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AN INVESTIGATION OF RADON MITIGATION IN PENNSYLVANIA

by
William E. Belanger, P.E.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III

841 Chestnut Street
Philadelphia, Pennsylvania 19107

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Abstract

Radon mitigation contractors were contacted to obtain information on the progress of radon mitigation in Pennsylvania. Information was obtained on the beginning and ending radon concentrations, the cost of the job, the mitigation method used, and the location by zip code. Most radon mitigations achieved reductions below 90 percent, and most achieved 4 pCi/l. 65 percent achieved 2 pCi/l. There was little relationship between the cost of the job and either the percent reduction or the beginning radon. Percent reduction was strongly related to beginning radon, with lower percent reductions associated with low starting radon.

Introduction

The Environmental Protection Agency and the Centers for Disease Control have advised every homeowner to test for radon. EPA recommends that the home be fixed if the radon level is above 4 picoCuries per liter (pCi/l) of radon. 4 pCi/l was chosen as a level above which the radon should be fixed. This was not chosen as a level where radon risks are acceptable. It was based on EPA's knowledge of how well a home can be fixed.

Since the 4 pCi/l action level was set in 1986, there has been considerable progress in radon mitigation. Thousands of people have been trained as radon contractors and have gone into the business. The techniques to fix the house have been greatly refined. The cost of radon control has decreased greatly. We felt that an update of the 1986 information would be useful to the public, and would help in updating the EPA guidance.

Procedure

This paper reports the results of a survey done by EPA's Region III (Philadelphia) office. The survey was done to assess the state of radon mitigation. We wanted to know how effective radon contractors were at reducing the radon levels and we wanted to know how much money homeowners were paying to have this work done. In cooperation with the Pennsylvania Bureau of Radiation

Protection, we contacted every radon contractor doing business in Pennsylvania. We asked for information on previous radon jobs they had done. This information was already maintained for use by Pennsylvania.

The information requested was the beginning radon, the final radon, the type of mitigation, the cost of the job and the zip code. We did not request the name or address or any other data which would identify the home or the homeowner. The information was keypunched and analyzed using a spreadsheet program. Distributions were calculated for initial radon, final radon, percent reduction, and cost.

Besides the tabulations above, it was also of interest to determine the factors which affected the percent reduction and the cost of mitigation. These parameters were therefore graphed as a function of each other and of radon concentrations. The analysis was limited to graphics because the graphs yield sufficient information for an understanding of the processes involved. A numerical analysis would yield little added information.

Results

Figure 1 is the distribution of radon concentrations prior to mitigation. The abscissa is logarithmic, so this distribution is approximately log-normal above 4 pCi/l. The distribution is typical of the high-radon areas of Pennsylvania. Note that below 4 pCi/l, there appears to be a "notch" cut out of the distribution. This shows that few houses are being mitigated when the initial concentration is below 4 pCi/l.

Figure 2 is the radon concentration after mitigation. The leftmost bar, labeled "NR", is the number of jobs for which post-mitigation radon measurements were not reported. In telephone contacts with the mitigators, we found that many mitigators did not routinely measure the radon after mitigation. In fact, the mitigators who did not do post mitigation testing are in the majority. Sixty-five percent of mitigators fall in this category. The Radon Contractor Proficiency (RCP) Program now includes mitigation protocols which require post-mitigation testing, so this should not be representative of more recent practice in the field.

The radon results in this figure therefore show only the results obtained by firms who do post-mitigation measurements. Since the other firms do not receive "feedback" on the quality of their work, it is reasonable to conclude that their results may not be as good as the firms who measure after mitigation. Without post-mitigation measurements there is no evidence to support any conclusion on this point, but the post-mitigation results quoted here are applicable only to the firms who measure. It appears that 93 percent of radon mitigations done by this group achieve 4 pCi/l.

Figure 3 further breaks down the post-mitigation measurements. Again for the contractors who measure, 80 percent of jobs achieve 3 pCi/l, 65 percent achieve 2 pCi/l and 40 percent achieved 1 pCi/l. This shows the mitigations to be very successful on the whole. The reader should note that these measurements are short-term post-mitigation measurements and may not represent the long-term radon concentrations in the mitigated houses and do not reflect any deterioration in the system with time.

There is no theory known to the author which would allow prediction of the statistical form of the post-mitigation radon distribution. However, examination of figure 3 shows a regular pattern in the post-mitigation results. A smooth curve can be drawn to fit the data. This is the broken line on the graph. If this curve is regarded as the expected number of results at each radon concentration, more jobs than would be expected fall between 3 and 4 pCi/l. One could loosely interpret this as indicating that something is favoring results just below 4 pCi/l. Either contractors are stopping when they reach this level or mitigation techniques are being chosen to achieve a particular radon concentration. This conclusion cannot be rigorously supported, but is consistent with what is taught in the radon mitigation courses. In these courses, contractors have been taught to target a particular radon result and they appear to be successful in doing this.

Figure 4 shows the percent reduction of radon achieved. Again, this could be calculated only for contractors who submitted post-mitigation measurements. 83 percent of the radon mitigation efforts achieved reductions were above 80 percent, and 65 percent of jobs achieved reductions above 90 percent. There is a peak in the percent effectiveness at about 97 percent. This is the most frequent percent reduction. From this it appears that most radon mitigations achieve large reductions in radon. A small percentage of mitigations yielded low reductions. These are primarily caulking and sealing efforts where little reduction was needed.

An analysis of the percent reduction achieved is shown in Figure 5. It can be seen that when the beginning radon is high, the percent reduction tends to be very high. Low percent reductions seem to occur only when the beginning radon is low. This appears to be a combination of several factors. Low starting radon leads to a choice of less effective radon reduction techniques. Efforts at further reduction are stopped sooner as "satisfactory" radon levels are achieved. It is also possible, but not proven, that low levels of radon are simply harder to reduce because of background radon and sources other than soil gas. Virtually all the mitigations here dealt only with radon entering the house in soil gas.

Figure 6 is the same as Figure 5, but the abscissa scale has been expanded. The solid curve drawn on the chart is the percent reduction needed to achieve 4 pCi/l. Note the remarkable way the line delineates the dense population of reductions achieved. This is further evidence that radon mitigations are being conducted to achieve a 4 pCi/l goal. This plot also reveals the low number of mitigations begun below 4 pCi/l.

Figure 7 shows the distribution of radon mitigation costs. This graph shows the cost of radon mitigation to be typically between $500 and $2500, with the most common cost being between $1000 and $1500. Several jobs cost over $4000, and 12 percent of jobs cost less than $500. The apparent regular distribution of costs suggests that there has not been a tendency to settle on a fixed price within the radon mitigation industry.

Figures 8 and 9 are an attempt to evaluate factors affecting the cost of radon mitigation. Figure 8 shows cost as a function of percent reduction. There appears to be little observable effect on cost from the percent reduction achieved. Most of the jobs costing above $2000 had high percent reductions. It is likely that the contractors did additional work in these jobs to achieve needed reductions. However, most of the jobs with high percent reductions cost about the same as other jobs. This indicates that the typical mitigation method, sub-slab-suction, achieved high percentage reductions in most applications.

Figure 9 shows the cost as a function of initial radon concentration. There does not appear to be a tendency for jobs with high initial radon to cost more than other jobs. Most of the jobs costing less than $500 had low initial radon, but a significant number of these jobs had radon levels above 10 pCi/l. Caulking and sealing would normally not be applied alone above 10 pCi/l. Because the jobs reported in this graph all had post mitigation measurements, it is unlikely that the contractors involved were "cutting corners". There is no explanation for these low costs, except that it is possible the homeowner did some or all of the installation. Some of the highest costs were associated with houses with low initial radon. This suggests that the houses that are hardest to fix are not necessarily those with the highest radon.

Conclusions

This analysis has yielded several important observations about radon mitigation as it is conducted today. It appears that few mitigations are done below 4 pCi/l. People appear to have embraced the EPA action level of 4 pCi/l. There is a great deal of success in achieving 4 pCi/l as a goal, and most radon mitigations achieve below 2 pCi/l. However, there is some evidence that some mitigations are deliberately structured to achieve 4 pCi/l. It is possible that additional reductions in radon could be achieved on these jobs, but that a decision has been made to stop when 4 pCi/l is achieved.

It is also possible that mitigation techniques have been deliberately selected based on their ability to achieve 4 pCi/l. For example, passive sealing seldom achieves more than a 50% reduction, and so would be selected as a control method only when radon is only slightly above 4 pCi/l. In either this or the above case, the mitigator training has encouraged this approach in the past. If it is desired to reduce radon in houses to as low a level as practical, it may be desirable to examine this policy.

Cost of radon mitigation appears to be a function of the complexity of the job, not the initial radon concentration or the percent reduction achieved. There is no evidence from this analysis that the radon mitigation industry is standardizing the costs of radon mitigation. Costs appear to be set competitively, and the costs are in line with other home repairs.

On the whole, radon mitigation appears to be quite successful, at least for the firms who test after mitigation.

The success rate for firms who do not do post-mitigation testing is unknown. Post-mitigation testing is a part of the mitigation guidelines that contractors must adopt as a part of EPA's Radon Contractor Proficiency program, so the amount of post mitigation testing should increase in the future.

References

U. S. Environmental Protection Agency. Radon Reduction Techniques for Detatched Houses. Washington, DC: EPA/625/5-87/019: 1-192; 1987.

U. S. Environmental Protection Agency. Radon Reference Manual. Washington, DC: EPA 520/1-87-20: 1 - 16-15.

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FIGURE CAPTIONS

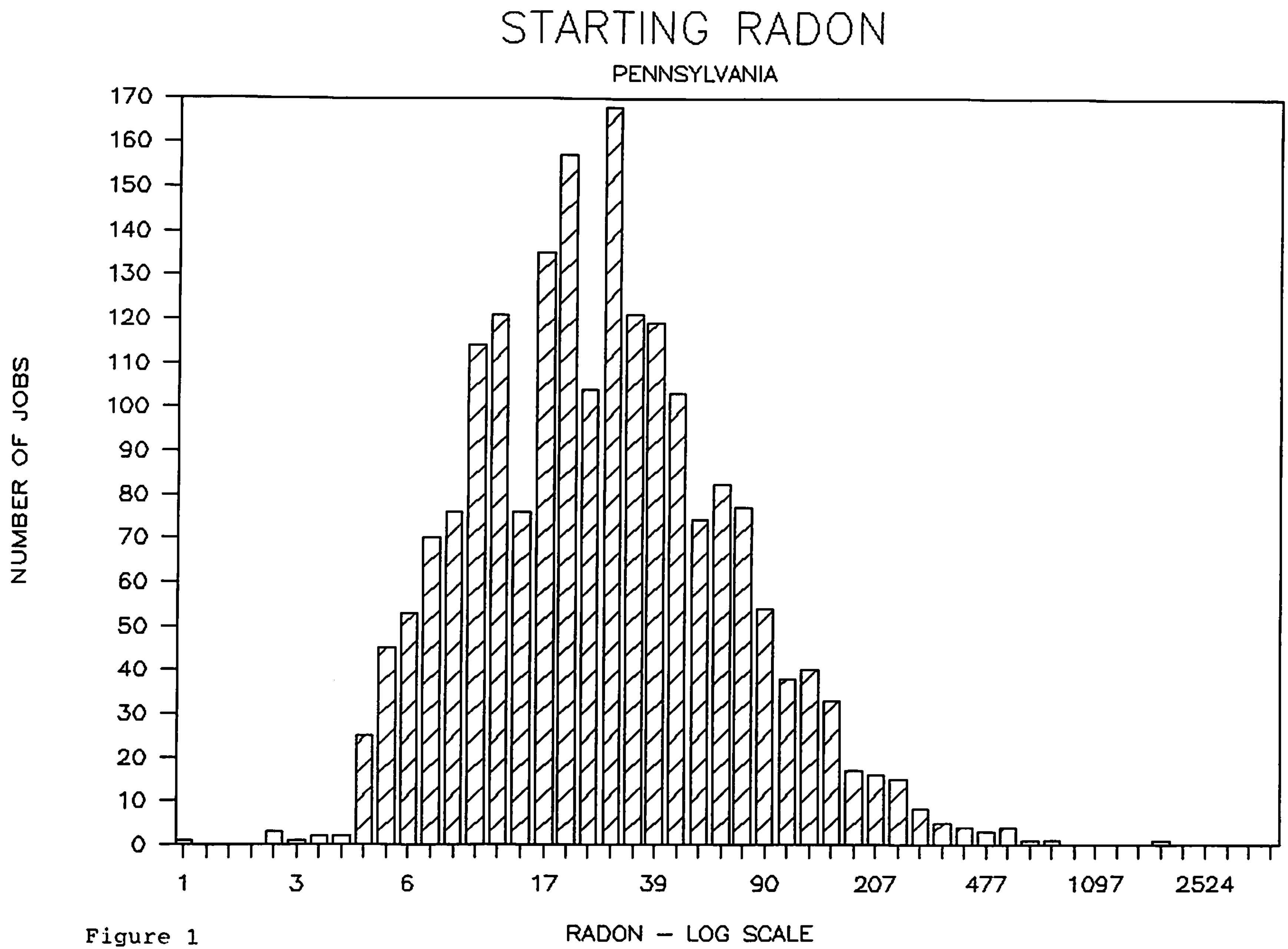
STARTING RADON
PENNSYLVANIA
NUMBER OF JOBS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
1
3
6
17
39
90
207
477
1097
2524
RADON — LOG SCALE

Figure 1

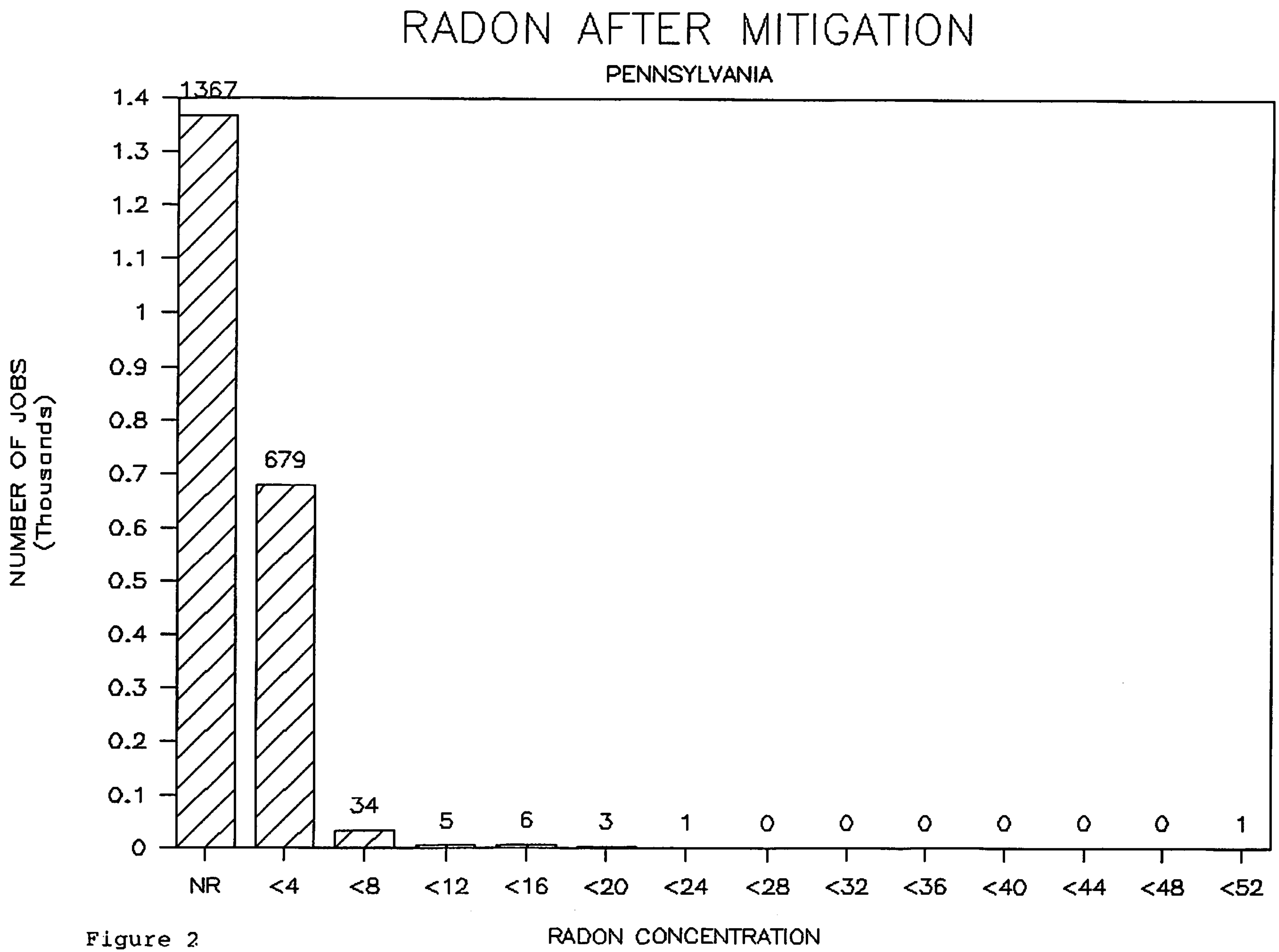
RADON AFTER MITIGATION
PENNSYLVANIA
NUMBER OF JOBS
(Thousands)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1367
679
34
5
6
3
1
0
0
0
0
0
0
1
NR
<4
<8
<12
<16
<20
<24
<28
<32
<36
<40
<44
<48
<52
RADON CONCENTRATION

Figure 2

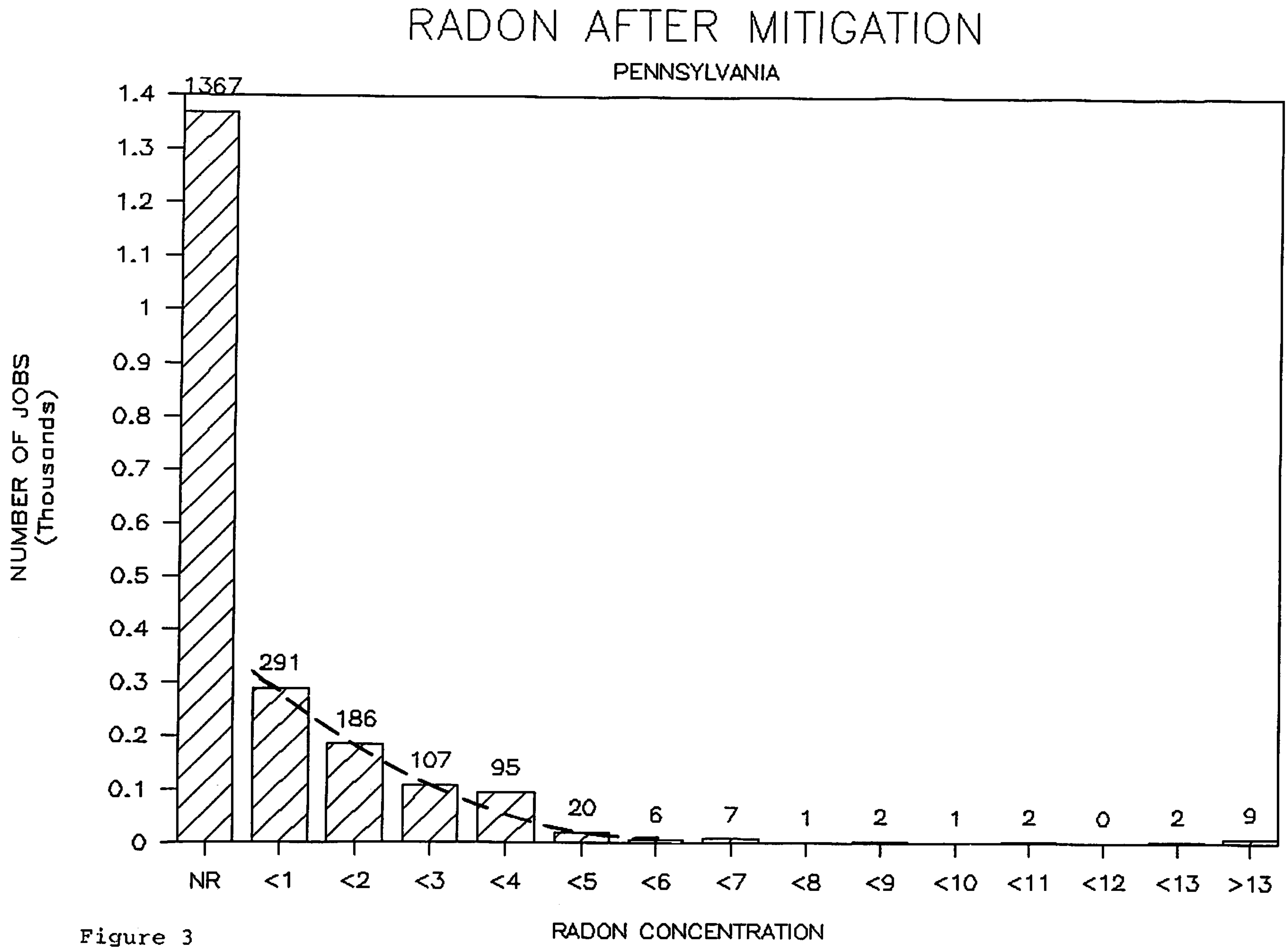
RADON AFTER MITIGATION
PENNSYLVANIA
NUMBER OF JOBS
(Thousands)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1367
291
186
107
95
20
6
7
1
2
1
2
0
2
9
NR
<1
<2
<3
<4
<5
<6
<7
<8
<9
<10
<11
<12
<13
>13
RADON CONCENTRATION

Figure 3

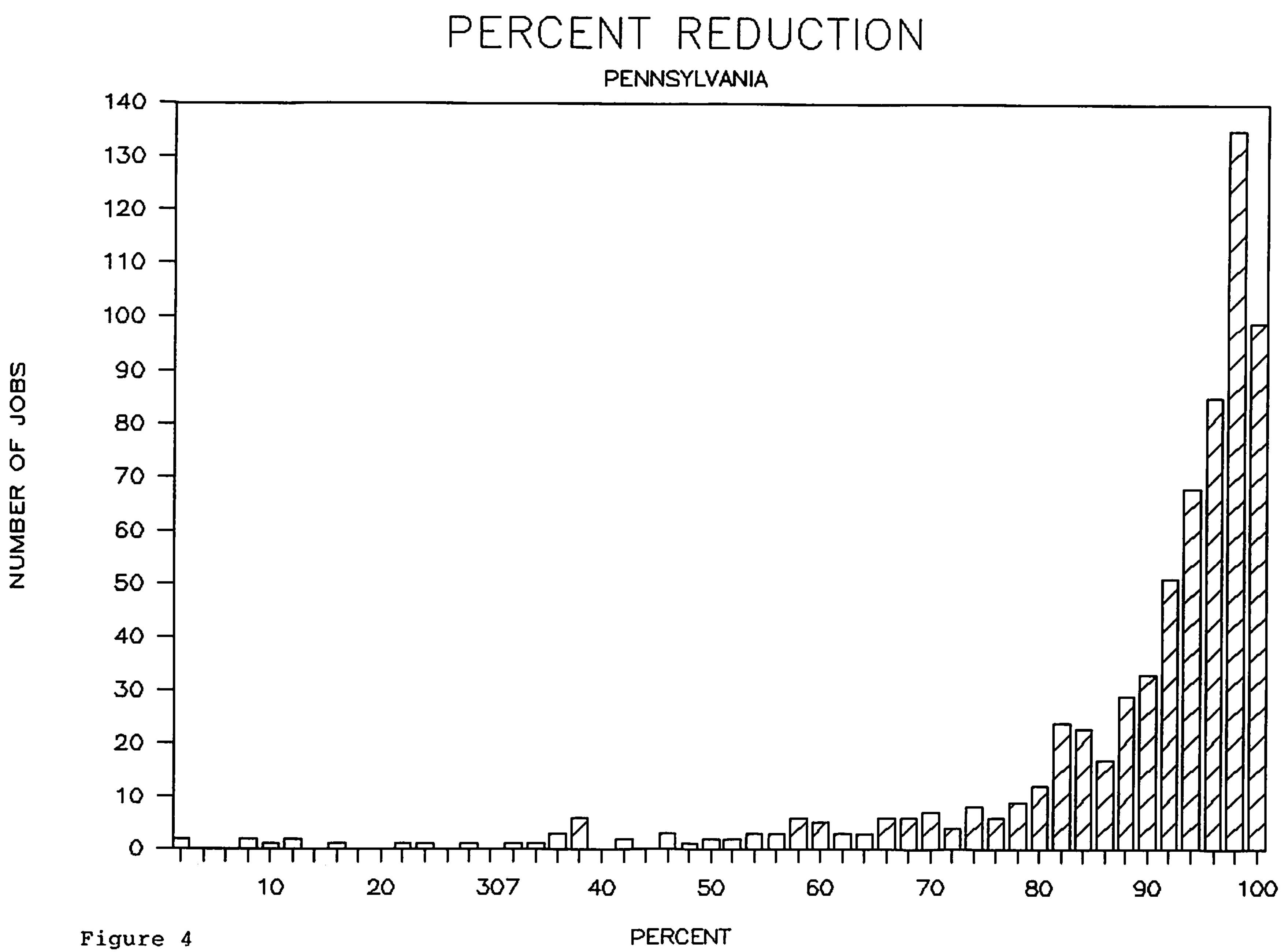
PERCENT REDUCTION
PENNSYLVANIA
NUMBER OF JOBS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
10
20
307
40
50
60
70
80
90
100
PERCENT

Figure 4

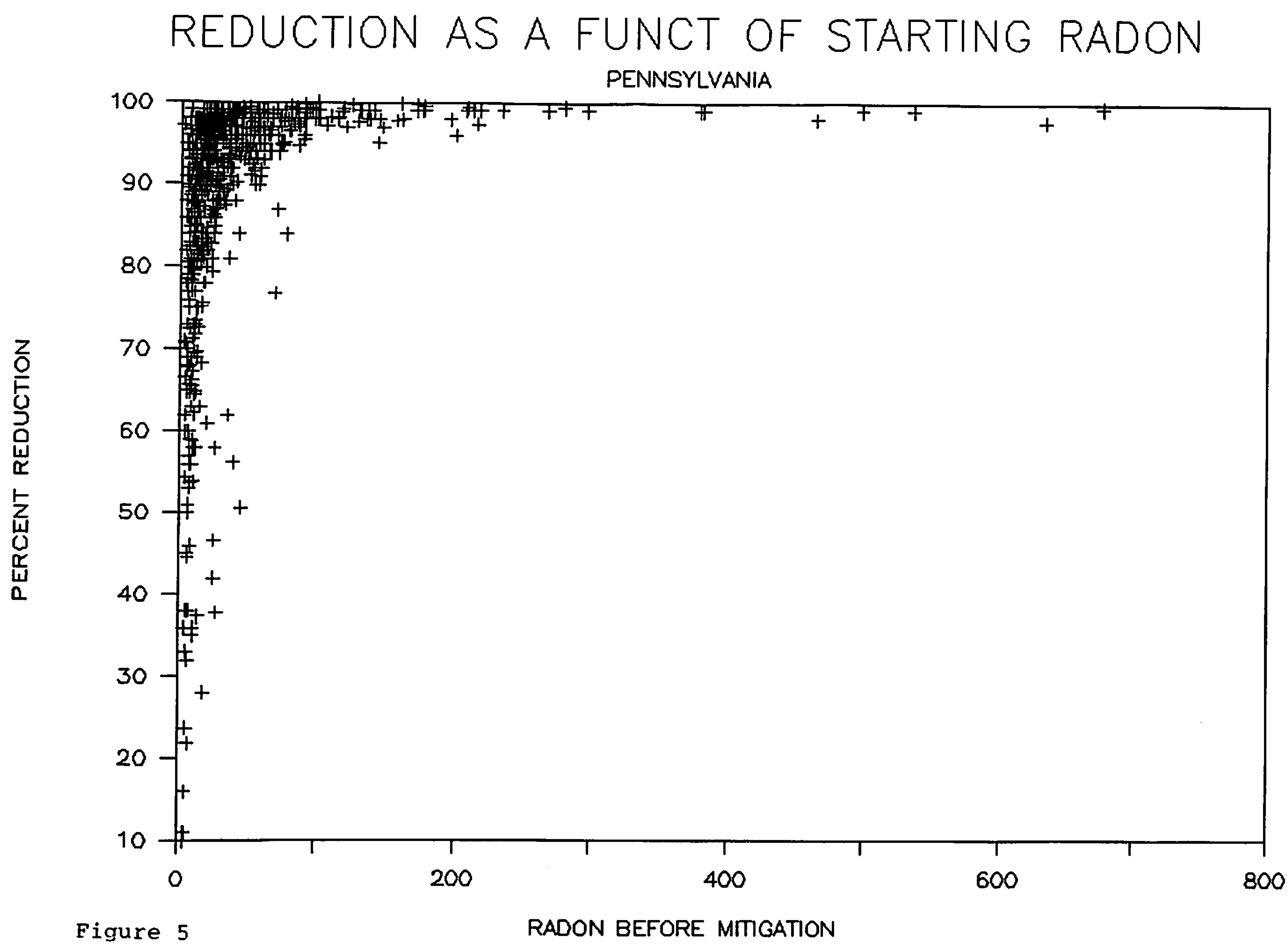
REDUCTION AS A FUNCT OF STARTING RADON
PENNSYLVANIA
PERCENT REDUCTION
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
RADON BEFORE MITIGATION

Figure 5

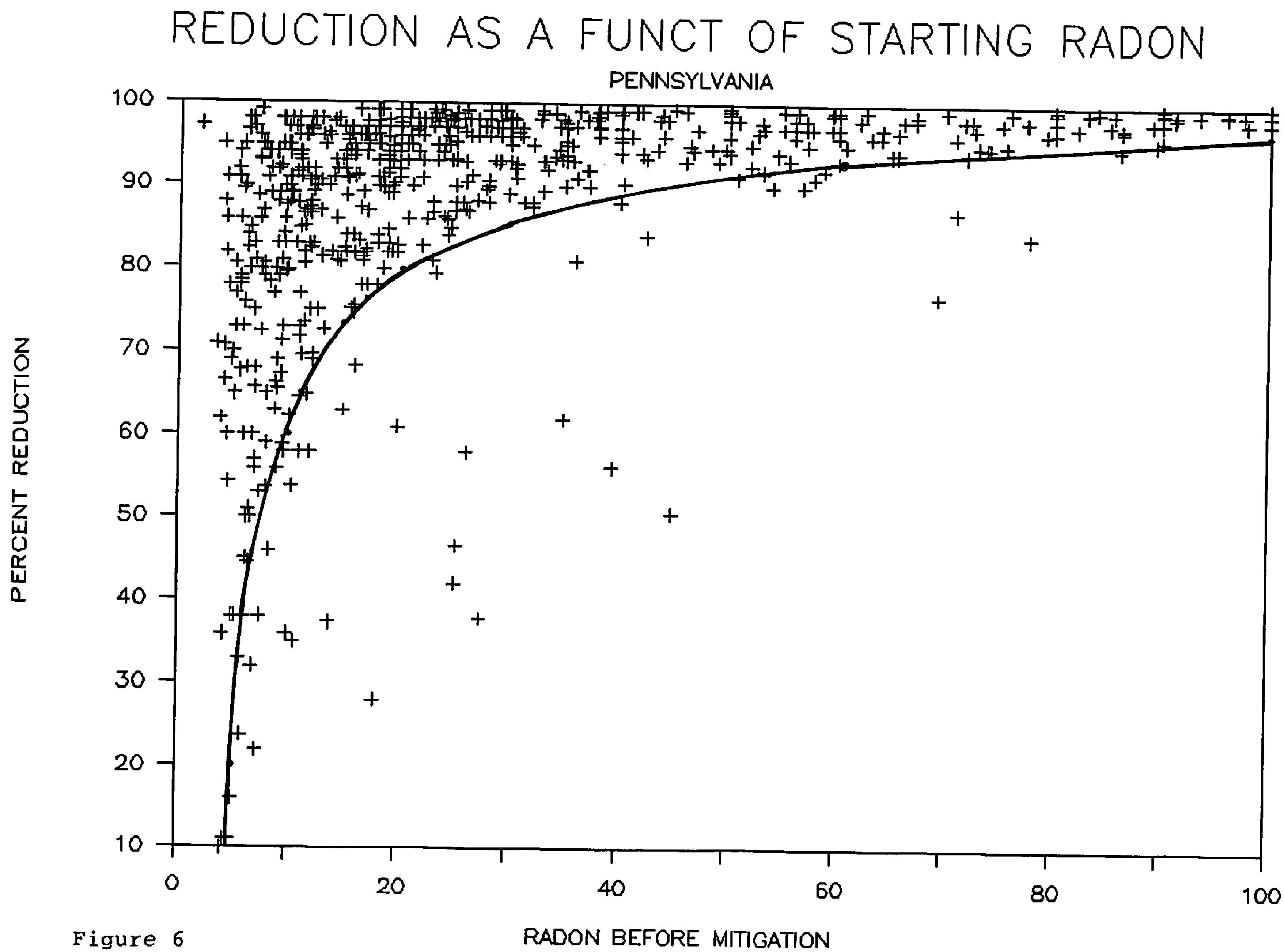
REDUCTION AS A FUNCT OF STARTING RADON
PENNSYLVANIA
PERCENT REDUCTION
100
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100
RADON BEFORE MITIGATION

Figure 6

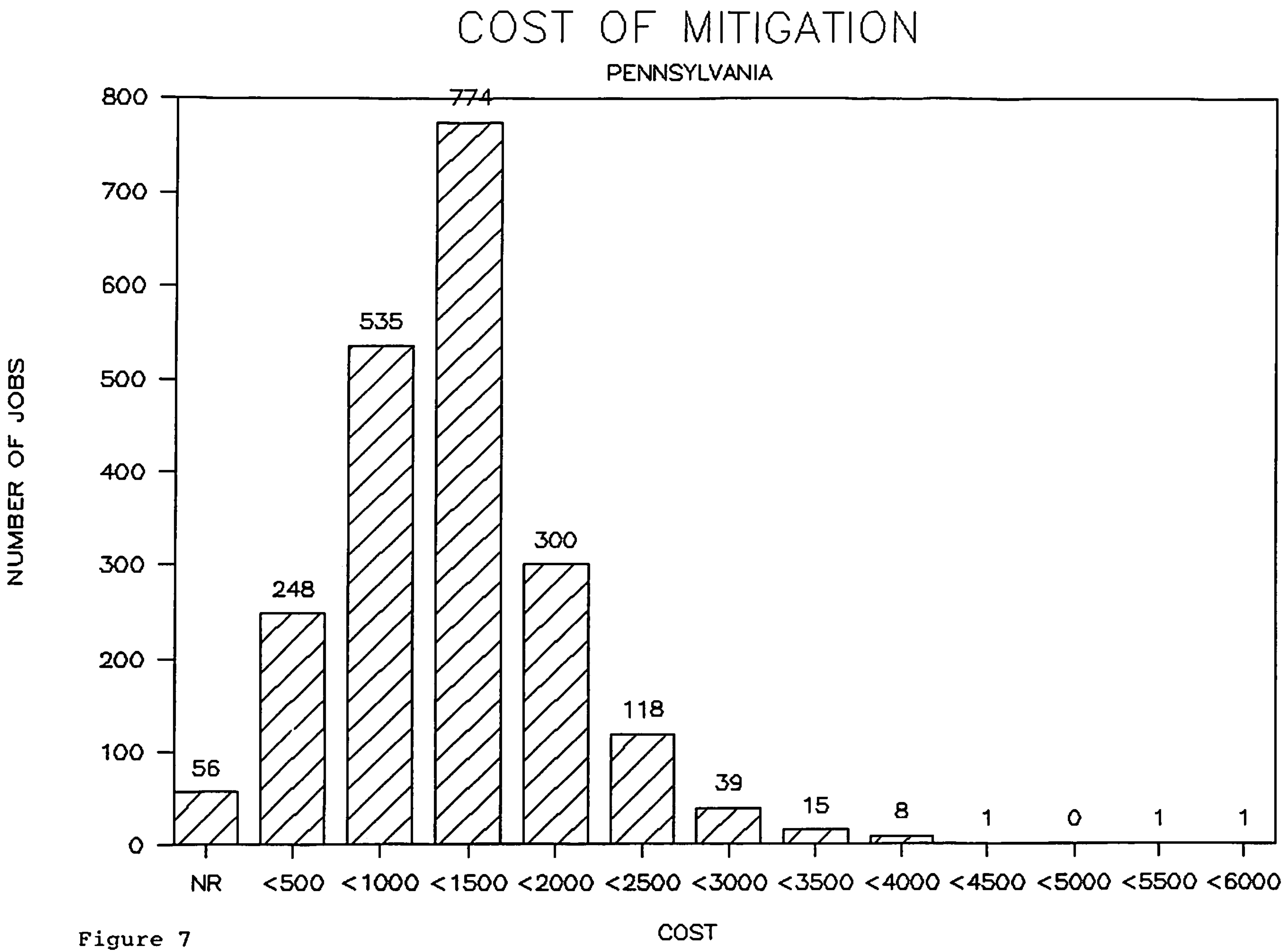
COST OF MITIGATION
PENNSYLVANIA
NUMBER OF JOBS
800
700
600
500
400
300
200
100
0
56
248
535
774
300
118
39
15
8
1
0
1
1
NR
<500
<1000
<1500
<2000
<2500
<3000
<3500
<4000
<4500
<5000
<5500
<6000
COST

Figure 7

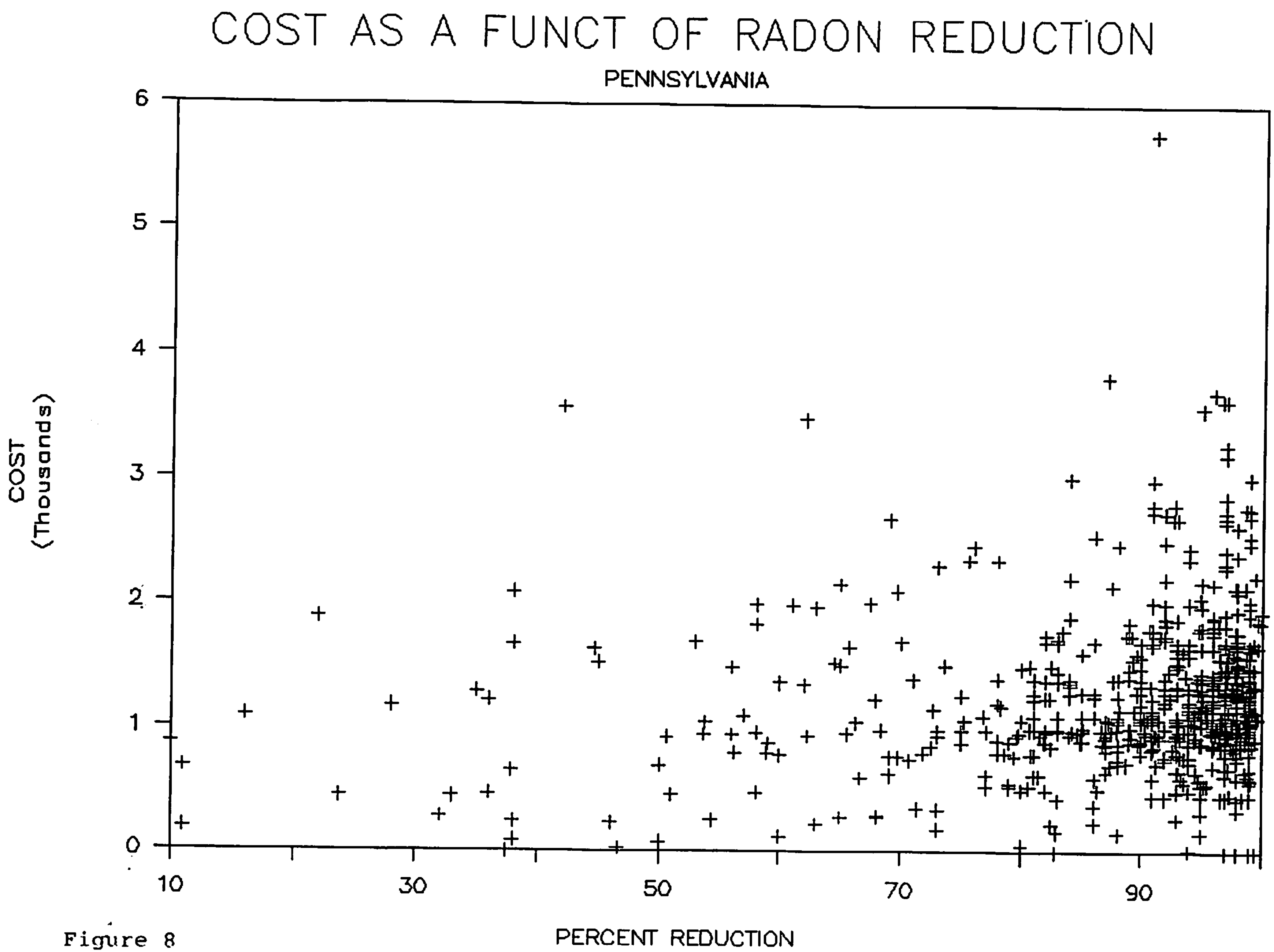
COST AS A FUNCT OF RADON REDUCTION
PENNSYLVANIA
COST
(Thousands)
0
1
2
3
4
5
6
10
30
50
70
90
PERCENT REDUCTION

Figure 8

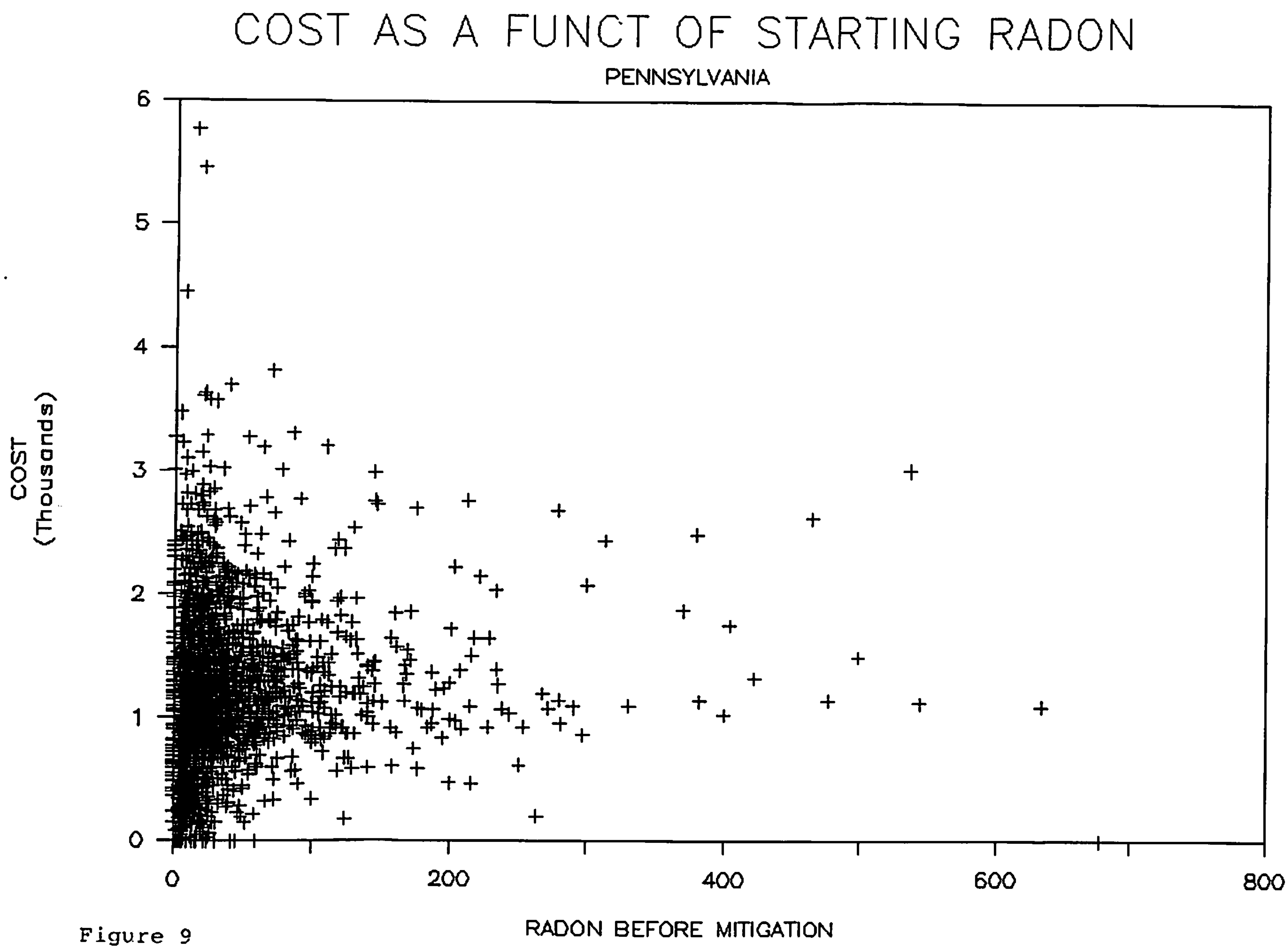
COST AS A FUNCT OF STARTING RADON
PENNSYLVANIA
COST
(Thousands)
0
1
2
3
4
5
6
0
200
400
600
800
RADON BEFORE MITIGATION

Figure 9