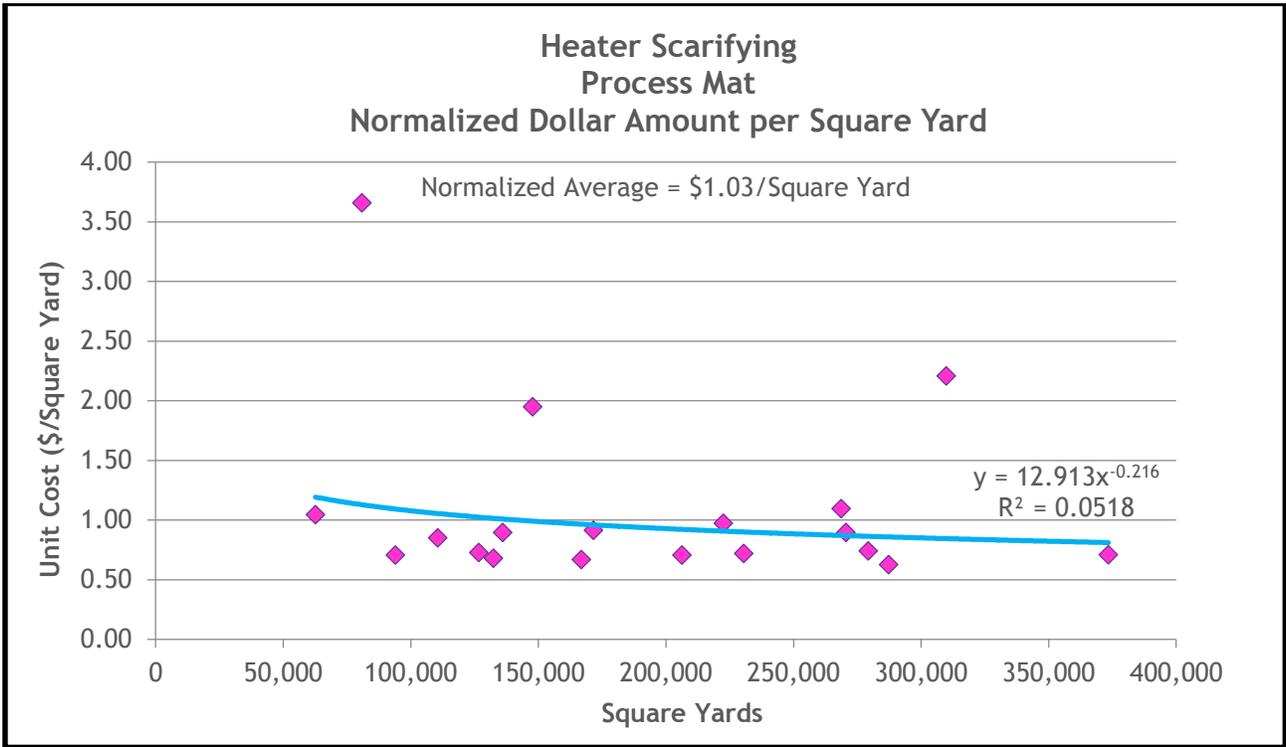


Figure 122 Heater Scarifying Process Mat Normalized Dollar Amount per Square Yard

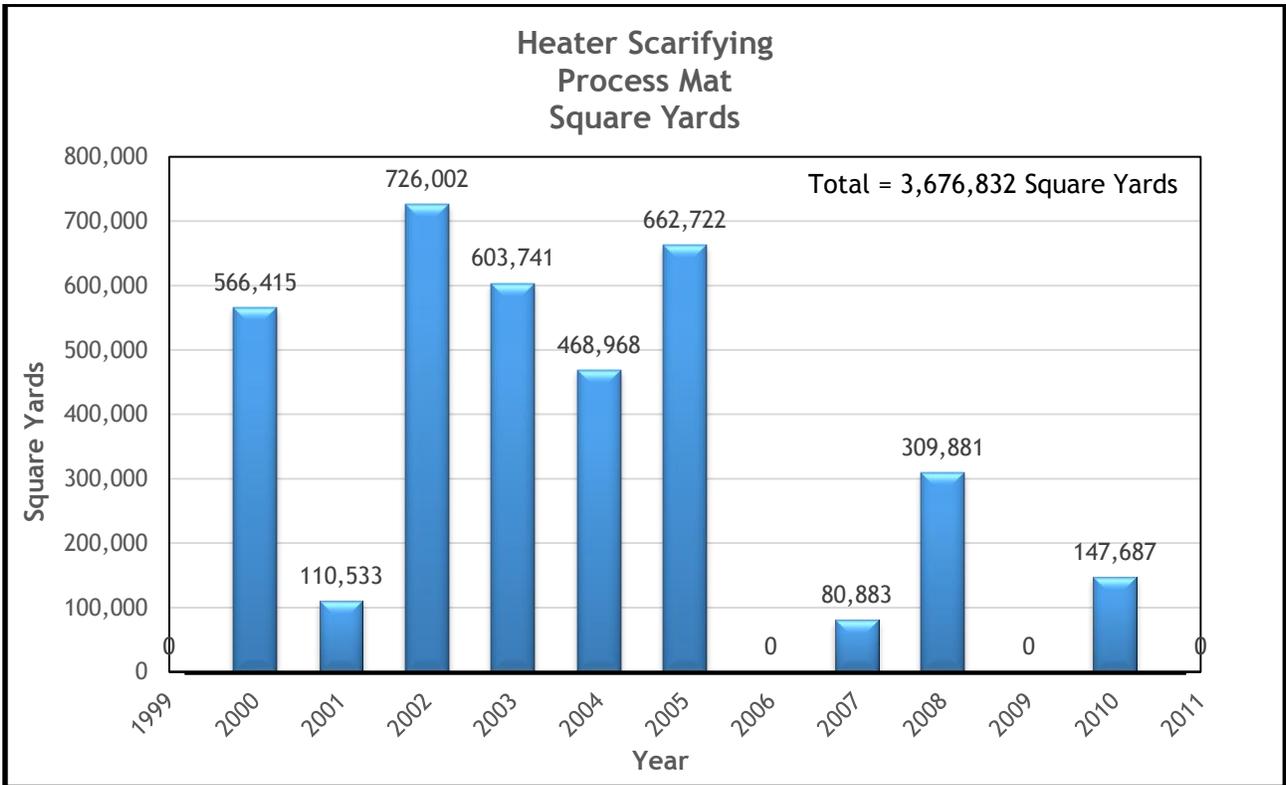


Figure 123 Heater Scarifying Process Mat Total Square Yards per Year

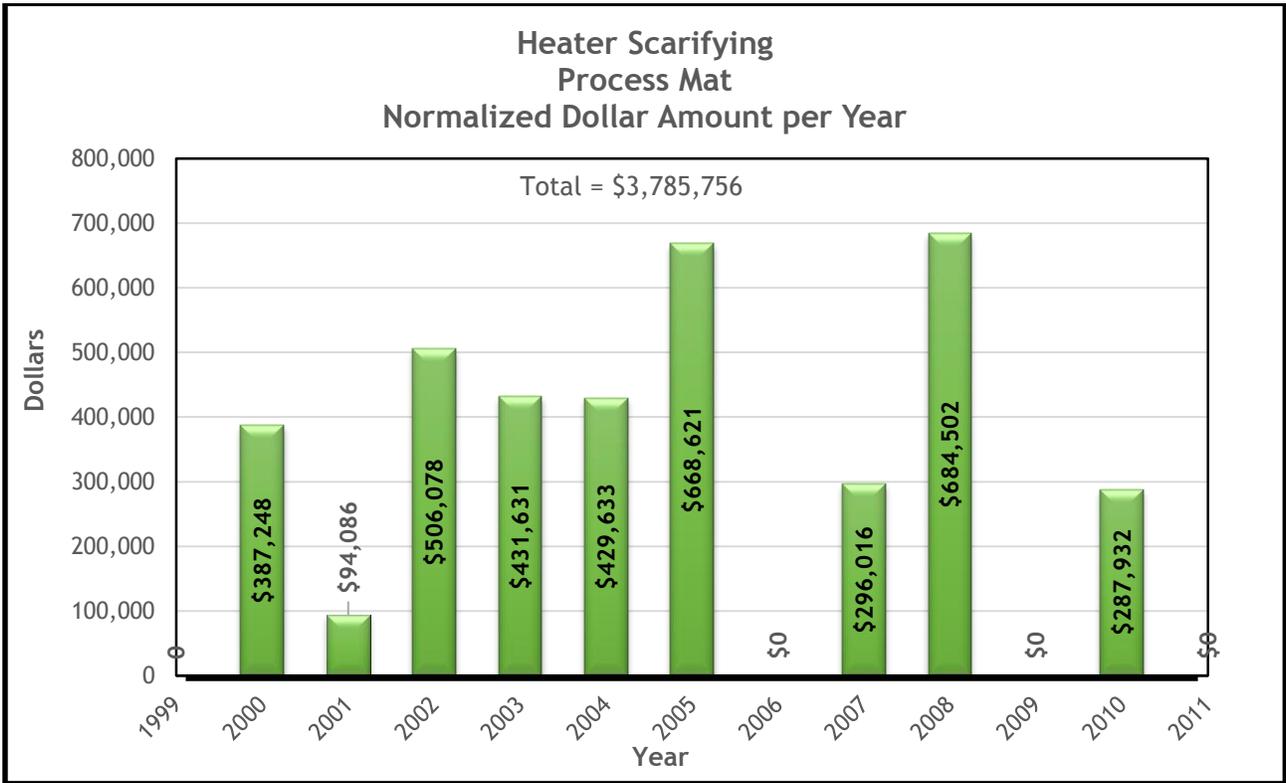


Figure 124 Heater Scarifying Process Mat Normalized Dollar Amount per Year

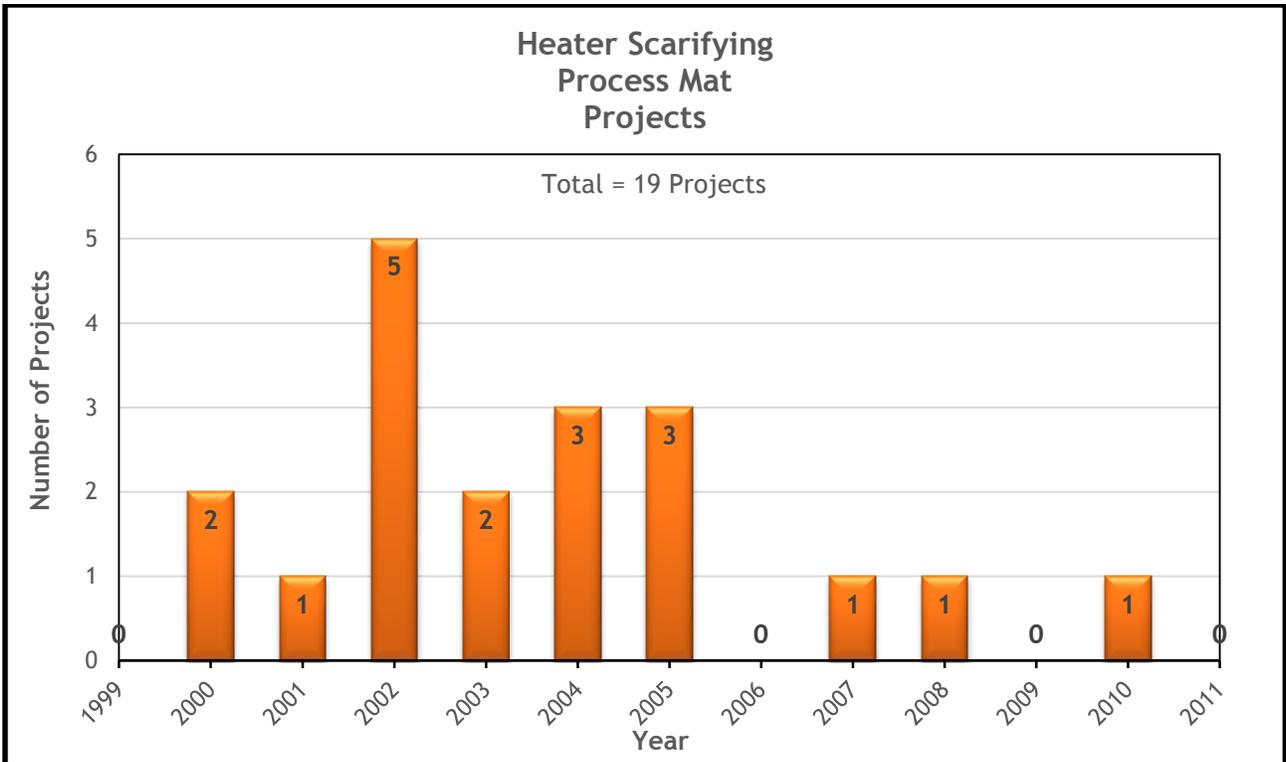


Figure 125 Heater Scarifying Process Mat Projects per Year

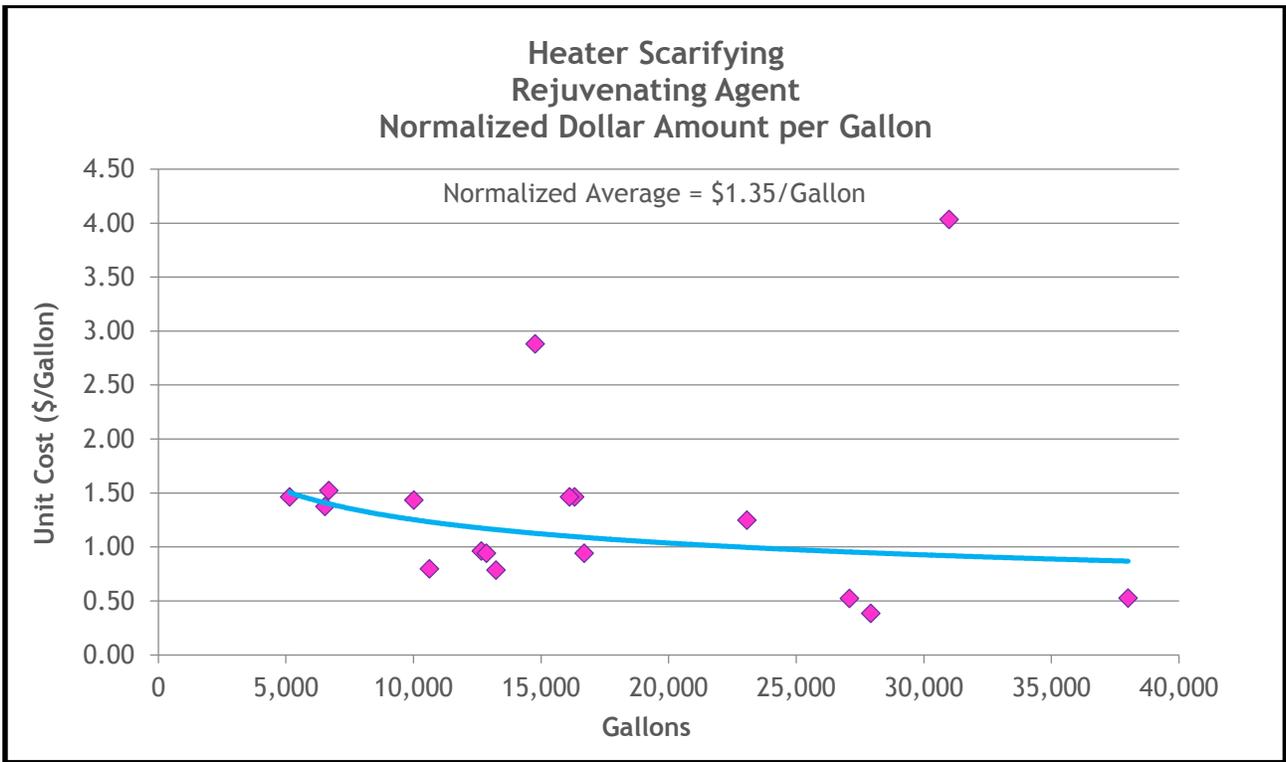


Figure 126 Heater Scarifying Rejuvenating Agent Normalized Dollar Amount per Gallon

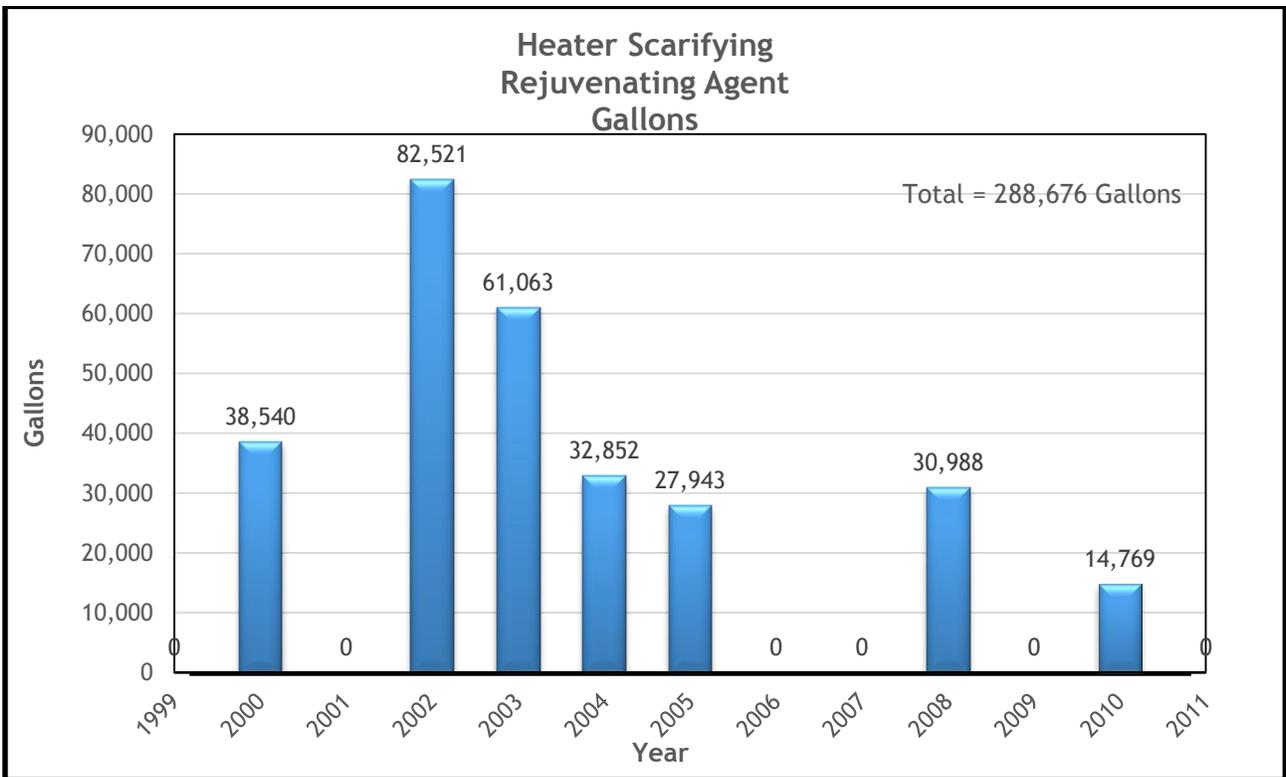


Figure 127 Heater Scarifying Rejuvenating Agent Total Gallons per Year

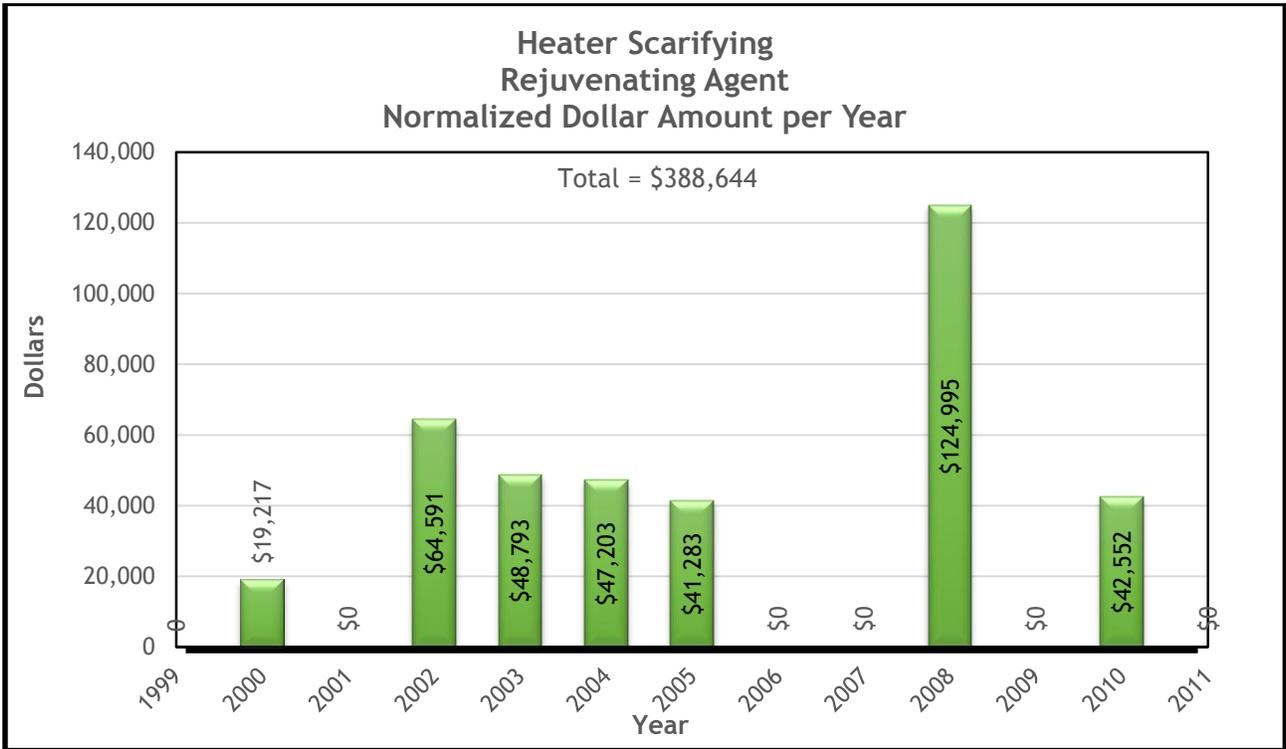


Figure 128 Heater Scarifying Rejuvenating Agent Normalized Dollar Amount per Year

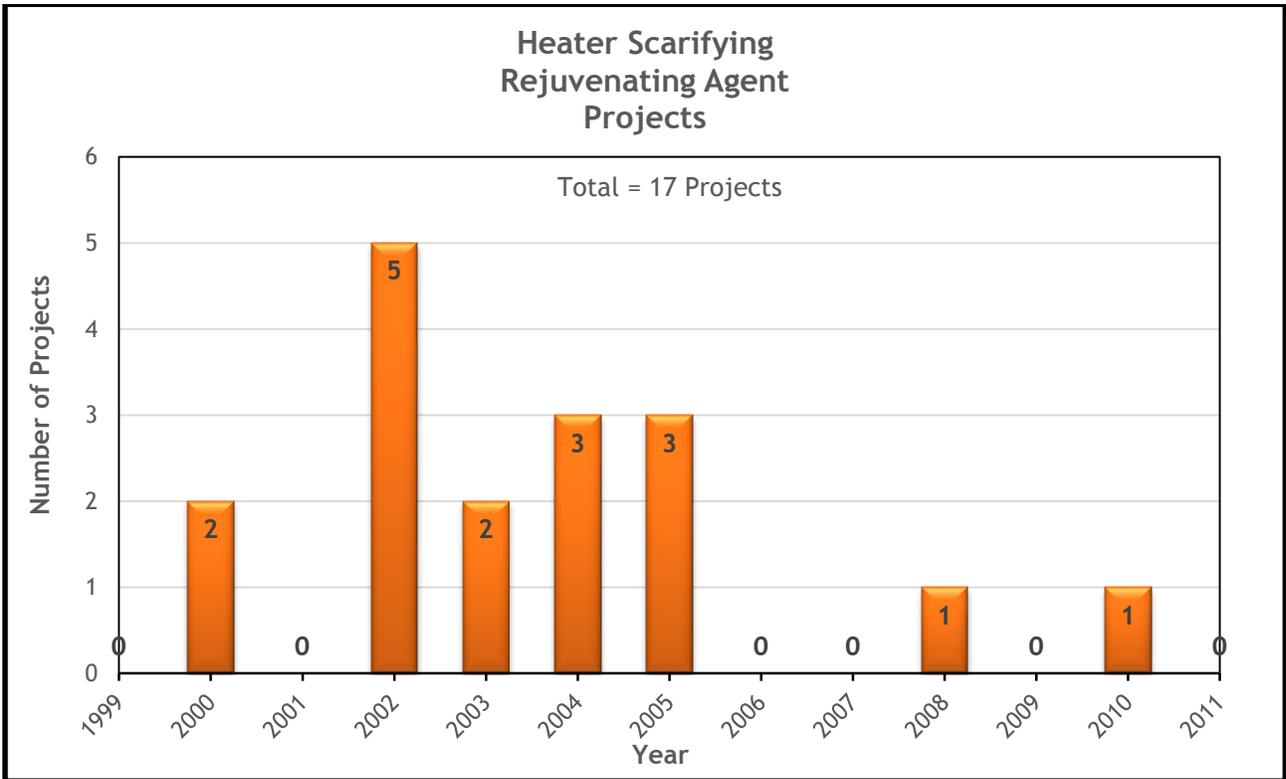


Figure 129 Heater Scarifying Rejuvenating Agent Projects per Year