Analysis of Computer Recycling Awareness of Residents Near Education and Computer Recycling Center of Santa Clara

Philip J. Chen

Abstract Education and Computer Recycling Center (CRC) of Santa Clara is a non-profit organization that receives most of its computer donations, ranging from 10 computers to as large as 24 full palettes (1.2 m^2 per palette) loaded with computers per donation, from large Silicon Valley companies. The computers donated by local residents constitutes far less mass donated to CRC compared to these companies. In this thesis, I investigate the degree to which residents are aware of computer recycling programs and the history of their computer disposal habits. Randomly selected residents living within a 1.2 km radius south of CRC were surveyed about their habits and computer recycling opinions. 78.9% of residents were not aware of nearby computer recycling programs. 46.3% of residents indicated they don't know or it doesn't apply when given a list of recycling options in the survey. This large percentage indicated that the study was premature in that better survey data could be obtained from this study site, given a few years of this study. CRC currently receives computers from approximately 30 individuals per day. A representative of CRC who was interviewed said that CRC would be capable of handling an increase in donations from residential computer waste. CRC operates with the help of State grants and raises additional funds through resale of some computers. With the amount of computer waste from residential donations, if CRC is capable of handling the mass, resources can be saved, landfill space can be conserved and materials can be reclaimed from this computer waste.

Introduction

Over the last decade, the use of desktop computers seems to have become more prevalent in the way people interact and function, at work and at home, as people use them for a variety of purposes ranging from entertainment to running businesses. As technology advances and new software requires faster computer components, people are more likely to opt for the more powerful computer systems offered, even though the older (now obsolete) systems are still functional. Malfunctions and lifetime of the equipment, normal wear and tear of computer components, can also render a desktop computer obsolete. As they find replacement parts unavailable or frustrating to find, people will find it more economical to purchase a new system rather than replacing the non-functional part. In either case, the desktop computer systems or components being replaced are usually stored, sold, donated or disposed of.

Computer recycling has been around for at least a decade. One study estimates that by the year 2005 about 150 million personal computers will have been sent to landfills. (EPR21998) With limited landfill space remaining for our cities, this figure shows that an effort must be made to reduce the volume of electronic waste generated. Reuse or recycling of these computers should reduce the strain on landfill space. Aside from space limitations for disposal, unmarketable or unrecyclable materials generated from computer waste are sent to energy recovery programs to be incinerated. (Clark 1995)

> "The loading of heavy metals in the municipal solid waste stream was a fundamental driver for the two collection programs (Union County and Hennepin County) where most of the residential solid waste stream is incinerated. Both Counties believe that removal of EEE waste from the waste stream may play an important role in reducing the heavy metal burdens in the fly and bottom ash, which can result in an indirect economic benefit for the community by lowering ash disposal fees." (USEPA Region 1 1999)

Reduction of electronic and electrical equipment (EEE) waste found in municipal solid waste through recycling programs may help reduce release of heavy metals into local areas around incineration facilities.

There are few operations today that recycle components such as plastics, cathode ray tubes (CRT) and precious metals from computers. These operations need to operate at near full capacity in order to function. (EPR21998) Barriers to smooth and successful operations are costs

required for the stages of demanufacturing of computers. In a study done by the EPA, the cost of demanufacturing CRTs overseas is estimated to be only $1/10^{th}$ of the equivalent costs in the San Jose area. (USEPA Region 1 1999) Location of demanufacturing, transportation and disposal costs can overwhelm all other factors for cost. Printed circuit boards, high-grade breakage (hard drives, motors and mixed metal parts), mixed metals and wires generally comprise the majority of revenue generated from scrap. (USEPA Region 1 1999)

My interest in this research comes from realizing that a desktop computer has metals that can be reclaimed and toxic materials that are hazardous to the environment. Currently the non-recyclable components are usually incinerated. (Clark 1995) Many of the components in a computer have integrated or composite materials. In order to reduce the total mass of electronic waste that will be incinerated, the industry needs to design components made of materials that are more readily separable to be reused or recycled and reduce the number of components that will be sent to the incinerator or landfills. Reuse of functional computer components reduces the amount of waste going to landfills. Reuse is a more environmentally friendly solution to dealing with electronic waste than incineration.

Previous research deals with the problem of non-profit recycling programs and barriers encountered with collection and distribution of computer waste. (EPR21998) "Recycling does not need to be on a large, industrial scale; all around us we see discarded items that are of value for other purposes." (Barton 1979) Some recycling operations operate on a large industrial scale but the Education and Computer Recycling Center (CRC) is a small-scale operation that deals with collection, repair and reuse of computers. Large industrial scale operations would encompass collection and processing of materials.

> "A workstation is a high end desktop computer. It is defined as one CPU (containing a motherboard, two interface cards, one hard drive, one floppy disk drive, one disk control card, one power supply, and associated cables and switches), one display, one keyboard, one mouse, cables, and a power strip." (Fiksel 1996)

Modern computer systems consist of parts that have many different integrated components that produce wastes which small-scale operations, like CRC, may not be able to handle. Some of these components such as cables and power strips could be kept indefinitely and reused. Resident participation in recycling programs ranged from 5% to 15% of the population studied. (USEPA Region 1 1999) The variation in participation depends on a variety of factors that

include success of advertisement, willingness to pay disposal fees, and time of collection. When people "outgrow" the use of their computer systems, they will have to find a means to dispose of their computer. People could easily dispose of their computers in the solid waste stream or dump it into a ditch somewhere. One objective of my study was to assess the awareness of residents around a computer recycling facility about computer recycling and their recycling history. I did not anticipate that people would know about the local computer recycling facility. Therefore, my hypothesis was residents around a computer recycling facility are not aware of CRC and residents have their unused computers idling around or in storage.

Methods

My study will evaluate the computer recycling habits and awareness of computer recycling opportunities of residents living near a computer recycling location in Santa Clara, CA. Other aspects of the study are to find out information from the local computer recycling operation about the types and amount of computer material they handle, from where they obtain their material and the amount of material they are capable of handling. Once residents with desktop computers near computer recycling facilities become aware of their local computer recycling service, the potential waste that could be generated from them may significantly increase the amount of material the recycling operation would handle. By taking the survey, I hope that the residents' awareness of the problem of computer recycling grew.

A few Bay Area computer recycling and collection locations are located in Oakland, Emeryville, Berkeley, Santa Clara and San Francisco. The focus of my study will be CRC of Santa Clara and the residents surrounding the Santa Clara facility.
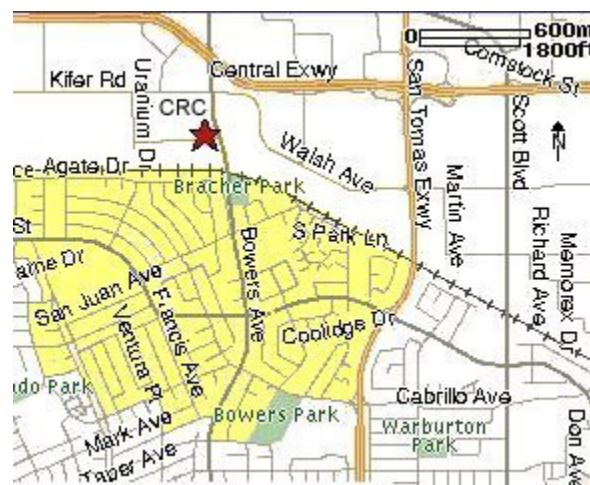
Figure 1: Survey Area South of CRC (shaded area)

CRC is located at 2971 Mead Avenue in Santa Clara, California. Around CRC are industrial and business areas to the north and residential areas to the south. Due to time constraints, the scope of this study was limited to this one location. Other Bay Area operations were located in local schools or industrial locations. CRC was chosen as the focus of my study because it is located in the middle of Silicon Valley. CRC was also chosen because it operates on weekends and normal business hours compared to other programs that may have operated on a less frequent basis.

Participants in my survey consist of residents who live within a 1.2 km radius south of CRC. Due to uncertainty of the amount of time it would take to survey the residents, I started in areas closest to the CRC and surveyed outward from the CRC. Prior to surveying, I generated a list of streets in the area that were randomly ordered. I proceeded to execute a random number generator program on my Palm Pilot (portable digital device) to determine which street to survey and whether to survey the first house or not. If the number generated was an odd number, I would proceed to survey the house. If the number generated was even, I would proceed to the next adjacent house and run the number generator again to determine if that residence was to be sampled. A total of 166 surveys from houses and apartments were collected. The survey was limited to English speaking participants. The survey was conducted in person. To prepare for instances where residents were not home or did not meet survey qualifications, an alternate residence was chosen to replace the chosen residence. Some of the selected residences had defective doorbells, inaccessible doors, or no soliciting signs. In these situations, an alternate was also chosen. Alternative residences were chosen by selecting the third house opposite and on the same street. If there were no houses on the opposite side, the third house on the same side of the street in the same direction would be chosen. If a corner house was selected, the alternative would be the first house on the next randomly selected street on my list.

After compiling the surveys, I assessed the community's awareness and attitude towards computer recycling. After conducting an interview with a representative from CRC, I assessed whether the CRC would be able to handle the extra waste generated by the residents who were unaware of CRC. The data collected should reflect the potential waste stream available and expected for this community in the near future. One aspect not covered by the study is the

amount of computer waste created by large companies. Large companies are currently responsible for the majority of computer waste handled by the CRC.

Pre-sampling data that I collected consisted of locations of computer collection organizations located in the Bay Area and a pre-sampling survey collection that helped fine tune the final survey used in the study. A small-scale representation of the final survey experiment was conducted to test questions and data that would be collected. The random sampling of people around Berkeley Neighborhood Computers (BNC) simulated a small-scale representation of the survey study. This data was not used in the final study because it was meant for designing a better survey. The sample size taken from the community surrounding BNC was much smaller than the actual study because only 10 samples were taken. The pre-sampling survey data helped revise a few of the questions in my survey which residents had trouble interpreting. Information on the potential waste stream will obviously not be representative of the entire Bay Area. It only represents the community surrounding computer collection organizations.

Results

Information from CRC was gathered in an interview with a manager at the Santa Clara location. CRC has another location in Santa Rosa and a drop off location in San Francisco. They have been in operation for about 10 years. CRC accepts all types of computer donations. Most of the donated material comes from companies and some from residential donations. Donations can range from as few as 10 computers to as large as 24 full palettes (1.2 m^2 per palette) loaded with computers, from large Silicon Valley companies at a time. From residential donations, they receive as many as 30 computers per day from individual donors.

The residential survey was conducted in person on Friday afternoons and evenings and weekend mornings, afternoons and evenings. These were the times that residents were thought to be most likely at home. On Fridays, people seemed to be preoccupied after coming home from work and response rates were rather low (about a 40% response rate). Weekend response rates were much higher (about an 80% response rate).

CRC always has material stored in their warehouses. The manager who I interviewed expected that if they received more computer material from residential donations, they are capable of managing the material. The problem they would encounter would be storage space. The major cost to their operation is the property on which their facility is located. Since the

CRC is a non-profit organization, they receive financial help from state grants and generate money from the sale of refurbished computers.

The computers that are repaired and refurbished for further use are also donated to non-profit organizations or churches and schools. Any material they cannot handle such as broken monitors and circuit boards are contracted out to demanufacturing companies who are licensed and have the proper equipment to handle these materials. Another service they provide, not required by law, is to ensure their patrons that the donated hard drives are formatted. This ensures that all the information patrons have on their hard drives will not be disclosed and privacy will be maintained.
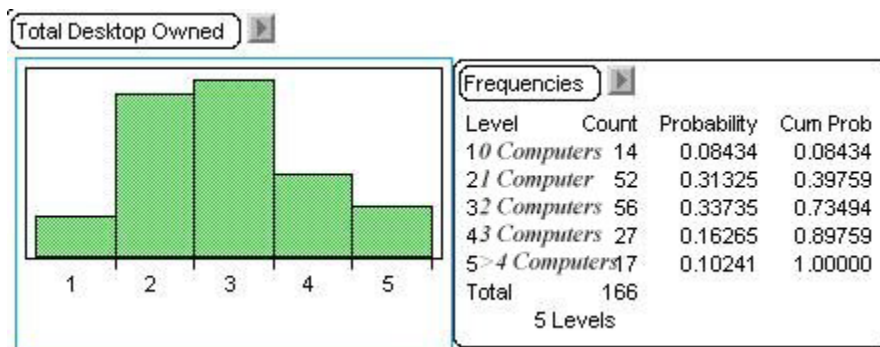
Total Desktop Owned

Frequencies

Level	Count	Probability	Cum Prob
1 0 Computers	14	0.08434	0.08434
2 1 Computer	52	0.31325	0.39759
3 2 Computers	56	0.33735	0.73494
4 3 Computers	27	0.16265	0.89759
5 >4 Computers	17	0.10241	1.00000
Total	166		
5 Levels			

Figure 2: Total Desktops Owned

Desktops Still in Use

Frequencies

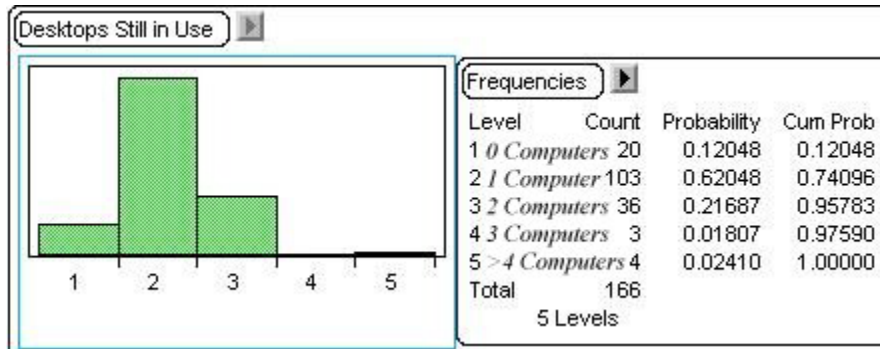| Level	Count	Probability	Cum Prob
1 0 Computers	20	0.12048	0.12048
2 1 Computer	103	0.62048	0.74096
3 2 Computers	36	0.21687	0.95783
4 3 Computers	3	0.01807	0.97590
5 >4 Computers	4	0.02410	1.00000
Total	166		
5 Levels			

Figure 3: Desktops Still in Use

Of the 166 surveys collected, the mean age of the residents surveyed is 36 ± 15 years. Figures 2 and 3 indicate the distribution to questions 4 and 5 of the survey (refer to appendix for survey questions). In the bar graph, 1 refers to the category of 0 computers, 2 refers to 1 computer, 3 refers to 2 computers, 4 refers to 3 computers and 5 refers to >4 computers. Of the residents surveyed, 33.7% have owned 2 computers and 31.3% have owned 1 computer. Of those computers owned, 62% of the residents are still using 1 computer and 21.7% are using 2 computers.
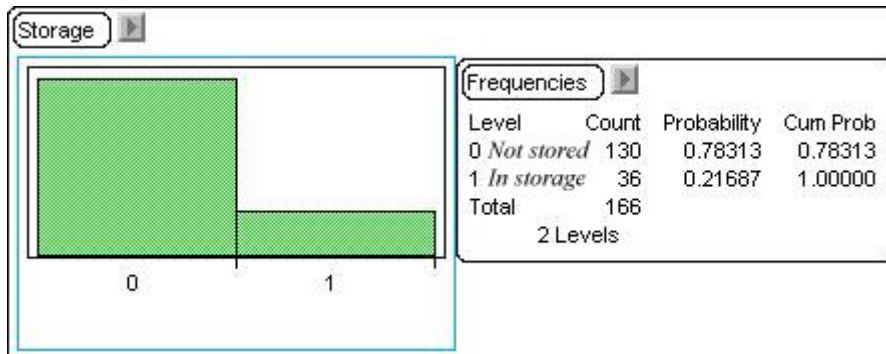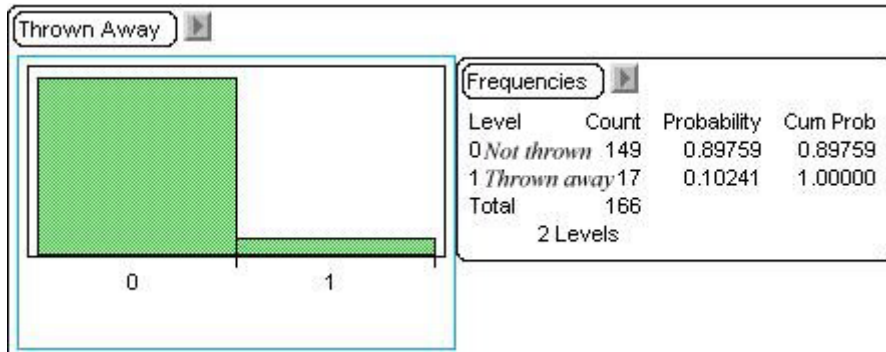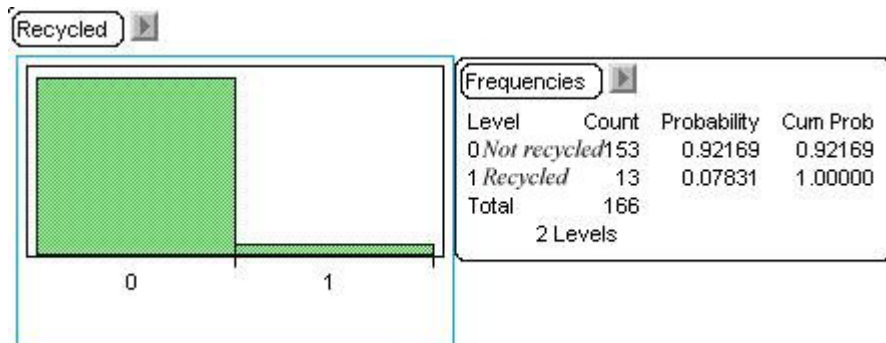
Figure 4: Desktop Computers in Storage

Storage

Frequencies

Level	Count	Probability	Cum Prob
0 *Not stored*	130	0.78313	0.78313
1 *In storage*	36	0.21687	1.00000
Total	166		

2 Levels

Figure 5: Desktop Computers Thrown Away

Thrown Away

Frequencies

Level	Count	Probability	Cum Prob
0 *Not thrown*	149	0.89759	0.89759
1 *Thrown away*	17	0.10241	1.00000
Total	166		

2 Levels

Figure 6: Desktop Computers Recycled

Recycled

Frequencies

Level	Count	Probability	Cum Prob
0 *Not recycled*	153	0.92169	0.92169
1 *Recycled*	13	0.07831	1.00000
Total	166		

2 Levels

Figure 7: Desktop Computers Given Away

Given Away

Frequencies

Level	Count	Probability	Cum Prob
0 *Not given*	126	0.75904	0.75904
1 *Given away*	40	0.24096	1.00000
Total	166		

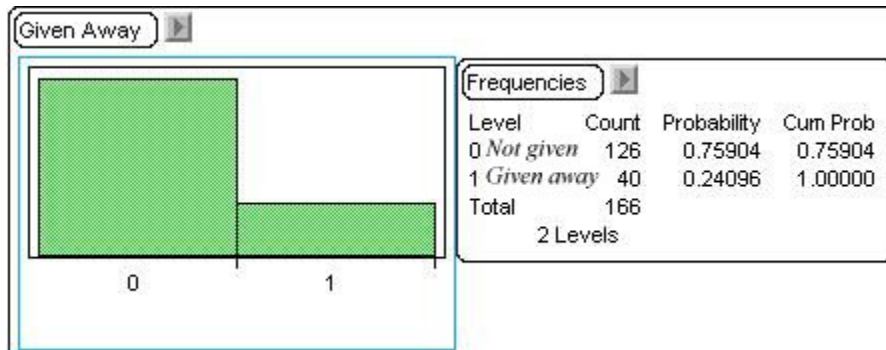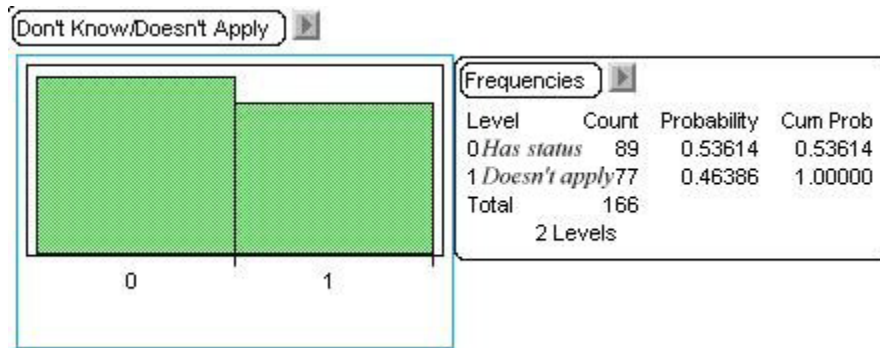2 Levels

Figure 8: Don't Know/ Doesn't Apply to Listed Statuses

In Figures 4 through 8, 0 indicates the resident denied to mark a status listed and 1 indicates they confirmed a status as having been done. Of the total computers not in use by residents, 21.6% are in storage, 10.2% have been thrown away, 7.8% have been recycled, 24.0% have been given away and 45.4% did not know or the situation did not apply to the listed statuses. Forty four percent of the people surveyed had reused computer parts from older computers in newer computers. Sixty one percent of the residents had purchased parts to replace or upgrade their computers. Eighty percent of the residents were not aware of any local computer recycling programs.

Question 6 of the survey (Figs. 4-8) asked the residents to indicate the number of computers they had in storage, thrown away, recycled, given away and doesn't apply or didn't know. Instead of indicating the number of computers, some people just checked the status of the computers they no longer used. Therefore information on the number of computers per status was not used. The status information could still be used to determine what were the habits the residents exhibited.

Question 11 of the survey hypothetically stated that if residents were required to pay a fee, ranging from $0 to $20 for computer recycling, how much would they pay. Of the residents surveyed, 36.7% did not want to pay any money, 15% were willing to pay $5, 29.5% were willing to pay $10, 9% were willing to pay $15 and 9.5% were willing to pay $20 for computer recycling. Question 12 asked whether residents would be willing to pay money, if they had a choice to pay or not pay, and 45% were willing to pay money if they had a choice. For question 16, 22.8% of the residents had purchased a computer within the last 6 months, 32.5% had purchased a computer within the last year, 23.5% had purchased one within the last 2 years, 12% purchased a computer 3 years ago and 9% had never purchased a computer before.

Discussion

From the survey data, only 10.2% of the residents have thrown away computers, 46.3% indicated that the status of unused computers listed did not apply or they didn't know and 21.6% was in storage. The large percentage for did not apply or didn't know is mainly due to the fact that the average resident is still using the computers they own. Before data collection, I had speculated that there would be a much larger percentage of residents with computers in storage. The large percentage of people indicating that the listed statuses did not apply means that many of the residents have not yet had to deal with getting rid of their computers. Two statuses that could possibly be added to question 6 is the option of having sold a computer and curbside pickup.

After the problem with the indication of number of computers per status in question 6, I learned that in survey design a question may appear to be stated clearly yet the answers obtained from respondents of the survey might not correspond with what was expected. Question 6 could be rewritten to list the different statuses and the resident could circle categories, similar to the format of previous questions, of the number of computers for those statuses. Question 16 did not include the option of never purchasing a computer before but since the survey was personally administered, the residents indicated they had never purchased a computer and I marked their response on the survey. Given more time for this study, these results would be reason to treat the data as another pretest for the survey.

During the course of one of the weekends, I noticed that many of the residents were cleaning out their houses and garages. Much of the refuse and old junk they had was placed next to the curb on the street. Large piles of junk were placed there for pickup by the city according to a resident I asked. Unaware of this curbside pickup program when I first started the project, I thought this might affect the computer disposal habits of the residents. If they were allowed to put anything on the curb for pickup by the city, they could also dispose of their desktop computers in the same fashion and not know its fate.

Biases in my data could have arisen from the times at which I conducted my survey. Due to my schedule and my wanting to maximize survey results, I surveyed on Fridays and weekends. Having to skip residences where no soliciting signs were posted, doorbells were malfunctioning or doors were inaccessible could also affect the study. To resolve this problem, a combination of both in person and mail in surveys could be used for the study site. The curbside pickup

program is a major finding that could change results in the study. If my assumption that residents consider curbside pickup as throwing away computers is true, then my results would show similar results since percentage of computer thrown away is small compared to the 46.3% for doesn't apply or don't know.

The percentages that were reported from my data did not include means or standard deviations because much of the data I collected was treated as nominal data. A detail in my survey that I would change in a future revision of the survey would be to change the last category in questions 4 and 5 from >4 to >= 4. Data would still be treated as nominal data and a standard deviation for the data would only reflect the truth of residents' answers. In the design of my survey, I did not include questions that specifically tested for the truth of the answers. These types of questions could be included in future revisions of this survey or study.

61.4% of the residents had upgraded computer components but only 43.9% have reused computer parts from old computers in their newer computers. This would suggest that there is an on-site accumulation of computer equipment that is not being used after being replaced. Since the data indicate accumulation, there will be a trend in computer waste that is generated by residents will increase with time. Because of the large 46.3% of residents indicated the statuses did not apply, assuming that the statuses listed covered the majority of options available for the residents to dispose of their computers, I come to the conclusion that this study was premature for the study site. Given a few years, more of the residents may deal with the questions posed to them in my survey after accumulating computer equipment. Although the study may have been premature for this study site, it is also beneficial towards computer recycling. By surveying the residents around CRC, I may have brought to the residents' attention that computer recycling is something to think about.

References

Barton, Allan F.M., 1979, Resource recovery and recycling. Pp. 10, John Wiley & Sons, Inc.

Carnegie Mellon University, December 1991, Department of Social and Decision Sciences, Design issues in waste management, Pittsburgh, PA.

Clarke, Peter, Recycling picks up industry support. Electronic Engineering Times, n851 (June 5, 1995): 140

EPR2 (1998 Electronic Product Recovery and Recycling Conference), April 22-23, 1998, Washington D.C.

Fiksel, J., 1996. Design for environment. McGraw-Hill.

Maryanne, Manager, Education and Computer Recycling Corporation of Santa Clara, Santa Clara, California. 2001, personal communication.

United States Environmental Protection Agency Region 1, Common Sense Initiative Computer and Electronic Sector, Analysis of five community consumer/residential collections end-of-life electronic and electrical equipment, April 1999.

Appendix

Survey of Consumer Use of Personal Computers

This survey should take about 5 minutes. The information collected from this survey will be anonymous; it will not be possible to trace the responses back to you.

1) Please circle the highest level of education that you have completed?
Some high school
High school
Some college
College graduate or higher

2) What is your age? _____

3) How long have you lived in your place of residence?
<1 year   1-5 years   6-10 years   >10 years

4) How many desktop computers have you ever owned? (include any currently in use)
0   1   2   3   >4

5) Of the desktop computers that you have owned, how many are you still using?
0   1   2   3   >4

6) What is the status of the computers that you have owned and do not use? (please indicate number of computers per status)
_____ in storage
_____ thrown away
_____ recycled
_____ given away
_____ doesn't apply / don't know

7) Have you reused computer parts from older computers in any new computer(s) that you use?
Yes

No

8) Have you ever purchased parts to replace or upgrade your computer(s)?
Yes
No

9) Are you aware of any local computer donation programs? (reuse)
Yes
No

10) Are you aware of any local computer recycling programs? (scrap)
Yes
No

11) If you were required to pay a fee for safe disposal of your computer, what is the maximum amount you would be willing to pay? (Operations that handle computers as waste or for recycling generally have operational costs and barely have enough to break even after handling the computer. An approximate net cost for recycling a computer is $9.50 or $0.30 per pound.)
$0
$5
$10
$15
$20

12) Would you be willing to pay money for disposal (to be recycled or reused) of your computer?
Yes
No

13) If you had to pay a fee, would you prefer to pay the fee at disposal or at the purchase of a new computer?
Disposal
Purchase

14) Would you know how to separate computer components if separating parts were necessary for recycling?
Yes
No

15) Would you be willing to separate computer components if you were to recycle it? (separating cards from motherboard, motherboard from case, power supply from case, etc. In other words, opening up the computer and separating the different parts from each other. Separation of parts may also reduce the costs the recycling organizations have and may reduce fees.)
Yes
No

16) When was your last desktop computer purchase?
<6 months ago
about 1 year ago

about 2 years ago
3 or more years ago

17) When will you expect your next computer purchase will be?
Within the next ___ year(s)
Do not plan to purchase
Don't know