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Street Sweeper Efficiency Study for the Town of Mammoth Lakes

** ** ** **

Prepared By

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June Lake, CA

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EXECUTIVE SUMMARY

Introduction

The Street Sweeper Efficiency Study is an *in-depth examination* of the problems and their solutions for the street sweeper program in Mammoth Lakes. This study is intended to help Mammoth Lakes attain and maintain the National Ambient Air Quality Standard under the Federal Clean Air Act for fine particulate matter, known as PM_{10}. The study includes analysis of the efficiency of the Mammoth Lakes (Town) street sweeper in removing the total *mass* of *road cinders* and the PM_{10} size *particles* from the Town *streets.*

The contribution of road cinders and their PM_{10} size particles to the Town's air pollution problem is intensified with the large influx of visitors to the area during the winter ski season. With the increase in area population and vehicle traffic, there is a sharp increase in the PM_{10} *emissions from traffic-related road dust* and *cinders*. On occasions when peak visitor periods coincide with extended periods of low wind speeds, the air pollution levels build up to concentrations that violate the National PM_{10} standard. (PM_{10} stands for particulate matter less than 10 microns in diameter. For comparison a human hair is about 100 microns in diameter.)

The road cinder problem was not completely solved when the Town, in 1989, purchased a Johnston Model 600 vacuum street sweeper. This study examines the efficiency of this machine and makes recommendations as to how this efficiency could be improved.

Procedure

The road leading to the Town maintenance yard was sectioned into 5, 10 foot by 10 foot sections. Road cinders were spread over the entire area by the Town cinder truck. The cinders in alternate squares were collected before the street sweeper passed over the test area. Following the street sweeper pass, the cinders that were not removed were collected. This was done for the same day and 5 days after the distribution of cinders on the roadway. It was estimated that during the 5 day test, 500 vehicles passed through the test area.

Analysis

During the same day test, 94.65% of the total mass of cinders were removed by the street sweeper from the test area. Of this, 62.2% of the PM_{10} size particles were removed. The 5 day test saw 89.59% of the cinders removed. Of this, 73.1%of the PM_{10} size particles were removed.

It was observed that the street sweeper did not distribute an even spray of water from the water distribution bar. This resulted in the silt particles being trapped in the more heavily watered areas and therefor not removed when the street sweeper cleaned the area.

Conclusion

The street sweeper is less efficient the longer the cinders remain on the street because of the deterioration of the road cinders due to the vehicles breaking up the larger particles into smaller particles. In fact, the street sweeper is 5.09% less efficient if the cinders have remained on the street for 5 days after application. The test areas traffic count estimation compared to the Towns streets was 1:647. This means that what took days to accomplish in the test area only takes hours on the Town streets.

The uneven distribution of water from the street sweeper water distribution bar also contributes to its lack of efficiency. This was observed after a large amount of silt particles were left behind in the over watered stripes.

The Towns street sweeper is removing on the average 67.7% of the PM_{10} size particles from the streets. This represents a greater efficiency than that predicted by the Environmental Protection Agency (34%). In spite of this improved performance, this study has demonstrated significant ways in which the efficiency can be further improved.

Recommendations

The following recommendations are based upon the analysis of the data in this study and the observations of the street sweeper in action.

1. Modify the street sweeper spray bar so that it can deliver an evenly distributed spray. This will decrease the over watered stripes and increase the machines efficiency in removing the PM_{10} size particles.
2. Research addition measures that could taken to increase the efficiency of removing the PM_{10} size particles from the Town Streets.
3. Implement a management plan to assure that the street sweeper will remove the cinders as soon as possible after their distribution onto the streets. The removal process should begin hours after the storms, not days.
4. Research alternative spray solutions that are environmentally safe and machine compatible so that the street sweeper can operate at colder temperatures. This would facilitate earlier removal of the cinders and therefor less cinder breakdown.
5. Duplicate the study following the implementation of recommendations 1 & 3 both in the test area and on one of the Town streets.

STREET SWEEPER

EFFICIENCY STUDY

for the

Town of Mammoth Lakes

1.0 INTRODUCTION

1.1 REQUIREMENTS

On July 1, 1987, the U.S. Environmental Protection Agency (EPA) promulgated new ambient air quality standards for particulate matter (PM). In promulgating the new standard, EPA changed the indicator for particulate matter from Total Suspended Particulates (TSP) to those particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}), and replaced the 24 hour TSP standard of 260 $\mu g/m^3$ with a 24 hour PM_{10} standard of 150 $\mu g/m^3$ with no more than one expected exceedance per year. The TSP annual standard of 75 $\mu g/m^3$ annual geometric mean was replaced with a PM_{10} annual standard of 50 $\mu g/m^3$ expected annual arithmetic mean. These new standards became effective on July 31, 1987.

At the same time the EPA replaced the TSP standard with the PM_{10} standard, the EPA set forth regulations for implementing the revised particulate matter standards and announced EPA's State Implementation Plan (SIP) development policy elaborating on PM_{10} control strategies necessary to assure attainment and maintenance of the PM_{10} NAAQS. (see generally 52 FR 24672)

The TSP to PM_{10} changes were based on health studies which demonstrate that PM_{10} and smaller particles can penetrate deep into the respiratory tract, leading to a variety of symptoms and respiratory diseases.

1.2 BACKGROUND

The air pollution problem in the Town of Mammoth Lakes (Town) is primarily associated with the large influx of visitors to the area during the winter ski season. With the increase in the area population and vehicle traffic, there is a sharp increase in the PM_{10}

emissions from wood stoves, fireplaces, and from traffic related road dust and cinders. On occasions when peak visitor periods coincide with extended periods of low wind speeds, the air pollution levels build up to concentrations that violate the National PM_{10} Standard. Based on ambient PM_{10} monitors, prior to 1990 the Town averaged about 12 violations of the 24-Hour PM_{10} Standard each winter. From December 22, 1990 through March 1, 1992, there were 6 recorded violations.

On November 30, 1990 the Town adopted the *Air Quality Management Plan for the Town of Mammoth Lakes*. This plan explored in depth the wood smoke - road cinder dust problem in the Town. It went on to make recommendations for solutions to correct these problems so that the Town would meet the Federal 24-Hour PM_{10} Standard.

Reentrained road dust and cinders contribute as much as 44% of the ambient PM_{10} concentration during the winter months. Cinders used as an anti-skid material and track out of mud and dirt onto the streets are a major source of PM_{10} emissions during the winter months. (Air Quality Management Plan for the Town of Mammoth Lakes) The U.S. Environmental Protection Agency reports that a 34% reduction in reentrained road dust can be accomplished by vacuum sweeping. (Control of Open Fugitive Dust sources, 1988).

In 1989, the town purchased a Johnston Model 600 vacuum street sweeper that is being used to remove the road dust and cinders from the Town roadways. In March 1994, a second vacuum sweeper was purchased by the Town.

1.3 THE PROBLEM

During the past several years it has remained evident that the Town still has a problem with road dust and cinders. In spite of a vigorous program to remove the road dust and cinders from the Town roadways, dust is still being detected by the particulate monitors in Town. In order for the Town to achieve compliance with the minimum Federal Clean Air Act standard, the street sweeper program efficiency must improve .

1.4 THE PURPOSE

The purpose of this study is to determine the efficiency of the Town's street sweeper under typical Town road conditions. In addition, recommendations will be given, based on observations, that could help to increase the street sweeper efficiency.

2.0 PROCEDURE

2.1 STUDY DESIGN

This study was designed to concentrate on multiple aspects of the Town's street sweeper. First, how efficient is the street sweeper in removing the road cinders and their associated dust immediately after they have been spread by the cinder truck. Secondly, how efficient is the street sweeper in removing the cinders and their associated dust after the traffic has driven over them for a period of time. Thirdly, observations were made on the street sweeper itself in order to make recommendations that could help increase the efficiency. The study compared the measured silt loading from the study data with the assumed value used in the Town SIP. Finally, the PM_{10} emission per vehicle mile travelled was calculated for the same day and the 5 day tests. A comparison of the PM_{10} emission was prepared for the before the street sweeper and after the street sweeper cleaned the test area. From these comparisons the street sweeper efficiency at removing the PM_{10} size particles was calculated.

The street sweeper efficiency study used Great Basin Unified Air Pollution Control District (GBUAPCD) sampling bags, sieve analysis for the cinder samples, and scientific scales to measure the sample masses. Samples were taken from the following sources:

1. The cinder storage pile.
2. The street test area prior to the testing.
3. The cinder truck broadcast apparatus.
4. The test area following the immediate broadcasting of the cinders by the truck.
5. The test area immediate following the broadcasting of the cinders by the truck and the cleaning by the street sweeper.
6. The test area after the cinders had been broadcasted and were left on the street for 5 days.
7. The test area after the cinders had been broadcasted and were left on the street for 5 days and the cleaning by the street sweeper.
8. The street sweeper discharge pile.

The tests were conducted on the driveway of the road leading from Commerce Drive to the Town Road Department Garage in the Industrial Park. (See Figures 1 and 2.) This site was chosen because of the accessibility of the cinder truck, the street sweeper, electric power for the sampling equipment, and the heavy traffic use of the road by all of the city vehicles.

The test area was a 50ft by 10ft area of the driveway sectioned into 5, 10ft by 10 ft squares. (See Figures 3 and 4.)

2.2 SAMPLING PROCEDURE

The samples were collected by a shop vacuum and were taken on the following schedule:

1. All 5, 10ft by 10ft squares, were vacuumed prior to the commencement of the testing. This material was analyzed to determine the background road dust concentration.
2. Following the first application of cinders by the cinder truck, squares 2 and 4 were vacuumed before the street sweeper cleaned the area.
3. Squares 1, 3, and 5 were vacuumed following the street sweeper cleaning of the area.
4. Following the second application of cinders, the cinders were left on the roadway for 5 days. Squares 2 and 4 were vacuumed before the street sweeper cleaned the area.
5. Squares 1, 3, and 5 were vacuumed following the street sweeper cleaning of the second application.

Each sample was bagged, labeled, and transported to the GBUAPCD sieve in Lone Pine, CA for analysis. The data from the sieve analysis is presented in Appendix A. Five sieves and a bottom pan were used in the sieve analysis. The sieve number and mesh sizes used in the street efficiency study are described in Table 1 below.

Table 1

Mammoth Lakes
Street Efficiency
Sieve Analysis

Sieve Number	Sieve Size	Particle Size
1	#10	> 2.0mm
2	#18	> 1.0mm
3	#35	> 0.5mm
4	#60	> 0.25mm
5	#200	> 0.074mm
6	Pan (Silt)	< 0.074mm

2.3 STREET SWEEPER OBSERVATIONS

During the same day and the 5 day tests, visual observations were made on the street sweepers operation. These were taken so recommendations could be made that could improve the operation efficiency. Figures 5 and 6 show the typical operation of the street sweeper.

3.0 ANALYSIS

3.1 SAME DAY SAMPLING

During the same day test, on the average, 3,468.50 grams of cinders were distributed into each 10 X 10 foot square. (373.3 g/m^2) The distribution of sizes of these cinders are seen in Figure 7. As can be seen from this figure, the majority of the particle sizes is in the large range. Figure 7 also includes the distribution of sizes of cinders after the street sweeper cleaned the area in a typical street sweeping pass of the area. It should be noted that the majority of the cinders that remain after the street sweeper passes the area are smaller than 0.5mm in diameter.

The mass collected by the street sweeper accounts for 94.65% of the total mass of cinders distributed by the cinder truck. This is seen in Figure 8. Figure 9 shows the distribution of particle sizes before and after street sweeping. This figure reconfirms the fact that the 5.35% of mass not collected by the street sweeper was the fine particles that ultimately become responsible for this source of PM_{10}.

3.2 FIVE DAY SAMPLING

During the five day test, on the average, 2,268.15 grams of cinders were distributed into each 10 X 10 foot square. (244.1 g/m^2) The distribution of sizes of these cinders are seen in Figure 10. As can be seen from this figure, the majority of the particle sizes are in the large range. Figure 10 also includes the distribution of sizes of cinders after the street sweeper cleaned the area in a typical street sweeping pass of the area. It should be noted that the majority of the cinders that remain after the street sweeper passes the area is smaller than 0.5mm in diameter.

The mass collected by the street sweeper accounts for 89.59% of the total mass of cinders distributed by the cinder truck. This is seen in Figure 11. Figure 12 shows the distribution of particle sizes before and after street sweeping. This figure reconfirms the fact that the 10.41% of mass not collected by the street sweeper was the fine particles that ultimately become responsible for this source of PM_{10}.

3.3 COMPARISON OF SAME DAY SAMPLING AND 5 DAY SAMPLING

It should be noted that when comparing Figure 7 to Figure 10 and Figure 9 to Figure 12 that after the cinders had remained on the roadway for 5 days that the large particles are absent from the test area. This is confirmed by examining Figure 13, which clearly shows that for other than the largest of cinder particles, the particle distribution is essentially the same before the street sweeper sweeps the area on the same day and 5 day tests.

The distribution of sizes after the street sweeper has passed the area is essentially the same for both the same day removal and after the 5 day removal as seen in Figure 14.

Figure 15 shows the distribution of cinder particle sizes for the before and after in street sweeping. A sample was taken from the top of the cinder truck and a sample was taken from the discharge pile from the street sweeper. It is clear that the large particles are lost or changed into small particles in the street cindering process as indicated in Figure 15.

3.4 VISUAL OBSERVATIONS

As seen in Figures 5 and 6, the street sweeper did not have an even distributed water spray coming from the spray bar in the front of the machine. This had the effect of over watering one area and not watering other areas. This resulted in the creation of a mud strip down the street as the machine passed. This mud area contained a lot of the fines that the street sweeper was not able to remove from the street. After the mud strips dried the fines were then available to become road dust.

3.5 STREET SWEEPER SILT LOADING AND PM_{10} EMISSION CALCULATIONS

The silt loading (grams/m^2) of the streets within the Town was measured as the amount of mass that passed the #200 mesh screen per 100ft^2 test square. This was calculated using the following equation.

$$\mathit{Silt\,Loading} = \frac{(\mathit{Fraction\,of\,Silt\,per\,Sample})(\mathit{Total\,Mass\,per\,10\,X\,10\,ft\,square})}{(100\,\mathit{ft\,square})/(10.76\,\mathit{ft\,square\,per\,meter\,square})}$$

The PM_{10} emissions were calculated using the following equation.

$$e = 3.67\left(\frac{sl}{0.5}\right)^{0.8}$$

Where:

e = *PM_{10} Emissions (grams / Vehicle Mile Traveled)*
sl = *Silt Loading (grams/m^2)*

(*Ref: AQMP, pg* 3-5)

The results of this calculation is included in Table 2, 3, 4, and 5 below.

Table 2

Mammoth Lakes
Silt Loading - PM_{10} Emissions
Same Day Test

	Mass (grams) #200 Screen Passed	Test Area ft^2	Silt Loading (g/m^2)	PM_{10} Emissions (g/VMT)
Before Street Sweeper	49.55	100	5.33	24.4
After Street Sweeper	14.72	100	1.58	9.23
Efficiency				62.2

Table 3 Mammoth Lakes Silt Loading - PM_{10} Emissions 5 Day Test				
	Mass (grams) #200 Screen Passed	Test Area ft^2	Silt Loading (g/m^2)	PM_{10} Emissions (g/VMT)
Before Street Sweeper	59.21	100	6.37	28.1
After Street Sweeper	11.15	100	1.24	7.58
Efficiency				73.1

Table 4 Mammoth Lakes Silt Loading - PM_{10} Emissions Before Sweeping				
	Mass (grams) #200 Screen Passed	Test Area ft^2	Silt Loading (g/m^2)	PM_{10} Emissions (g/VMT)
Same Day Test	49.55	100	5.33	24.4
5 Day Test	59.21	100	6.37	28.1
Average	54.38	100	5.85	26.3

Table 5 Mammoth Lakes Silt Loading - PM_{10} Emissions After Sweeping				
	Mass (grams) #200 Screen Passed	Test Area ft^2	Silt Loading (g/m^2)	PM_{10} Emissions (g/VMT)
Same Day Test	14.72	100	1.58	9.23
5 Day Test	11.15	100	1.24	7.58
Average	12.94	100	1.41	8.41

3.6 STREET SWEEPER EFFICIENCY OF MASS LOADING

Figure 16 compares the efficiency of the street sweeper on the removal of cinders on the same day they were distributed and after 5 days. It should be noted that after 5 days on the street there is approximately 10.7% more fines, the material collected in the pan or the material that passes through the 0.074 mm screen.

3.7 STREET SWEEPER EFFICIENCY OF PM_{10} PARTICLE REMOVAL

Table 2 shows the silt loading, PM_{10} emission factor, and PM_{10} removal efficiency for the same day test. As can be seen, the street sweeper is 62.2% efficient in removing the PM_{10} size particles when the cinders are removed the same day they are spread. This compares to an overall efficiency of 90.25% for the entire mass of cinders.

Table 3 shows the silt loading, PM_{10} emission factor, and PM_{10} removal efficiency for the 5 day test. As can be seen, the street sweeper is 73.1% efficient in removing the PM_{10} size particles when the cinders are removed five days after they are spread. This compares to an overall efficiency of 89.59% for the entire mass of cinders.

Table 4 shows the loading, PM_{10} emission factor, and PM_{10} removal efficiency for the same day and 5 day tests before the street sweeper removed the cinders. Table 5 shows the loading, PM_{10} emission factor, and PM_{10} removal efficiency for the same day and 5 day tests after the street sweeper removed the cinders. In comparison it can be seen that the street sweeper in general is on the average 67.7% efficient in removing the PM_{10} size particles from the streets.

The Environmental Protection Agency roports that a 34% reduction in reentrained road dust can be accomplished by vacuum sweeping (Control of Open Fugitive Dust Sources, 1988). This study observed a average of 67.7% efficiency using the Town street sweeper.

4.0 CONCLUSIONS

The street sweeper, as seen in Figure 8, is 94.65% efficient in removing the total mass of the cinders on the same day test. This compares to 89.59% efficiency if the cinders are left on the streets for 5 days. In contrast, the street sweeper on the average is 67.7% efficient in removing the PM_{10} size particles. This represents a greater efficiency than that predicted by the Environmental Protection Agency (34%). In spite of this improved performance, this study has demonstrated significant ways in which the efficiency can be further improved.

It is clearly seen from Figures 7 and 9 that the street sweeper in being 94.65% efficient in removing the cinders from the streets is removing the large and leaving the very small particles behind. This is also evident in Figures 9 and 11 from the 5 day test. It is also evident that the largest particles are either being broken into smaller particles or being kicked off the roadway by the vehicles driving over them as seen in Figures 9 and 11. As a result of the particles being broken into smaller sizes the street sweeper became less efficient as seen in Figure 16.

It is interesting to note that the street sweeper is 73.1% efficient in removing the PM_{10} size particles after 5 days as compared to 62.2% efficient on the same day. An explanation for this difference could be that, as seen in Figures 9 and 11, the distribution is skewed towards the PM_{10} size particles. This means that with fewer larger particles and more smaller particles and the street sweeper removes only a finite number of particles each pass, there are more PM_{10} particles removed after 5 days because there are more PM_{10} size particles in the distribution.

Of further note is the distribution of vehicles / day in the test area as compared to the actual busy Town streets. In 1990 there were, on average, 8,625 vehicle miles traveled per day (VMT/D), 0.75 miles on Main Street for an average of 6,469 daily trips. (*Air Quality Management Plan for the Town of Mammoth Lakes*, November 30, 1990, page 3-6.) This compares to an estimated 500 daily trips in 5 days or 100 daily trips average in the test area. This means that what took 5 days to accomplish in terms of cinder degradation and cinder distribution in the test area is accomplished in 8 hours on Main Street. This compelling evidence is additional support for the street sweeper to begin the clean up job as soon as possible after the storm has subsided.

A large amount of the fines that were left behind by the street sweeper were contained in the over watered strip that was left as a result of the uneven spray bar water distribution. These stripped areas became dusty as soon as the strips dried.

The data gathered and analyzed in this report is consistent with that calculated in the Air Quality Management Plan for the Town of Mammoth Lakes. The Air Quality Management Plan for the Town of Mammoth Lakes calculated the silt loading to be 8.7 g/m^2. This was based on the assumption that the silt content of the cinders was approximately 2%. This figure compares to 8.41 g/m^2 measured in this study. The figure used in the original SIP is within 3% of the actual measured amount.

5.0 RECOMMENDATIONS

The following recommendations are based upon the analysis of the data in this study and the observations of the street sweeper in action.

1. Modify the street sweeper spray bar so that it can deliver an evenly distributed spray. This will decrease the over watered stripes and increase the machines efficiency in removing the PM_{10} size particles.
2. Research addition measures that could taken to increase the efficiency of removing the PM_{10} size particles from the Town Streets.
3. Implement a management plan to assure that the street sweeper will remove the cinders as soon as possible after their distribution onto the streets. The removal process should begin hours after the storms not days.
4. Research alternative spray solutions that are environmentally safe and machine compatible so that the street sweeper can operate at colder temperatures. This would facilitate earlier removal of the cinders and therefor less cinder breakdown.
5. Duplicate the study following the implementation of recommendations 1 & 3 both in the test area and on one of the Town streets.

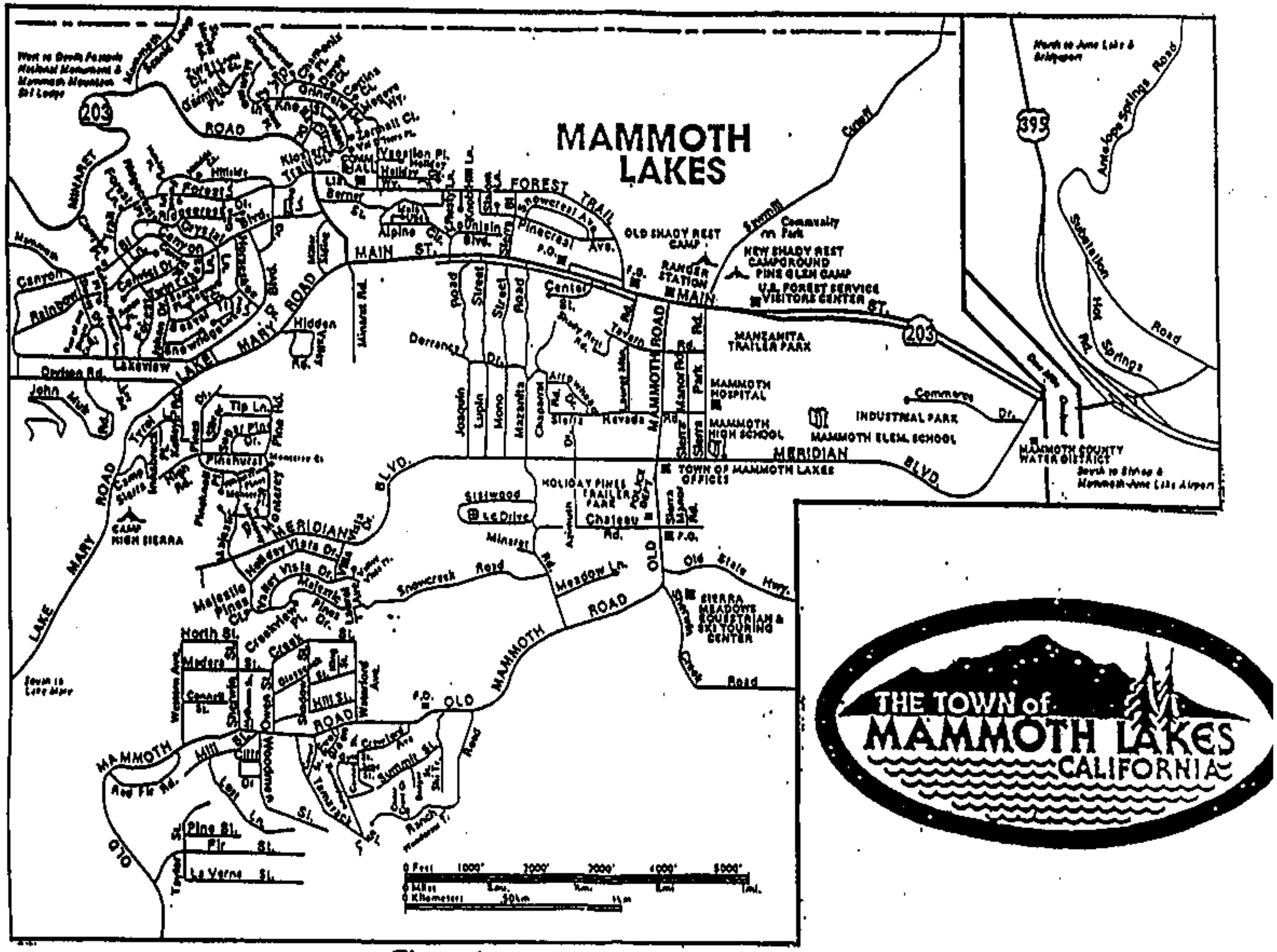
MAMMOTH LAKES
MAIN ST.
FOREST TRAIL
MERIDIAN BLVD.
LAKE MARY ROAD
OLD MAMMOTH ROAD
MAMMOTH ROAD
MINARET ROAD
OLD SHADY REST CAMP
NEW SHADY REST CAMPGROUND
PINE GLEN CAMP
RANGER STATION
U.S. FOREST SERVICE VISITORS CENTER
MANZANITA TRAILER PARK
MAMMOTH HOSPITAL
MAMMOTH HIGH SCHOOL
MAMMOTH ELEM. SCHOOL
INDUSTRIAL PARK
MAMMOTH COUNTY WATER DISTRICT
TOWN OF MAMMOTH LAKES OFFICES
HOLIDAY PINES TRAILER PARK
CAMP HIGH SIERRA
SIERRA MEADOWS EQUESTRIAN & SKI TOURING CENTER
203
395
THE TOWN of MAMMOTH LAKES CALIFORNIA

Figure 1

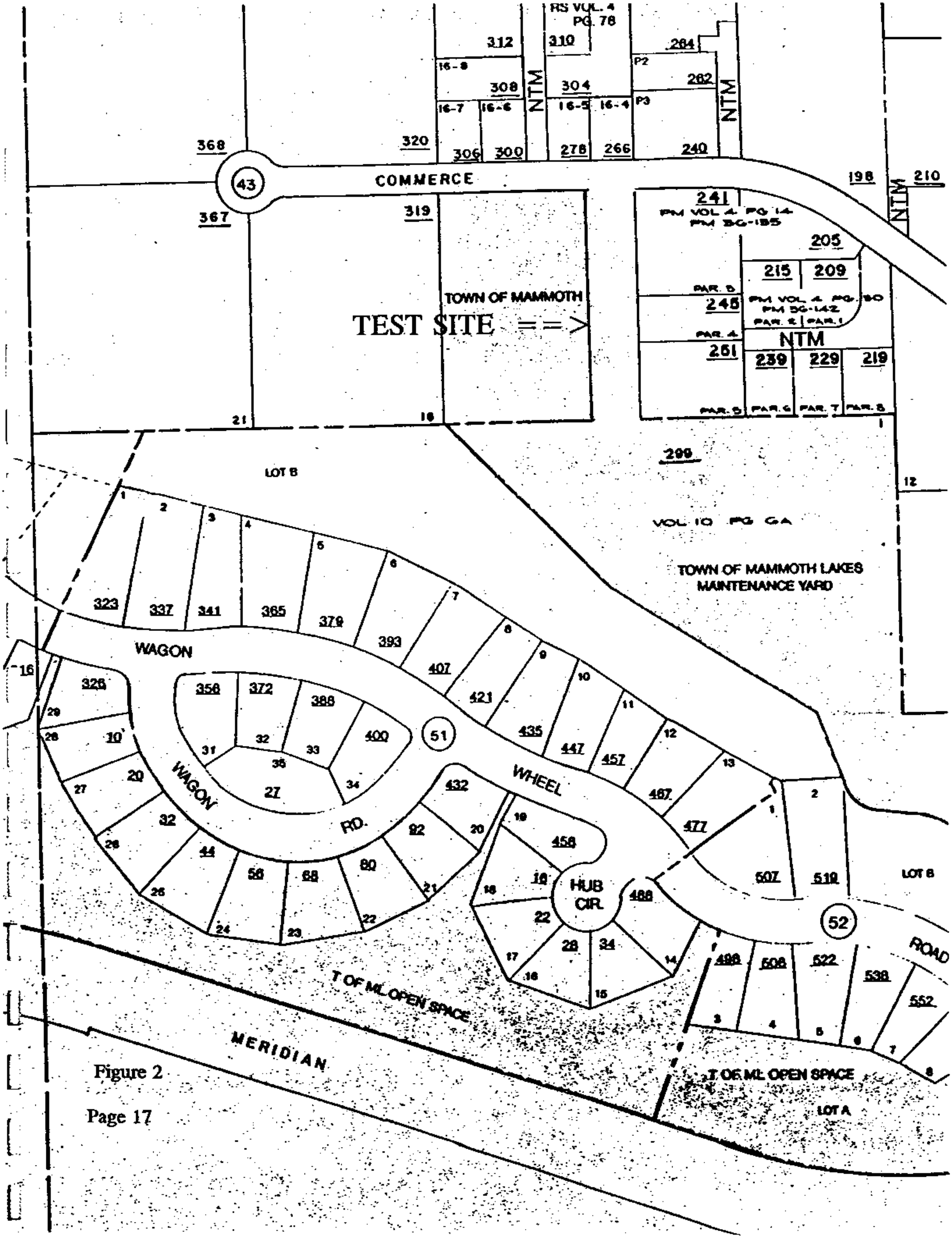
COMMERCE
TOWN OF MAMMOTH
TEST SITE ==>
TOWN OF MAMMOTH LAKES
MAINTENANCE YARD
LOT B
WAGON
WHEEL
WAGON
RD.
HUB CIR.
ROAD
T OF ML OPEN SPACE
MERIDIAN
LOT A
NTM
PM VOL 4 PG 14
VOL 10 PG 6A

Figure 2

Test Site

Street Sweeper ===> Path	After Sweeper 1	Before Sweeper 2	After Sweeper 3	Before Sweeper 4	After Sweeper 5
	10'	10'	10'	10'	10'

Figure 3

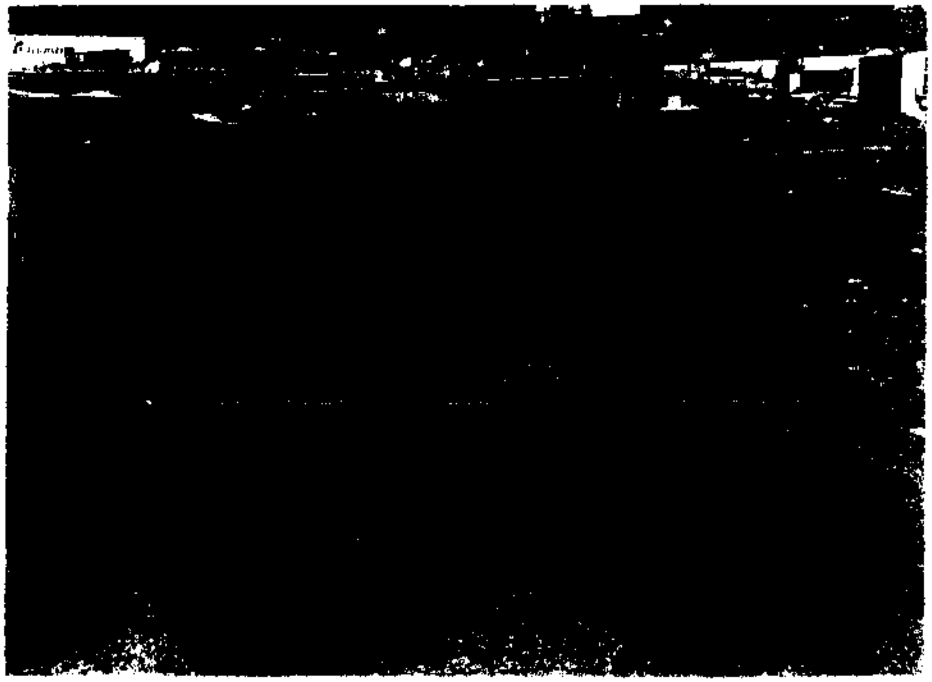


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Figure 4

Figure 6

Figure 5

DISTRIBUTION OF CINDER SIZES FOR TOTAL LOADING: SAME DAY SAMPLE

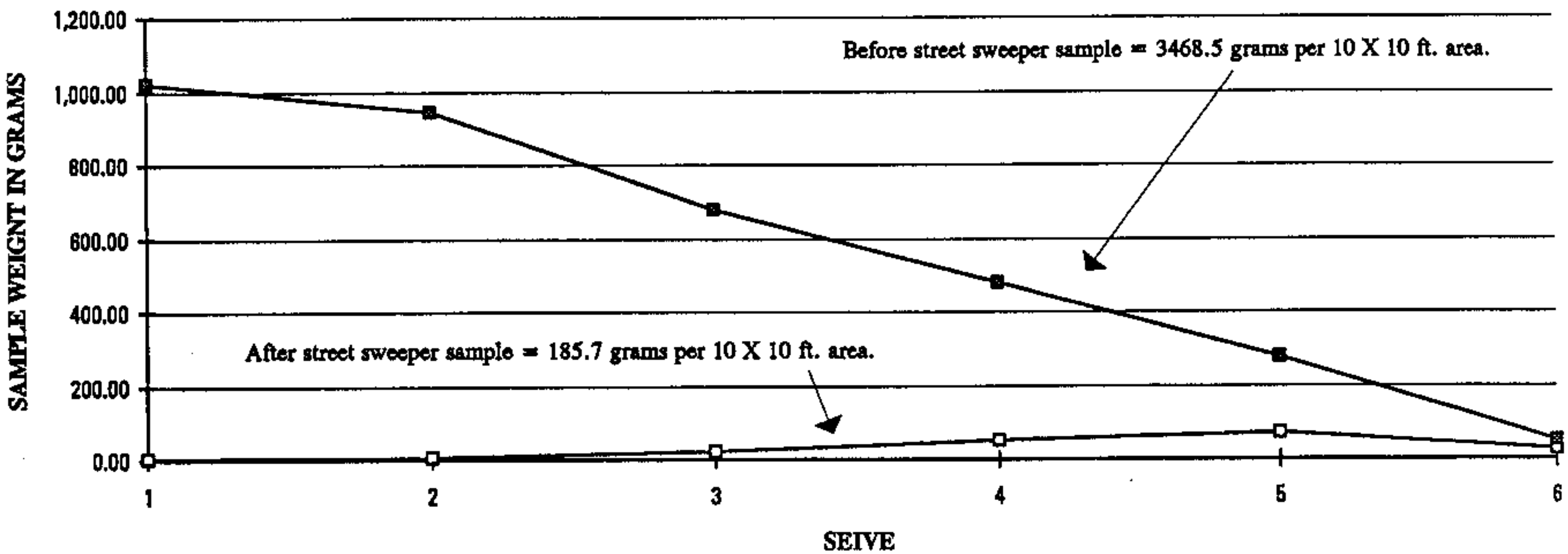


Figure 7

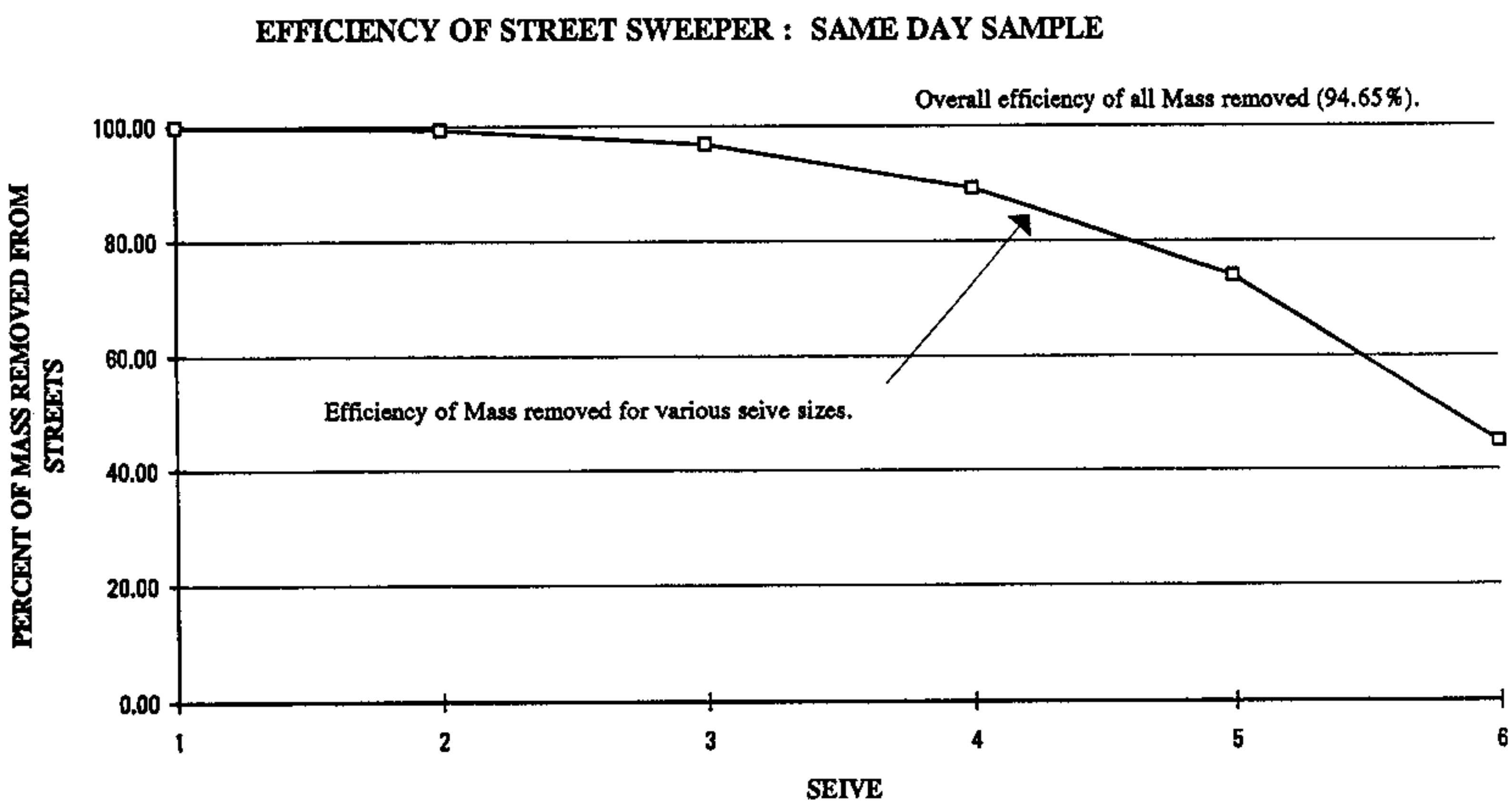

EFFICIENCY OF STREET SWEEPER : SAME DAY SAMPLE
Overall efficiency of all Mass removed (94.65%).
Efficiency of Mass removed for various seive sizes.
PERCENT OF MASS REMOVED FROM STREETS
SEIVE
100.00
80.00
60.00
40.00
20.00
0.00
1
2
3
4
5
6

Figure 8

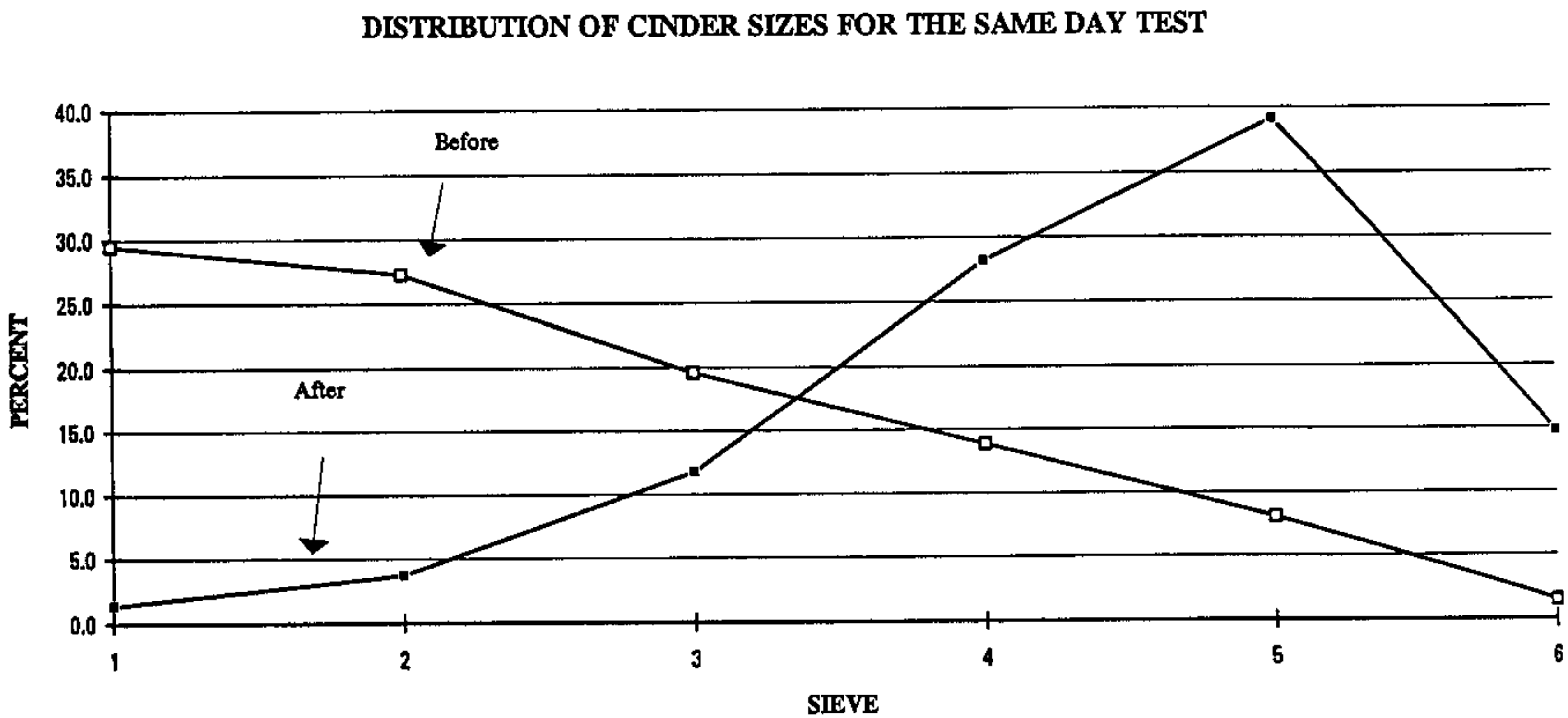

DISTRIBUTION OF CINDER SIZES FOR THE SAME DAY TEST
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
PERCENT
Before
After
1
2
3
4
5
6
SIEVE

Figure 9

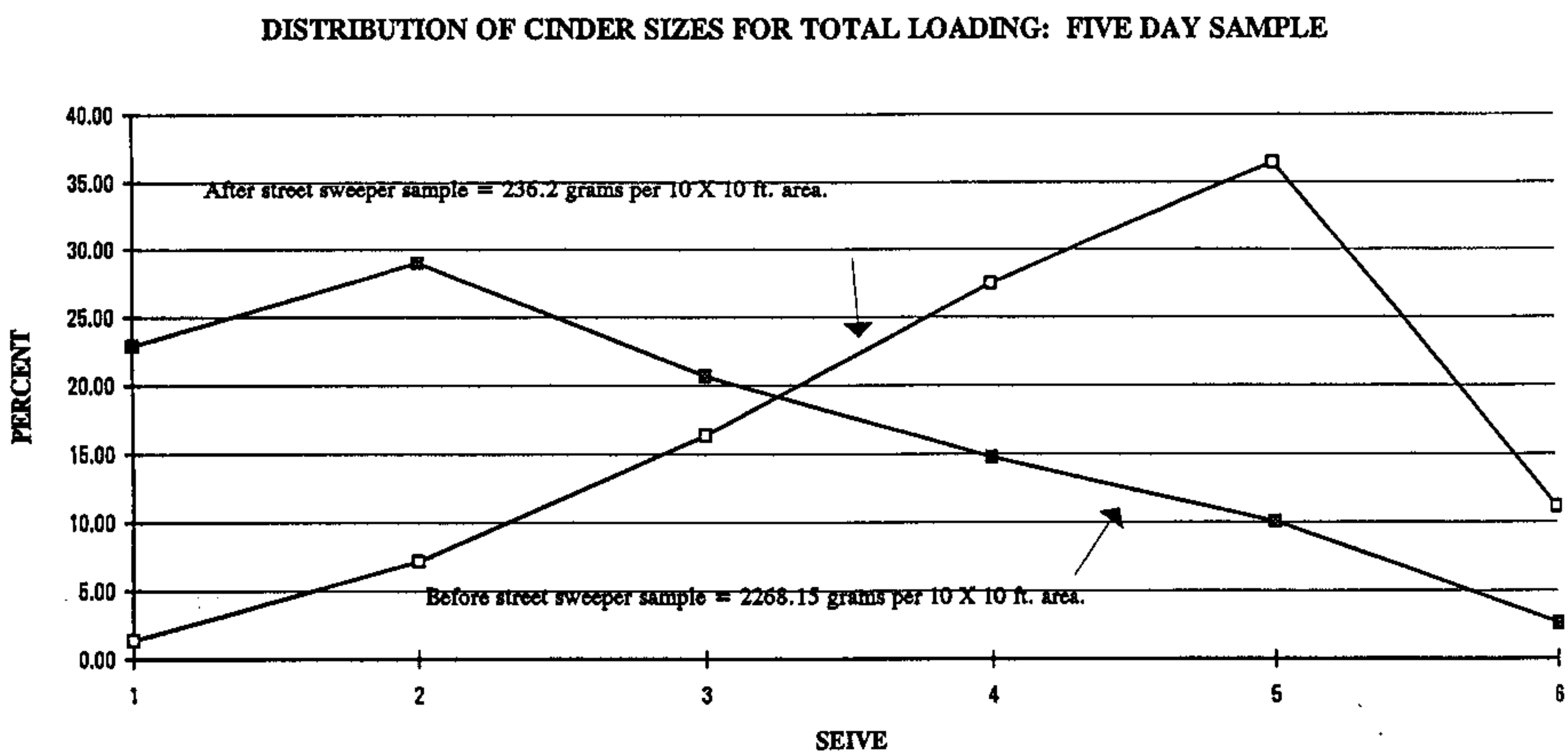

DISTRIBUTION OF CINDER SIZES FOR TOTAL LOADING: FIVE DAY SAMPLE
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
PERCENT
After street sweeper sample = 236.2 grams per 10 X 10 ft. area.
Before street sweeper sample = 2268.15 grams per 10 X 10 ft. area.
1
2
3
4
5
6
SEIVE

Figure 10

EFFICIENCY OF STREET SWEEPER: FIVE DAY SAMPLE

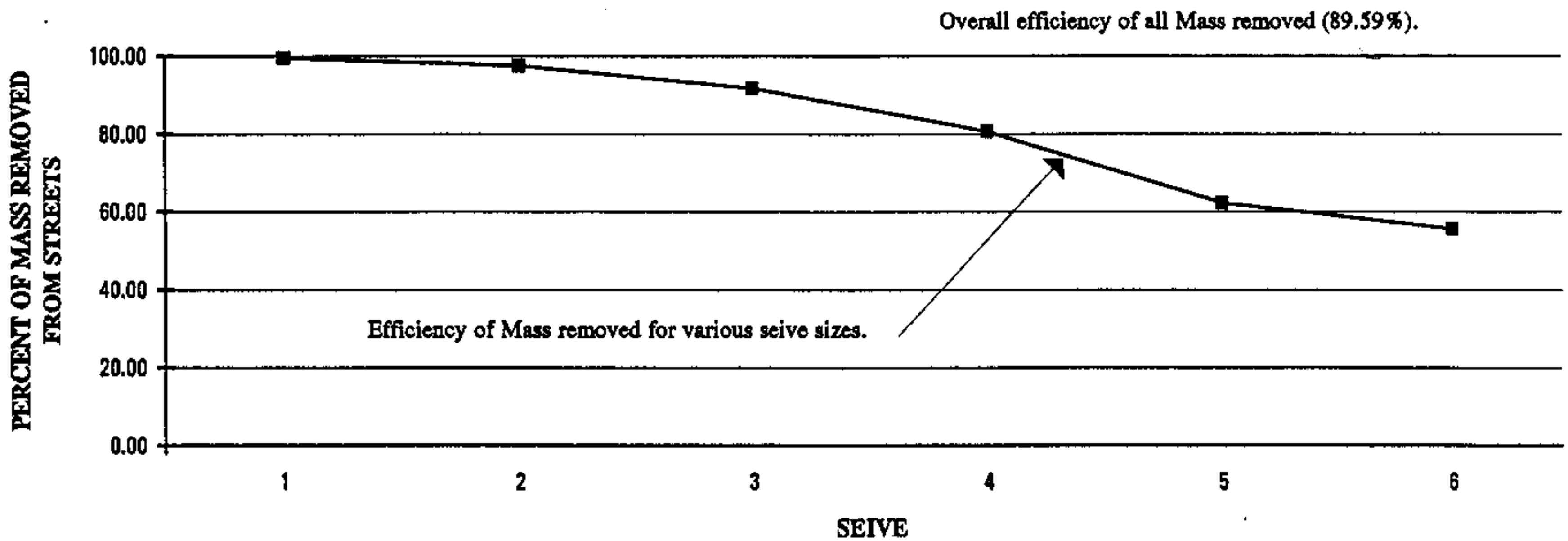


Figure 11

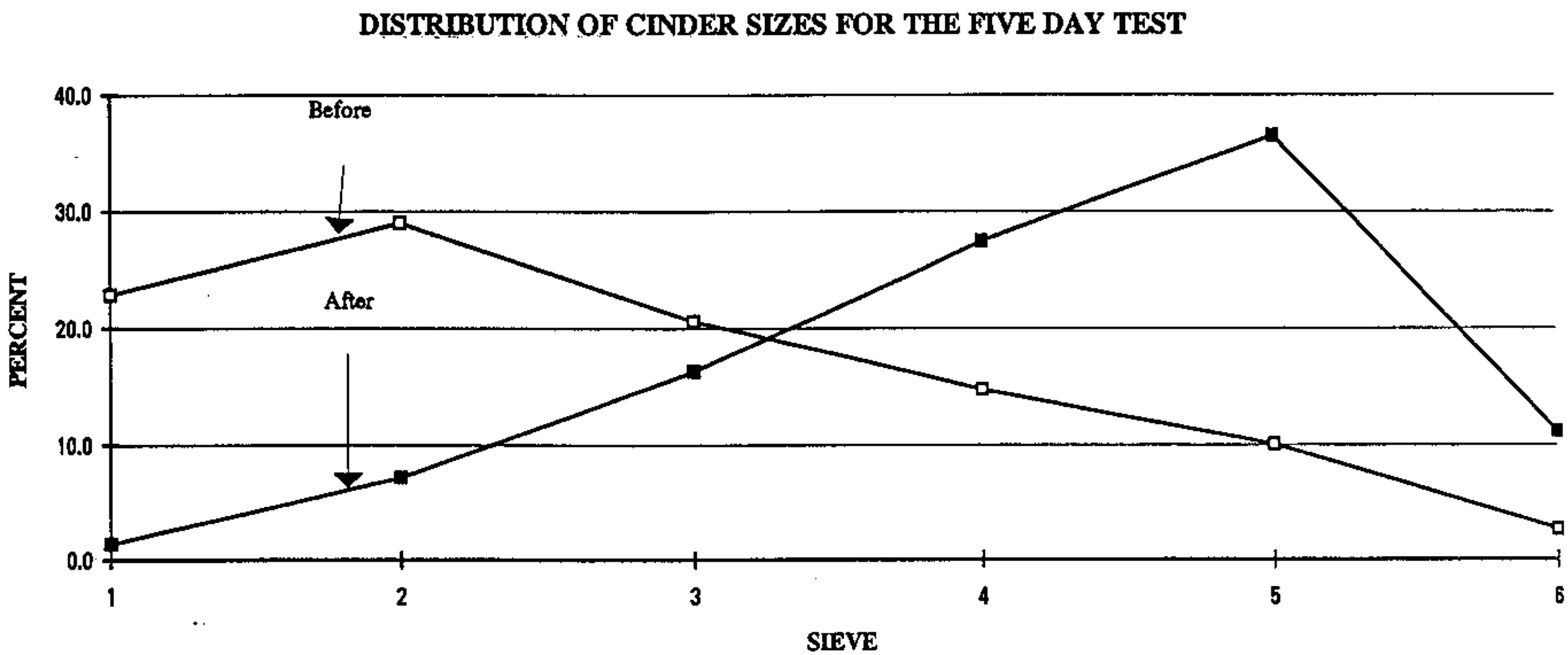

DISTRIBUTION OF CINDER SIZES FOR THE FIVE DAY TEST
40.0
30.0
20.0
10.0
0.0
Before
After
PERCENT
1
2
3
4
5
6
SIEVE

Figure 12

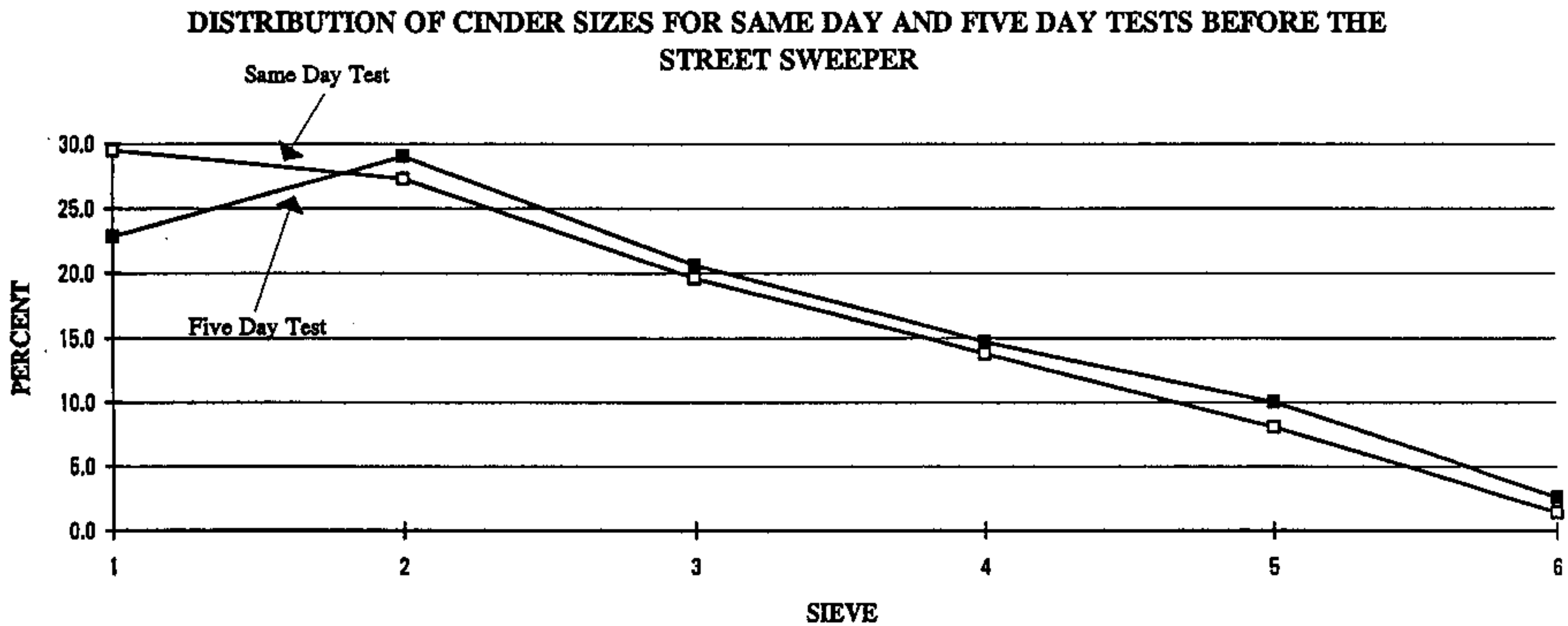

DISTRIBUTION OF CINDER SIZES FOR SAME DAY AND FIVE DAY TESTS BEFORE THE STREET SWEEPER
Same Day Test
Five Day Test
PERCENT
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1
2
3
4
5
6
SIEVE

Figure 13

DISTRIBUTION OF CINDER SIZES FOR SAME DAY AND FIVE DAY TESTS AFTER STREET SWEEPER

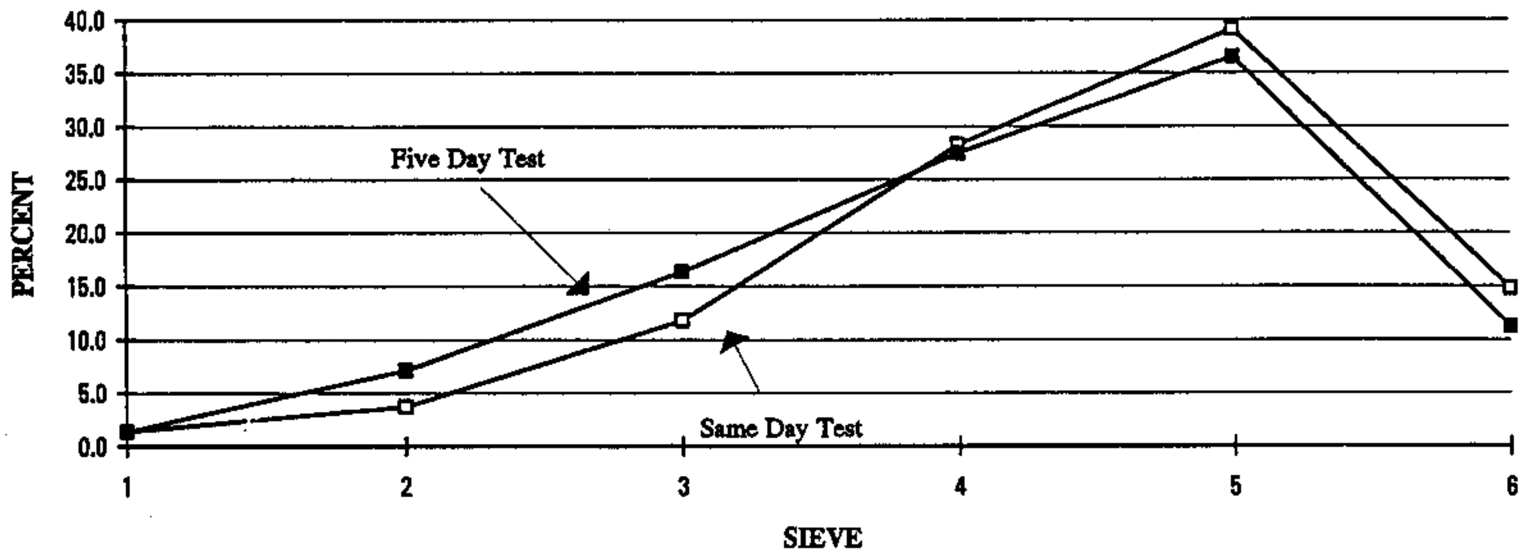


Figure 14

DISTRIBUTION OF CINDER SIZES FROM THE STOCK PILE TO THE DISCHARGE PILE

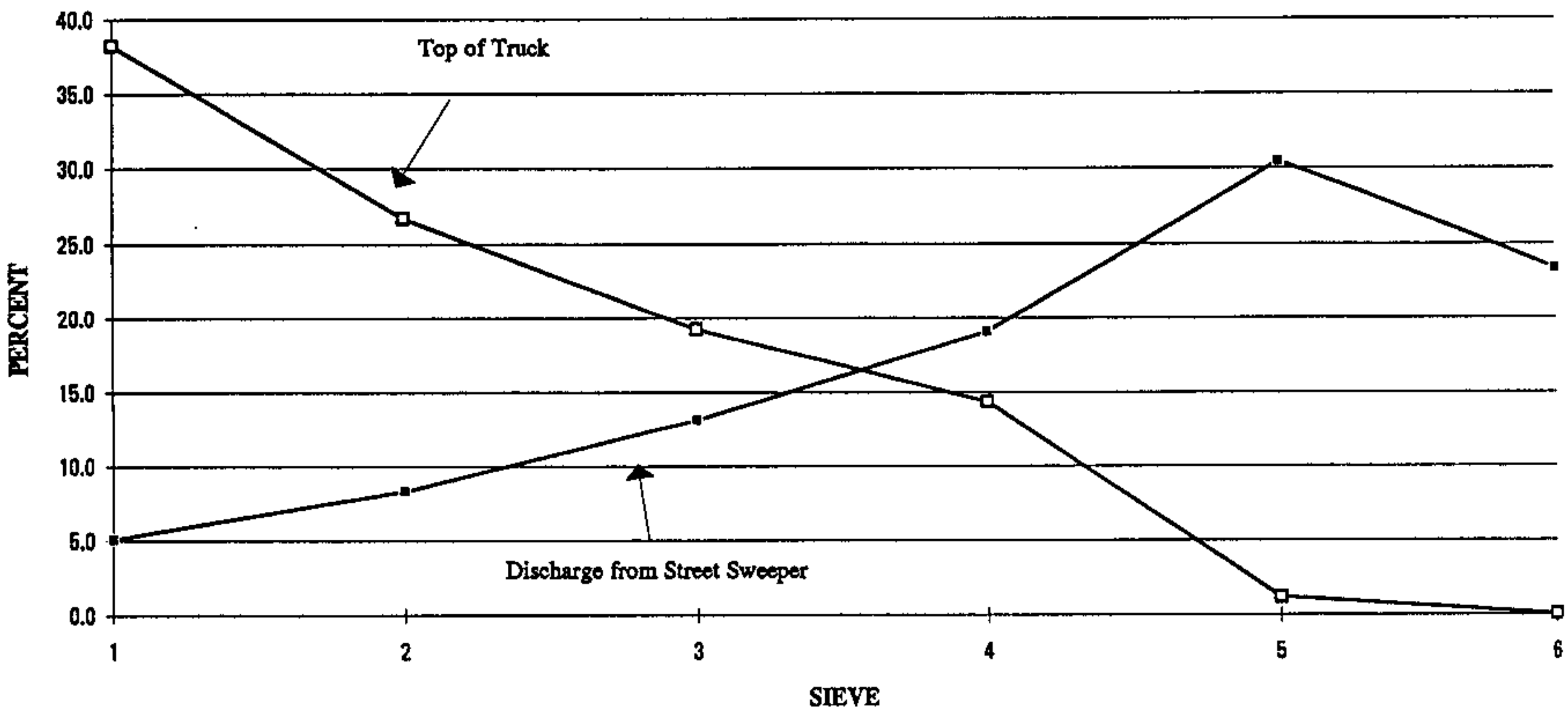
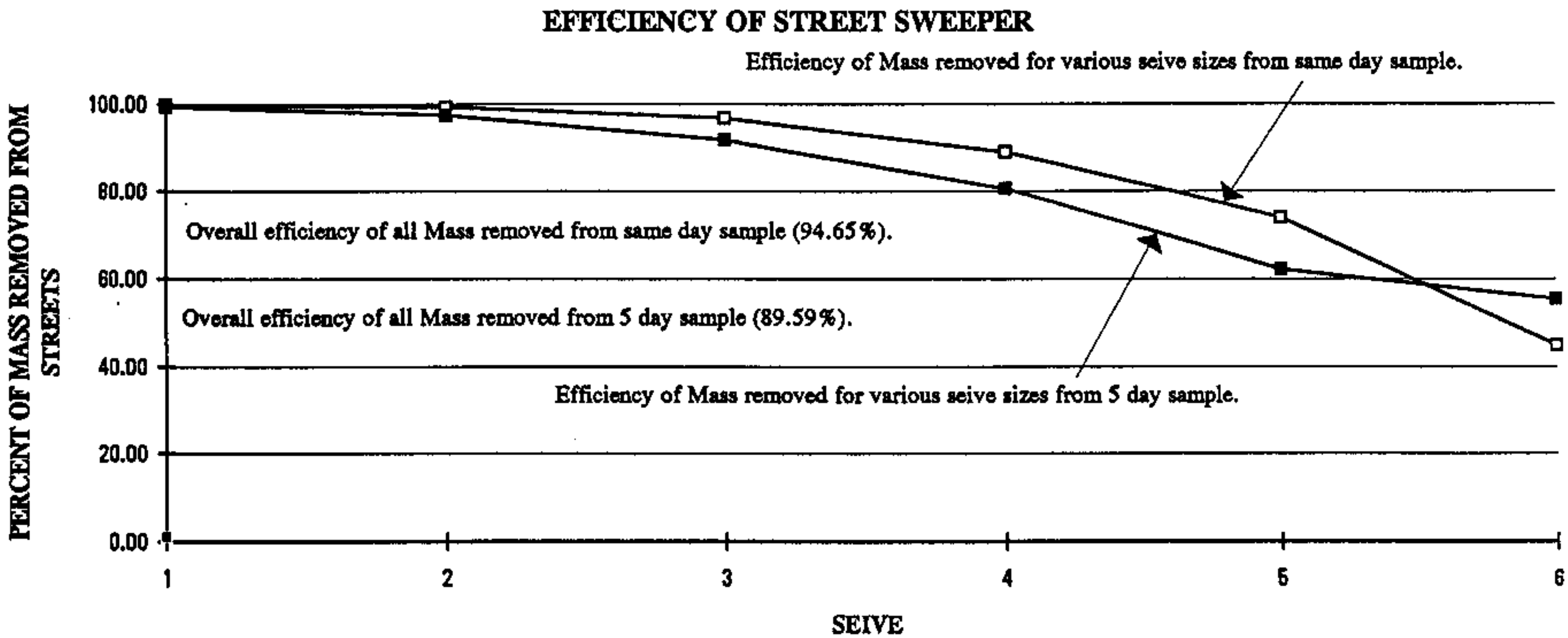


Figure 15



EFFICIENCY OF STREET SWEEPER
Efficiency of Mass removed for various seive sizes from same day sample.
100.00
80.00
60.00
40.00
20.00
0.00
Overall efficiency of all Mass removed from same day sample (94.65%).
Overall efficiency of all Mass removed from 5 day sample (89.59%).
Efficiency of Mass removed for various seive sizes from 5 day sample.
PERCENT OF MASS REMOVED FROM STREETS
1
2
3
4
5
6
SEIVE

Figure 16

STREET SWEEPER

EFFICIENCY STUDY

APPENDIX

			STREET SWEEPER DATA (1994)					
Description	Wt Average (gr)	Wt (grams) sieved	Sieve #10	Sieve #18	Sieve #35	Sieve #60	Sieve #200	Pan
	10 x 10 ft square	per 10X10ft square	(2.0mm)	(1.0mm)	(0.5mm)	(0.25mm)	(0.074mm)	
Rd Clean Up	522.20	522.20	26.50	43.30	68.30	99.60	158.80	121.90
Rd Clean Up %			5.07	8.29	13.08	19.07	30.41	23.34
Top Truck	1,095.80	1,095.80	418.80	292.40	210.80	157.00	12.70	0.40
Top Truck %			38.22	26.68	19.24	14.33	1.16	0.04
Broadcast Truck	551.70	551.70	133.30	168.70	142.50	98.80	4.80	0.10
Broadcast Truck %			24.16	30.58	25.83	17.91	0.87	0.02
Same Day Test								
2 & 4 Before Av	3,468.50	1,903.90	561.55	519.20	372.70	263.45	152.80	27.20
2 & 4 Percent			29.49	27.27	19.58	13.84	8.03	1.43
Full Sample Totals			1,023.02	945.87	678.98	479.95	278.37	49.55
1, 3, &5 After Av	185.70	185.70	2.50	6.87	21.83	52.40	72.60	27.33
1, 3, &5 Percent			1.35	3.70	11.76	28.22	39.10	14.72
5 Day Test								
2 & 4 Before Av	2,268.15	1,141.75	261.45	331.60	235.75	168.35	114.75	29.85
2 & 4 Percent			22.87	29.00	20.62	14.72	10.04	2.61
Full Sample Totals			518.61	657.76	467.63	333.94	227.62	59.21
1, 3, &5 After Av	236.17	236.17	3.30	16.83	38.53	64.83	86.13	26.33
1, 3, &5 Percent			1.40	7.13	16.32	27.45	36.47	11.15
Dump Pile	1,468.80	734.70	158.40	156.10	134.50	120.50	117.40	40.90
Dump Pile Percent			21.56	21.25	18.31	16.40	15.98	5.57
Same Day								
E=Wt(after)/wt(bef)		90.25	99.76	99.27	96.78	89.08	73.92	44.84
5 Day								
E=Wt(after)/wt(bef)		89.59	99.36	97.44	91.76	80.59	62.16	55.53