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DESCRIPTIVE STUDY OF MICHIGAN STATE UNIVERSITY WASTE MANAGEMENT AND RECYCLING PRACTICES AND RECOMMENDATIONS FOR IMPROVMENT

presented by

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Major Professor's Signature

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DESCRIPTIVE STUDY OF MICHIGAN STATE UNIVERSITY WASTE MANAGEMENT AND RECYCLING PRACTICES AND RECOMMENDATIONS FOR IMPROVEMENT

By

Gaurav Dabholkar

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ABSTRACT

DESCRIPTIVE STUDY OF MICHIGAN STATE UNIVERSITY WASTE MANAGEMENT AND RECYCLING PRACTICES AND RECOMMENDATIONS FOR IMPROVEMENT

By

Gaurav Dabholkar

Large amounts of industrial as well as domestic wastes are generated on MSU campus. With these amounts of wastes, a university similar in size to Michigan State University can be regarded as an industry or a small city. The previous studies at MSU indicate that a large number of recyclables are disposed of as a part of the municipal solid wastes.

As a part of the project, various sources of wastes on MSU campus have been categorized and the types of wastes from that location have been discussed. The university waste management offices have been listed along with their functions. The waste management activities and recycling efforts in MSU were studied. Also, a waste basket sorting project was conducted to study the general composition of the classroom and office wastes.

These results were presented to experts to get their opinions as to where and how MSU should focus to reduce the wastes generated. The best practices at other colleges were reviewed and summarized. A list of recommendations was presented to the Office of the Provost that included methods for reducing campus wastes, increase recycling and control the materials brought into the university with the help of the MSU Purchasing Office.

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LIST OF ABBREVIATIONS

MSW	Municipal Solid Waste
MSU	Municipal Solid Waste
EPA	Environmental Protection Agency
ORWM	Office of Recycling and Waste Management
ORCBS	Office of Radiation, Chemical and Biological Safety
ULAR	University Lab Animal Resources
PET	Polyethylene terephthalate
HDPE	High Density Polyethylene
SCUP	Society for College and University Planning
DCPAH	Diagnostic Center for Population and Animal Health
APPA	Association for Higher Education Facility Officers
NACUBO	National Association of College and University Business Officers
USEPA	U.S. Environmental Protection Agency
USDA	U.S. Dept. of Agriculture
MIOSHA	Michigan Occupational Safety and Health Administration
NRC	Nuclear Regulatory Commission
USDOT	U.S. Dept. of Transportation
NFPA	National Fire Protection Association
FDA	Food and Drug Association
RHA	Residence Hall Association
MRF	Materials Recovery Facility

1 INTRODUCTION

1.1 Background

Our understanding of solid waste disposal has greatly increased over the past years. As science and technology progresses, so does our awareness of the environmental impacts and issues associated with unregulated waste disposal. In the first fifty years of the 20th century, waste management techniques were fairly primitive compared to the methods today. It was in the 1960s and the years after that when people started to realize the impacts of improper waste disposal.

Figures 1.1 to 1.6 indicate the trends of solid waste generated, recycling rates, composting rates, energy recovery by combustion, municipal solid waste (MSW) landfilled, and the containers / packaging waste generated and recycled in the US from 1960 to 2005 (U.S.EPA 2006).

Figure 1 Trend of Solid Waste Generation in US (U.S.EPA 2006)

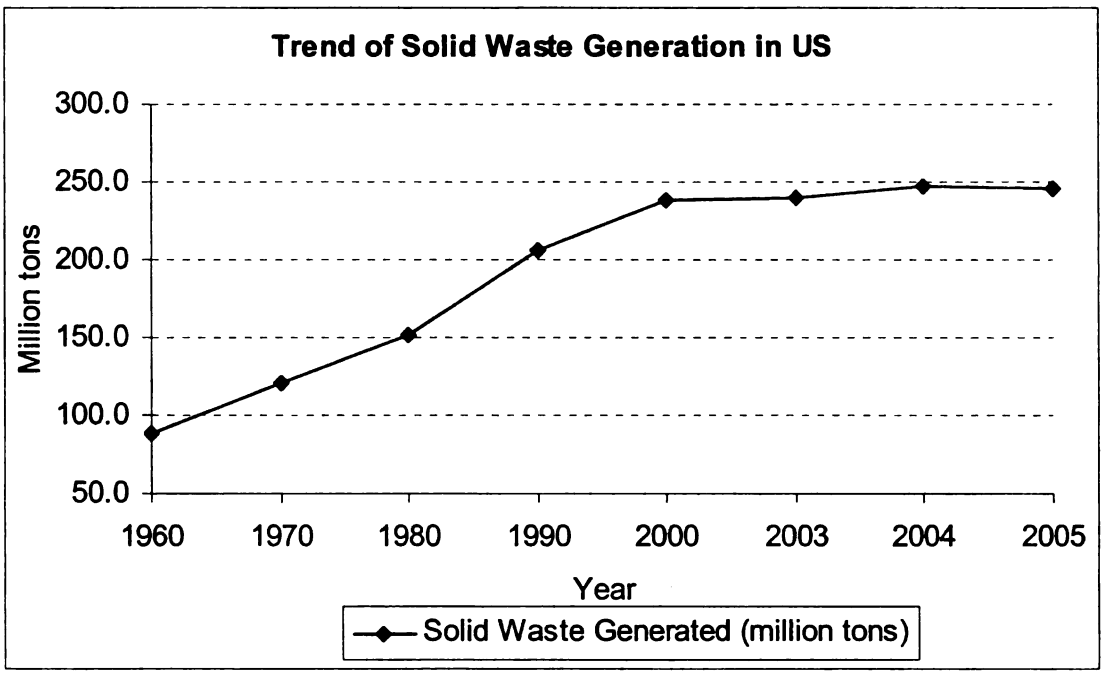


Figure 2 Trend of Recycling in US (U.S.EPA 2006)

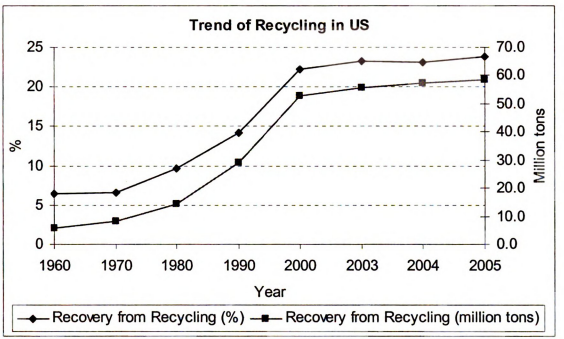
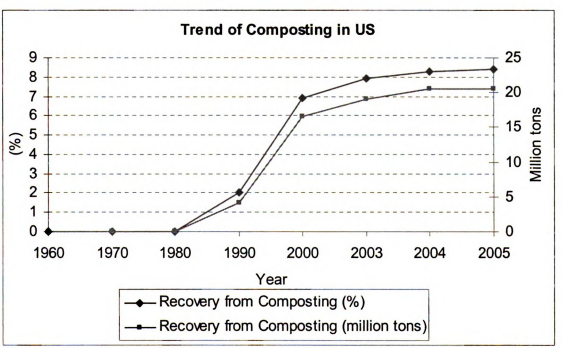


Figure 3 Trend of Composting in US (U.S.EPA 2006)



Note: Data for years 1960, 1970 and 1980 not indicated in the graph as the values are negligible.

Figure 4 Trend of Energy Recovery from Waste Combustion in US (U.S.EPA 2006)

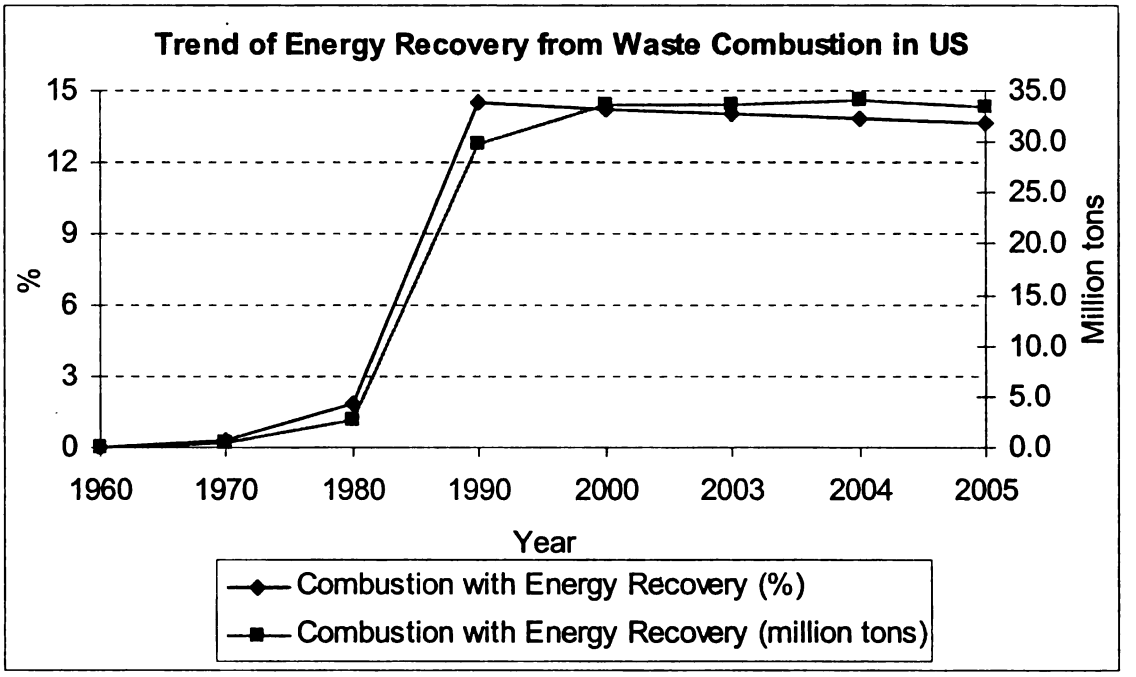


Figure 5 Trend of MSW Landfilled in US (U.S.EPA 2006)

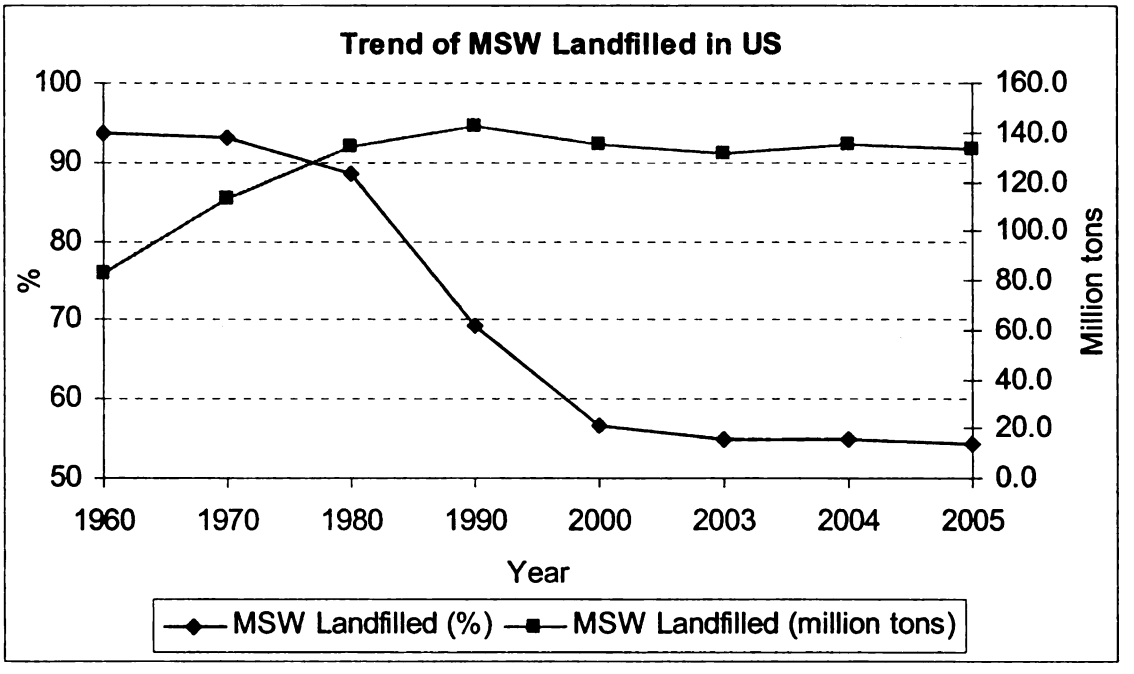
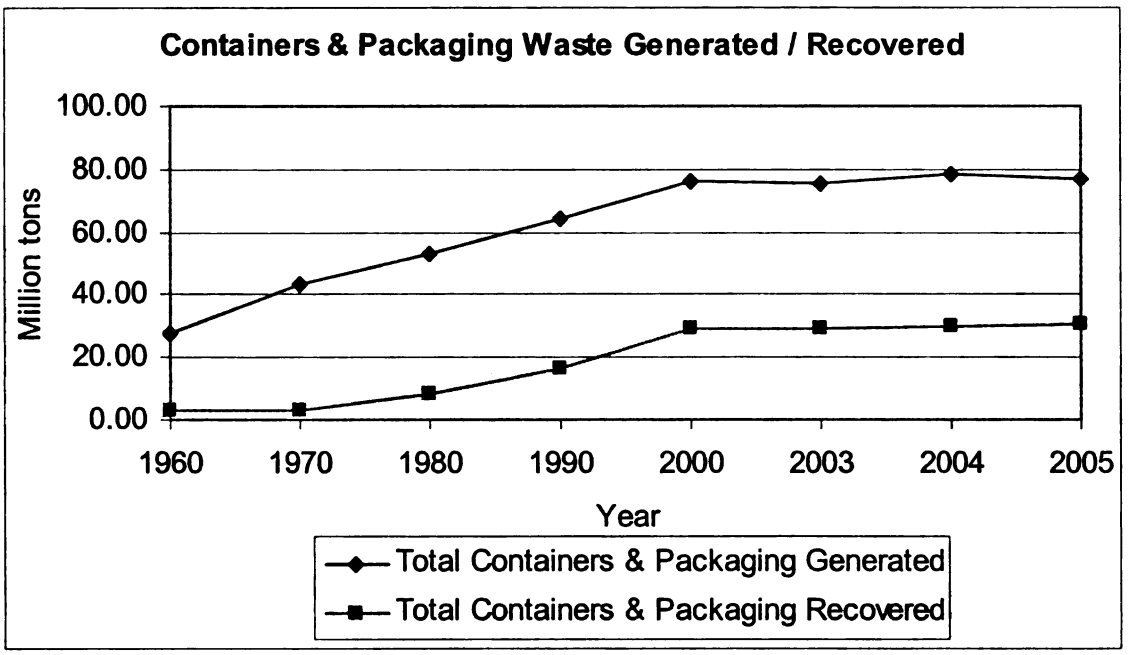


Figure 6 Containers and Packaging Waste Generated / Recovered (U.S.EPA 2006)



1.2 Objective

The total number of degree granting institutions recorded in the US was 4,236 in 2004. The total student enrollment for fall 2003 was recorded at 16.9 million while the total faculty and staff employment by these educational institutions was at about 1.175 million (U.S. Department of Education 2005). A university similar in size to Michigan State University (MSU) can be regarded as a small city or an industry when it comes to management and disposal of waste. The objective of this project is to present a White Paper that accounts the solid waste streams on the main campus of Michigan State University, and to make recommendations for reducing the environmental, economic and social impacts of University waste activities.

The MSU Solid Waste White Paper Project was initiated by Dr. Susan Selke of the School of Packaging, Michigan State University, Dr. Satish Joshi, Assistant Professor – Department of Agricultural Economics, Terry Link, Director – Office of Campus Sustainability, Ruth Daoust, Manager – MSU Surplus and Pete Pasterz, Manager – Recycling and Waste Management. The project was funded by Michigan State University, VP for Finance and Operations.

MSU Solid Waste White Paper Project – Plan:

1. Study the different waste streams in the MSU campus
2. Collect data regarding the amounts of waste generated
3. Analyze the method of operations of different MSU departments responsible for handling that waste, the method of disposal employed (recycling, land filling, composting, etc).
4. Recommend smart solutions to reduce the campus waste through different techniques – from environmentally conscious purchasing, use and management of goods to disposal / recovery of recyclable materials, define short term and long term goals, and present the findings to the Office of the Provost.

2 REVIEW OF LITERATURE

2.1 Previous Reports on Michigan State University Waste Streams

Study by Marsha Crawford

In a study conducted by Marsha Crawford at Michigan State University, statistical analysis of the municipal solid waste was presented. The MSW sent from MSU was manually sorted into nine general categories. In fiscal 1994-95, 1098.4 tons of materials were recycled by all the recycling programs combined. It was estimated that 8046.4 tons of waste was generated for that year and the recycling rate was estimated at 13.6%. The following table indicates the then estimated current and potential diversion of materials from MSU.

Table 1 Estimates of current and potential diversion from MSU in 1994-95 (Crawford 1996)

	Diversion of Materials in 1994-95 (tons)	Additional Potential for Diversion (tons)	Total Potential for Diversion (%)
Academic/ Administrative	805.7	797.0	51.0%
University Apartments	38.0	344.8	27.5%
Residence Halls	354.6	1096.0	38.3%

It was estimated that by additionally increasing the rate of diversion from MSW stream for each source – Academic/Administrative (797 tons), University

Apartments (344.8 tons) and Residence Halls (1096 tons), an overall recycling rate of 41.4% could be achieved (Crawford 1996).

Third Party Review of Facility Requirements for Recycling and Waste Management Program

A third party review was conducted to assess the need for a recycling facility at MSU. The final report of Resource Recycling Systems, Inc; "Third Party Review of Facility Requirements for Recycling and Waste Management Program" was published in March 2000, by the Michigan State University Physical Plant Division and the Office of Recycling and Waste Management. The report stated a need for a facility for sorting commingled recyclables from both a financial and an operations perspective, since there was no such facility available within range. The needs of such a facility were evaluated in four areas – space for staff and staff operations, vehicle storage space, recyclable material processing space, and support functions on-site. The cost of the facility was estimated at $1.8 million and additional costs to cover transition operations. Revenue from recyclables was estimated at $168,000 per year, and $108,000 per year in avoided landfill costs. The pay back period was estimated at 6.5 years for the initial investment.

Campus Sustainability Report

The Campus Sustainability Report was published by the Office of Campus Sustainability and the University Committee for a Sustainable Campus in September, 2003. The project was funded through a Sustainable Development Challenge Grant from the U.S. Environmental Protection Agency. The report has

separate sections for social indicators, economic indicators, and environmental indicators. Of particular interest are the information presented on consumption of materials and on surplus and recycling operations. The report does not contain specific policy recommendations. The report was meant to be a bench mark of the then current scenario and the main aim stated was to update and add more sustainability indicators to get better understanding, so that decisions can be made toward long term sustainability (Office of Campus Sustainability 2003).

MSU Student Survey Information

The Residence Hall Association carried out surveys of residence hall students in late October or early November of 2000 and 2001 to understand student attitudes about recycling. A total of 1796 students in university housing responded to the survey conducted in the year 2000. 73% said "yes" when they were asked about their awareness of the Residence Hall Association recycling program. 50% of students surveyed reported that they utilized the program monthly, 41% weekly, and 9% daily. When asked about the importance of the program, 27% replied it was extremely important, 37% responded it was important, 28% somewhat important and 8% not important. When asked about their willingness to pay extra, a strong majority of 76% responded they would not be willing to pay more in room costs to sustain a comprehensive recycling program, while 24% said they would be willing to pay more. When asked about items being recycled, newspaper was the most often recycled at 56%, plastic was reported to be recycled by 33%, glass by 21%, "tin" by 24%, and "cardboard" by 27%. In the 2001 survey, students were asked about importance of a

comprehensive recycling program in University housing. A total of 2365 students responded; 27% rated it extremely important, 34% important, 28% somewhat important and only 2% not important (Barker 2005).

In Fall 2000 and Spring 2003, surveys of freshmen were conducted. There were a total of 781 respondents in Fall 2000 and 773 in Spring 2003. In the survey, 86% of respondents in Fall and 73% in Spring reported that they were personally concerned about environmental problems "a fair amount" or "a great deal". When asked how willing they were to do more for the environment, 88% in Fall and 86% in Spring indicated they were either "very willing" or "somewhat willing" to do more for the environment. When asked about how frequently they recycled glass jars and bottles and aluminum cans, 79% of respondents in Fall and 78% in Spring replied "frequently" (Mertig 2003).

2.2 Practices at Other Colleges and Universities

All over the U.S., universities have undertaken initiatives for recycling and waste reduction. The following are success stories of their recycling efforts and accomplishments which could be implemented at MSU.

Rutgers University is one of the leading universities in recycling activities. The following materials are commonly recycled at Rutgers University: paper and paper products (white and colored office paper, notebook paper, magazines, newsprint, manilla paper, envelopes and junk mail, corrugated); metal cans (food and beverage aluminum / steel cans); glass (any color); plastic containers (milk, soft drinks, detergent containers, #1-#7). Other materials recycled are antifreeze, asphalt, auto tires, lead and nickel cadmium batteries, concrete, contaminated soil, food waste, laboratory chemicals, leaves, motor oil, scrap metal, textiles, fluorescent tubes, ballasts, carpet, appliances and wood, and printing and toner cartridges. The Environmental Health and Safety Department runs a chemical exchange program for unused and surplus chemicals (Rutgers 2007).

The New Jersey state legislature passed the New Jersey Source Separation and Recycling Act. According to that act, state institutions, such as Rutgers, were required to recycle at least 60 percent of their solid waste by 1995. The Rutgers Recycling Program was started in 1987. The Recycling and Reduction Policy and the Recycled Products Procurement and Use Policy were passed in May 1992 by the Rutgers University Senate to achieve targets set by the state. A recycling rate of about 67.7% of its solid waste was achieved for the 2004 calendar year. This is about 20,000 tons of waste. Rutgers University has

three campuses and the recycling rate achieved at each location is different. The Newark campus achieved a recycling rate of 94 percent; New Brunswick, a rate of 46 percent; and Camden, 11.5 percent. According to an article by Meisel Abigail, edible food waste from campus cafeterias is pulped, the moisture is removed to reduce volume and it is placed in 55 gallon barrels. This waste is sold to a farmer as animal feed. This diversion of food wastes has been included in the diversion rates (Meisel 2007). In addition to this, Dr. Kevin Lyons, Director of Purchasing at Rutgers University has contributed significantly to the University's policies. A lot of effort has been put into green purchasing; recyclable materials are a key part of the University's purchasing policies (Rutgers 2007).

The University of Wisconsin at Madison has a strong recycling program in place. In 2003, 27% of the wastes were recycled. The University collects the following categories of materials as a part of the recycling program: office paper (white and colored paper, envelopes – window and labels OK, paper ream wrappers, file folders, junk mail); corrugated, brown paper bags, paper board boxes, magazines, phone directories, books and commingled containers. Phone directories are collected in separate bins than regular office paper, and books that can be used by others are sent to the library Open Return or are donated to Friends of UW libraries for reuse and / or resale. Aluminum beverage cans, steel food cans, caps and empty aerosol cans, food / beverage glass jars and bottles, and all plastic types #1 - #7 are collected as commingled containers. Other materials picked up on request are tires, light bulbs / tubes and light ballasts (may not be recycled but disposed of in a safe manner), auto batteries,

automotive oil, waste oil (non-automotive), plastic and steel barrels. Polystyrene packaging material, wood scrap, pallets and skids are placed next to the waste dumpster for pickup. Rechargeable batteries are sent for recycling using the campus mail with "Battery recycling" label. A roll-off dumpster is available for scrap metal. Surplus and unwanted materials during move-outs are collected under SWAP (Surplus With A Purpose) for recycling, reuse, sale or safe disposal; the program is run by Materials Distribution Services. The SWAP store has an online catalog of materials/items available and also runs online auctions. Ink jet cartridges are sent for recycling through campus mail addressed to "Ink Jet Recycling". Toner cartridges marked with "To MDS for Recycling" are left for pickup at the MDS drop-off area. The University of Wisconsin has a website under the Safety Department for exchanging of excess chemicals on campus (http://www2.fpm.wisc.edu/chemsafety/). The state of Wisconsin requires the use of copy paper with 10-30% recycled content. The university now has 100% recycled paper available for the departments to use (University of Wisconsin 2007).

Massachusetts Institute of Technology started a water conservation project in 1990 and received the Facilities Management Excellence award from the American Institute of Plant Engineers for these efforts in 1995. Various water conservation methods implemented were use of chilled water for cooling purposes instead of domestic water in laboratories, low flow toilets, urinals, low flow kitchen and bathroom aerators, and low flow shower heads. Harvesting of rain water has also been started at MIT as a part of the water conservation effort.

The rising water and sewer rates had increased to a point that most of the projects had only a 2 year payback. An example of their successful efforts is the reduced consumption of water from 27.6 million gallons to 3.6 million gallons in Building 13 using a water capture and reclamation system. The project cost was $140,000 and the annual savings were $160,000. The water consumption was reduced by 60% between 1997 and 2005 because of the changes made (Massachusetts Institute of Technology 2007).

The recycling rates at MIT were 5% in 1999. With increased community involvement, more recycling options and campus wide recycling efforts, recycling increased to 40% in 2005. In 2005, over 500 tons of mixed paper, 45 tons of bottles/cans and 60 tons of computer parts/monitors were recycled, and 190 tons of wood and metal were recovered from discarded furnishings. One of the reasons for their success is collection of commingled recyclables – glass bottles, aluminum and steel cans, and all plastics. Also, all kinds of paper such as all white and colored paper, newspapers, glossy paper and magazines, computer printouts, carbonless forms, envelopes with or without plastic windows, manila envelopes, self-stick notes and memos, and file folders are accepted in one common container. MIT's recycling program includes other materials such as corrugated, toner cartridges, batteries, monitors, and materials from renovation/demolition activities. TechnoCycle is another program for recycling of technological materials. Old and unwanted items such as CDs and diskettes, audio and video tapes, cell phones, pagers, keyboards, PDAs, and rechargeable

batteries are collected in TechnoCycle bins or a pick-up can be requested (Massachusetts Institute of Technology 2007).

Stanford University has a 5R recycling program – reduce, reuse, recycle, buy recycled and rot (composting). In 2005, 58% of solid wastes were diverted away from the landfill. Three main categories of materials collected at Stanford University are corrugated, all kinds of paper (commingled), and metals/glass/plastic bottles and containers (commingled). Paper makes up 70% of the recycling stream at Stanford University. The bottles and cans are sorted according to material using specialized automatic equipment. Apart from the regular collection of recyclables, Stanford University recently started collecting food waste. Food waste mixed with yard waste is sent to an off-campus composting facility. The food waste includes pre-consumer food residuals (vegetables, fruits, grain, plant material including flowers from the tables, meats, fish, bones), post consumer organic matter (plate scrapings, coffee grounds, tea bags) and paper (soiled paper and napkins, paper tray mats, and pizza boxes). Food and compostable waste has been collected since January 2003 at Stanford University. About 67.5 tons or 135,000 lbs of wastes are diverted from the waste stream per month (Stanford University 2007).

Miami University was the winner of the 2004 and 2005 RecycleMania Per Capita competition for colleges and universities. The recycling rate in 2004 was reported to be 52.18 lbs/person and 66.19 lbs/person in 2005 (RecycleMania 2007). Receptacles are provided in each room of residence halls to collect recyclables in three main categories: paper products (newspapers, magazines

and catalogs, books, office paper, computer paper, envelopes and junk mail, cardboard boxes, pizza boxes, "to go" boxes, and paper bags), plastic and glass (all types of PET and HDPE plastic bottles and glass food and beverage bottles), and aluminum beverage cans. Receptacles are provided on each floor. For off-campus students, three drop-off sites are provided for collection of recyclables; one of the sites is open 24 hours a day, 7 days a week (Miami University 2007).

The University of Oregon's Campus Recycling Program was awarded the U.S. Environmental Protection Agency's 2005 College/University Partner of the Year Award. Apart from the commonly recycled materials such as corrugated, mixed paper, glass, plastic and metal cans/containers, the university also collects materials that are not very common as a part of their recycling program. Cassette tapes, CDs and cases, diskettes, video tapes, Tyvek envelopes, bubble wrap and overhead transparencies are collected campus-wide, separately from other recyclables; some of these are sent through campus mail. Receptacles for 5 different grades of paper and for bottles and cans are located on all floors of all campus buildings. For outdoor collection, 20 locations are provided around campus (near or in front of buildings). The University of Oregon also operates a chemicals exchange system. The University of Oregon has a website dedicated to the recycling program with a large amount of information (University of Oregon 2007).

Bowling Green State University has defined 5 categories of materials that are collected for recycling – aluminum and steel cans (food and beverage); glass containers (clear, green, brown and blue); newspaper, phone and course books;

mixed office paper (white and colored papers, most junk mail except glossy, envelopes with/without windows, labels, and stamps, sticky notes, file folders, index cards, carbonless forms); and plastic bottles #1 and #2. Offices, classrooms and dorm rooms have been provided with five gallon containers for collection of recyclables. Large containers are located on each floor of academic and residential buildings. Apart from this, 19 locations are dedicated on campus for collection of corrugated. The recycling program is supported by $3.00 directed from general fees of every student per year; the revenue generated from the recycling of materials; the avoided disposal costs, grants from the State of Ohio, the Wood County Solid Waste District, and the money specified in the contract for campus disposal rights (Bowling Green State University 2007).

Tufts University reported a recycling rate of 32.2% for 2004-05 at the Medford campus, from paper, cardboard, bottles and cans recycling. During the academic year about 0.5 tons of food waste is sent for composting each day; the wastes discarded by the Dining Services in the landfill have been reduced by 62% because of these efforts. 147.7 tons of food waste and 502 tons of yard waste were composted in the year 2004 and about 156 tons of food waste and 437 tons of yard waste in 2005. A fulltime recycling co-coordinator was appointed in 2004. A "Jumbo Drop Yard Sale" program was established 6 years ago; it is now managed by the Tufts Recycles! program. On Labor Day, the new students and the members of the community are allowed to buy goods at low cost. The program reuses the materials and diverts them away from the landfill, provides

employment to students, and the surplus food, books, clothing and linens are donated to various non-profits (Tufts University 2007).

Kalamazoo College has a recycling rate of 36.7%, according to the 2005 Recycle Mania Scoreboard. The recycling program collects materials including corrugated cardboard, magazines, newspapers, old notebooks, telephone books, office paper, books, junk mail, binders, folders and commingled materials. The commingled containers include used laundry soap containers, plastics (#1 or #2 and #6 – polystyrene), aluminum cans, tin cans, aerosol cans and tennis ball containers. Overhead projector transparencies, computer and other electronics components are also recycled. A "Reuse Exchange Program" is also in place for people to donate used office equipment and supplies for others to use. At the end of each Spring quarter, unwanted clothes, nonperishable food items, working appliances, books, and similar goods are collected in donation barrels in the lobbies of all dormitories and are donated to local charitable organizations (Kalamazoo College 2007).

The University of Colorado at Boulder has a successful recycling program in place. A 2003 study by Stuart M. Takeuchi reports the diversion rates were at 26.7% in 2002 (1,457 tons of materials from a total of 5,454 tons diverted from landfilling). Takeuchi reports that the campus spent $106,923 less to recycle than to dispose the same volumes as trash; $443,275 was spent for recycling as against $550,198 that would be required for solid waste disposal (Takeuchi 2003).

A total of six different categories of materials are collected under the CU recycling program – office pack (white & colored paper, carbonless forms, file folders, index & greeting cards, brochures, envelopes and junk mail, blueprints, adding machine tape and white ream wrappers); newspaper; commingled containers (aluminum, steel & tin cans, clean aluminum foil, glass bottles & jars, #1 & #2 plastic bottles & jars, paper milk cartons, drink boxes and empty aerosol cans); corrugated board (flattened corrugated cardboard, pizza boxes, brown paper grocery bags, brown/orange envelopes; magazines and phone books; and special materials (diskettes, transparencies, Tyvek, toner cartridges). The special materials are sent for recycling through the campus mail. In offices, a receptacle with a divider is provided for newspaper and "office pak". The desk side recycling bins are emptied once a week by collections staff. Receptacles are provided in each room of residence halls with a centralized location for collection of the recyclables. Recycling bins are located next to trash dumpsters in family housing. Recycling staff visit offices and departments for training and awareness purposes. They have also developed a Green Products Guide to inform about recycled options for a wide variety of products. Five tons of recyclables are taken to a campus recycling center and processed by student employees every day. A tour of the campus recycling facility is available during new student welcome activities in the fall. The University Memorial Center at UC-Boulder has an ink refilling service. A private company refills the empty cartridges at about half the cost of new. The cartridges can be refilled about 10 times before they fail. They also sell remanufactured laser toner cartridges for 25-40% lower cost than new.

The company provides a 100% satisfaction guarantee (University of Colorado at Boulder 2007).

The University of Michigan has a very broad recycling program. In 2004-05, the university reported a recycling rate of 36.4% in the "Recycling Matters" newsletter. Recycling rates (paper and mixed containers) for individual buildings were reported, with the Advanced Technology Lab as the top recycler at 71.3% of its wastes. Commingled recyclables, defined in three main categories, that are collected from the university campus are containers (glass bottles and jars, ceramics, milk cartons and juice boxes, #1 and #2 plastics, aluminum and steel cans including aerosol cans, clean foil, scrap metals); paper (corrugated, brown paper bags, newspapers, magazines, catalogs, office paper and junk mail, shredded paper, telephone books and paper back books); and special items which are handled differently (batteries & hazardous materials, electronic media, laser toner and ink jet cartridges, overhead transparencies, polystyrene, scrap wood and pallets, small electronics). Each of the special items stated above is collected separately and some may not be recycled but rather disposed of in a safe manner. The School of Natural Resources and Environment set up a location for collection of used transparencies next to paper and container recycling location on each floor the building which doubled the yearly collection rate. The overhead transparencies are sent to 3M's program for transparency recycling. The Waste Management Services operates 4 vehicles 5 days a week – 2 for trash collection and 2 for recyclables collection (one for paper and the other for mixed containers). The collected recyclable materials are sent to the Ann

Arbor Materials Recovery Facility (MRF), where they are separated and sold for recycling. During the move-in and move-out period, the university runs a program to collect reusable and recyclable items. The Football Recycling program was started in 1999. Corrugated board and beverage bottles are collected as a part of the program. In the 2005 football season, 11.98 tons of paper and 22.46 tons of mixed containers were collected at the stadium; a recycling rate of 22.3% was achieved. A food recycling program was started in 1997. Five of the University's 10 residence hall kitchens send food waste from food preparation (no post-consumer food waste) for composting at the City of Ann Arbor compost site. In the fiscal year 2004, 67.54 tons of food waste was sent for composting, while 66.09 tons was sent in 2005. A chemical redistribution program and a chemical tracking program are in place at The University of Michigan as a part of the Environmental Pollution Prevention Program. The Purchasing Department at The University of Michigan supports and encourages the use of recycled and remanufactured products. A "Buy Green" web site is maintained by the Purchasing Office, to promote purchasing of environmentally preferable products such as remanufactured toner cartridges, and 100% post consumer recycled paper (University of Michigan 2007).

3 MATERIALS AND METHODS

This chapter describes the methods used to conduct the research for the MSU Solid Waste White Paper project. The project can be divided into three main sections.

3.1 Waste sources and waste management offices at MSU

Various sources of wastes to be researched on the MSU campus were discussed and identified. The waste sources were classified according to function. The sources of wastes identified were as follows: 1. Lecture Halls, Classrooms and Computer Labs, 2. Administrative and Faculty Offices, 3. Laboratories and Research Facilities, 4. Medical and Veterinary Facilities, 5. Residence Halls, University Apartments and Kellogg Center, 6. Cafeterias and Other Food Service Facilities, 7. Transportation Department, 8. Grounds Department, 9. MSU Farms, 10 Power Plant, 11. MSU Laundry, 12. Printing Department, 13. University Stores, 14. Construction, Demolition and Renovation Activities, and 15. Special Events. The MSU waste management offices were identified as: Office of Recycling and Waste Management (ORWM), Office of Radiation, Chemical, and Biological Safety (ORCBS), University Lab Animal Resources (ULAR) and the MSU Surplus Store. The responsible personnel for each of the waste sources and the waste management offices were contacted. A meeting was set up to discuss the function of the department, the activities being done currently and to get an understanding of the common types of wastes generated from those sources. During the meetings, opportunities to reduce waste and increase recycling if any, were discussed and identified. In some

cases, such as classrooms and laboratories, the information was provided by ORWM and ORCBS.

3.2 MSU Waste Basket Sort

The waste basket sort was conducted to gather waste composition data from the following places: 1. Administrative and Faculty Offices and 2. Classrooms, Lecture Halls and Computer Labs. A pilot study was conducted before the main study to get an idea of the materials that could be expected, and to estimate the time and the effort that would be required. Following is the description and results of the pilot study.

The refuse for the pilot study was collected from an academic building. Wells Hall, one of the buildings on campus that has a number of lecture halls, was selected for the pilot survey. The refuse was collected from 7 waste baskets from 7 different locations on the first floor of Well's Hall – 4 from small lecture halls (C100, C102, C111, C113), one from a big lecture room and two from refuse baskets in the corridor in front of lecture halls B102 and B108. The collection of refuse was about completed in about 18 minutes (3:32 PM – 3:50). This time frame was chosen to get most of the day's trash and before the janitors arrived. The items from the waste were sorted and items falling in similar categories were weighed together. The weight was measured on a Pelouze, Model 4010 weighing scale. Total weight of the refuse was 7.2 lbs. Table 2 summarizes the items and their quantities found in the trash.

Table 2 Pilot Study Waste Sort Data

Category	Weight (lbs)	Notes
Paper		
White Office	*	3 to 4 sheets mixed with colored paper
Mixed Office	0.21	93.69 g (measured in School of Pkg., MSU)
Magazines/Glossy	0.05	24.45 g (measured in School of Pkg., MSU)
Other Paper	0.2	Wet paper napkins
News Print	0.4	
Plastics		
Clear PET #1	0.4	6 non deposit (All water bottles)
	*	2 deposit (All pop bottles)
Glass		
Clear Container	1.2	2 drink bottles
Metals		
Alum. Cans/Foil		4 deposit cans
Manufactured/Other		
Packaged Goods	0.8	11 Non-recyclable drink containers
Other	1.2	Miscellaneous non-recyclable waste
Food Waste	1.8	Food waste and liquids.
Total	5.86	

Notes:

- The white office paper was mixed with colored paper and could not be measured by weight as it was a very small quantity.
- Non-recyclable drink containers: 1 McDonalds paper coffee cup, 1 Subway paper cup, 5 Sparty's coffee cups, 2 Starbucks coffee cups, 1 QD clear plastic cup, 1 PS pop cup.
- Miscellaneous non-recyclable waste mainly contained chocolate wrappers, snack pouches, food wrappers, PS food packages and plates, plastic knives, plastic containers, paperboard boxes, aluminum foil and plastic films.
- The weight does not add up to 7.2 lbs as some of the categories could not be individually weighed, being in very small amounts. Also, some of the beverage cups contained residual liquids and the weight of the trash bags was not added in the table.
- Small plastic bags were used for containment of the refuse for weighing the waste. A small error might have been introduced.

Based on the results of the pilot study, a full scale study was conducted. A "convenience sampling" method was used to collect the samples as it was the most practical method with limited time and budget. A total of 120 waste bins were sorted. A total of 30 waste bins were collected from the Administrative and Faculty Offices. The following strata and corresponding sample sizes were chosen to represent the Administrative and Faculty Offices: Hannah

Administration Building – 5 waste bins, Agricultural Hall – 5 waste bins, Packaging Building – 5 waste bins, Engineering Building – 10 waste bins, Biomedical and Physical Sciences building – 5 waste bins. A total of 90 waste bins were collected from the Classrooms, Lecture Halls and Computer Labs. The following strata and corresponding sample sizes were chosen to represent the Classrooms, Lecture Halls and Computer Labs: Bessey Hall – 10 waste bins, Berkey Hall – 30 waste bins, Wells Hall – 30 waste bins, Business School – 10 waste bins, Education Bldg. – 10 waste bins.

Based on the information from the pilot study, the weight of the waste collected was estimated to be approximately 120 lbs. It estimated that for 2 persons, 3 hours would be required to collect the waste from the Administrative and Faculty Offices and 5 hours to collect the waste from the Classrooms, Lecture Halls and Computer Labs. It was estimated that 9 hours would be required to sort the wastes. Four undergraduate students were employed to carry out the tasks. The collection and sorting were done on 17, 18 and 19 October 2005, in the School of Packaging, MSU. The data collected from the study have been summarized in the results and discussion section.

3.3 Inputs from other groups

3.3.1 Society for College and University Planning (SCUP)

The Smart and Sustainable Campuses Conference was held at the University of Maryland, College Park, MD from November 3rd to 4th 2005. The organizers of the conference included the Association for Higher Education Facility Officers (APPA), U.S. Environmental Protection Agency (EPA), National

Association of College and University Business Officers (NACUBO), Society for College and University Planning (SCUP) and the University of Maryland, College Park.

The purpose of the conference was to share initiatives in other universities on smart growth and sustainable practices, case studies, and business services. Interactive round table workshops were organized by SCUP for universities taking efforts towards campus sustainability. The MSU Solid Waste White Paper Project team presented the research findings to various experts in one of the workshops. The experts recommended methods and solutions to help develop a step by step plan for a solid waste management strategy for Michigan State University.

3.3.2 Inputs from guest speaker

Dr. Kevin Lyons is Professor and Director of Purchasing at Rutgers University, and author of a book titled *Buying for the Future: Contract Management and the Environmental Challenge*. Dr. Lyons was invited to speak about opportunities at MSU. He met with the research team, members of the purchasing department, and held an open seminar on green purchasing on November 28, 2005.

4 RESULTS AND DISCUSSION

This chapter has been divided into 2 major sections. The first section is a brief overview of all the MSU waste streams and the relevant recycling efforts associated with them. The second section is about different departments responsible for managing campus waste streams and recycling activities.

4.1 Sources of Waste at Michigan State University

The following are the major waste sources at the Michigan State University campus:

1. Lecture Halls, Classrooms and Computer Labs
2. Administrative and Faculty Offices
3. Laboratories and Research Facilities
4. Medical and Veterinary Facilities
5. Residence Halls, University Apartments and Kellogg Center
6. Cafeterias and Other Food Service Facilities
7. Transportation Department
8. Grounds Department
9. MSU Farms
10. Power Plant
11. MSU Laundry
12. Printing Department
13. University Stores
14. Construction, Demolition and Renovation Activities
15. Special Events

Sources listed from 1-13 are various facilities that are permanent sources of wastes, while the sources listed at numbers 14 and 15 are periodic events that are also a big part of campus waste.

4.1.1 Lecture Halls, Classrooms and Computer Labs

There are approximately 350 lecture halls and classrooms and 50 computer labs located in various academic buildings on campus. The main types of wastes generated are general refuse and office waste. The main recyclables are office paper, newspapers, plastic bottles, and cans.

4.1.2 Administrative and Faculty Offices

The main types of wastes generated in administrative and faculty offices are general refuse and used office appliances and furniture; electronic wastes such as monitors and other computer accessories are also generated. The main recyclables generated are toner cartridges, office paper, newspapers, magazines, and corrugated board (Gosselin 2005).

4.1.3 Laboratories and Research Facilities

Extensive research is being conducted in a variety of fields in MSU laboratories. The main types of waste generated are general refuse and office waste. Laboratories are the sources of chemical, biological and radioactive wastes. These wastes are managed by Office of Radiation, Chemical and Biological Safety (ORCBS) and University Laboratory Animal Resources (ULAR). The waste management activities are monitored and strictly regulated by government agencies such as the U.S. Environmental Protection Agency (USEPA), U.S. Dept. of Agriculture (USDA), Michigan Occupational Safety and

Health Administration (MIOSHA), U.S. Dept. of Transportation (USDOT), Nuclear Regulatory Commission (NRC), and National Fire Protection Association (NFPA).

The Meat Laboratory and the Diagnostic Center for Population and Animal Health (DCPAH) are big and highly active laboratory facilities. They have different methods of managing and disposing their wastes.

The Diagnostic Center for Population and Animal Health (DCPAH) was established in the mid 1970s. Its primary purpose is to study and understand the causes of unexpected deaths of farm animals and companion animals. The new DCPAH facility has been operational since September 2004. It is one of the best and busiest such facilities in the U.S. and receives samples from all over the country. A total of nine laboratories operate under the banner of DCPAH; they primarily generate biohazardous and chemical wastes. All biohazardous wastes such as tissue samples, blood samples, blood stained gauze and swabs, contaminated packaging materials, and sharps are autoclaved as part of the institutional safety program. This waste is landfilled at Granger separately from regular refuse. The chemical waste generated is collected once or twice every week by the Office of Radiation, Chemical and Biological Safety (ORCBS). One of the three incineration facilities at MSU is owned by DCPAH and is maintained by University Laboratory Animal Resources (ULAR). Animal carcasses are incinerated at this facility. Fees are charged for incineration of animals brought in from farms or zoos (Bolin 2005).

The Meat Laboratory is a part of the Animal Science complex located in Anthony Hall. It is a USDA-inspected teaching, research and outreach facility,

managed by the Department of Animal Science and the Department of Food Science. Wastes generated by the Meat Lab are mainly non-edibles from animals, and biohazardous, chemical and radioactive wastes. The animals required for research such as chicken, turkeys, lambs, hogs and cattle are mainly sourced from MSU farms. The lab has designated areas to harvest the animals as well as for processing and refrigeration. The non-edibles from animals, such as feathers, hair and feet, are collected and disposed by an independent contractor. There are approximately 24,000 lbs of such non-edibles generated annually. ORCBS collects chemical, biological and hazardous wastes from the three research laboratories in this facility (Booren 2005).

4.1.4 Medical and Veterinary Facilities

The medical facilities located on the MSU campus are Olin Health Center and the Clinical Center Clinics. Olin Health Center is a full service outpatient facility. The center complies with State of Michigan regulations for handling of biohazardous waste. The main types of wastes generated other than general refuse are blood-stained gauze, swabs, speculums and items contaminated with human fluid; these are collected by ULAR. Contaminated sharp items (sharps) such as needles are collected by ORCBS. Olin Health Center engages an independent contractor (Pharma Logistics) to dispose of expired medicine from the Pharmacy. The contractor either sends the medications back to the manufacturer or disposes of them in accordance with FDA regulations (Forney 2005).

There are also several MSU-owned medical facilities that are located off-campus. These include Okemos Pediatric Clinic, Westside Pediatric Clinic, Breslin Cancer Center, MSU Adult Medicine Clinic, MSU Urology Clinic, MSU Sports Medicine Clinic, MSU Surgery, MSU Women's Healthcare Clinic and Pediatric Sub-specialty Clinics. MSU Urology and MSU Sports Medicine engage ORCBS as their biohazardous waste haulers. The rest of the facilities engage independent contractors to handle their biohazardous waste (Forney 2005).

Veterinary facilities on campus that are part of the College of Veterinary Medicine include the clinical pathology lab, junior surgery lab and veterinary hospital. The main types of wastes generated other than general refuse are sharps, biological waste, chemotherapy waste, infectious waste and chemical waste. The wastes generated such as chemical wastes and sharps are collected by ORCBS. The biological wastes, which include infectious wastes, vacutainer tubes, blood stained gauze and chemotherapy waste, are collected and disposed of by an independent contractor as per the regulations. Chemical wastes are collected by ORCBS. Chemicals such as formalin and certain chemicals containing mercury are kept separate. Some of the instruments have a different system; the chemical is stored in the instrument and as the chemical is consumed by the instrument, the waste chemical gets stored in a pouch in the same machine (Frahn 2005); (Haynes 2005).

4.1.5 Residence Halls, University Apartments and Kellogg Center

There are about 24 residence halls on the MSU campus. The main types of wastes generated are general refuse and office wastes, which are collected by

ORWM. The main recyclables generated are newspaper, white paper, mixed paper, phone books, magazines, corrugated, and loft lumber. These recyclable items are collected by ORWM. As a part of the campus wide recycling efforts, loft lumber is collected at the end of the spring semester, when students vacate the residence halls. Wastes from maintenance activities in the residence halls such as fluorescent and incandescent tubes, lead acid batteries from emergency lights, light ballasts, and cleaning supplies and paints are handled by ORCBS. Old furniture from students' rooms and public areas along with equipment from offices and other building operations is sent to MSU Surplus for reuse or recycling. New furniture is delivered wrapped in blankets or in plastic to minimize use of corrugated board (Pasterz 2005).

MSU has three apartment complexes – University Village, Cherry Lane and Spartan Village. The main types of wastes generated are household wastes. University Village and Cherry Lane have a drop-off recycling collection for a 3-hour period, one evening per week. Spartan Village has permanent drop-off recycling (24 hours per day, 7 days per week). Materials accepted are newspapers, corrugated board, steel cans, aluminum, clear glass, brown glass, PET and HDPE bottles, magazines, white paper, and mixed paper. Plans are in place to develop similar sites in Cherry Lane and the "Faculty Bricks" (Faculty Bricks is an apartment complex for housing MSU faculty and staff located next to Cherry Lane Apartments). University Village is closing and being demolished for reconstruction. A "Give or Take Center" is also in operation for University Apartment residents. MSU students and their families can donate various

educational materials as well as household items, and other students and families can take these materials at no cost. University Apartments also sponsors a community yard sale each spring.

The main type of waste generated from Kellogg Hotel and Conference Center is general refuse. Refuse is compacted and collected once a week by ORWM, and is included in those totals. The kitchen has 3 garbage disposal units. Grey water from kitchen operations is filtered before being released into the sewage system. The two grease traps contain approximately 700 gallons of waste each, and are emptied twice per year by an independent contractor. The contractor dries and incinerates the waste. Chemicals such as paint and thinners from facility maintenance are collected by ORCBS. As a part of campus wide recycling efforts, used cooking oil is recycled through Kruger Commodities. Towels and linens are sent to the MSU Laundry. The hotel's green program encourages guests to reuse towels and bed linens, changing them only every 3 days on multi-night stays unless the guests request more frequent service. The foodservice operations recycle steel cans, aluminum cans, and plastic bottles. ORCBS collects fluorescent and incandescent bulbs, aerosol cans, batteries, and light ballasts for recycling. Cleaning operations in dormitories and other Division of Housing and Food Service facilities use washable rather than disposable cleaning rags. The Division also focuses on using recycled products. Bathroom tissue contains 95% recycled content (10% post-consumer). Paper towels contain 100% recycled content (50% post-consumer). Corrugated and expanded polystyrene packaging material from new computers and office equipment is

collected. Corrugated is handled by ORWM; expanded polystyrene is taken to Dart Container in Mason. Some parts from electronic equipment are removed for reuse within Housing and Food Service before the equipment is taken to MSU Surplus (Vaszily 2005).

4.1.6 Cafeterias and Other Food Service Facilities

The main types of wastes generated from MSU cafeterias and other food service facilities are general refuse, food waste and frying grease. Some of the food waste generated in the kitchen goes into the garborator (an industrial version of a home garbage disposal) and then into the sewage system. Most food wastes from meals also go into the garborator. Some food waste gets mixed with other general waste and is finally landfilled. A pilot study conducted by a group within the Biosystems and Agriculture Engineering Department on cafeteria wastes indicates that, on average, 0.28 pounds of food residuals are generated per person entering the dining room; a value that is consistent with studies at other universities. This corresponds to a total of approximately 6,160 pounds per day of food waste generated at Michigan State. As a part of recycling efforts, napkins used in residence halls contain 100% recycled content. It has been reported that some food is donated to area soup kitchens and similar facilities. The residence hall cafeterias used approximately 152,000 lbs of cooking oil in 2004/5. The used oil is collected for recycling by Kruger Commodities. Recyclable items such as corrugated boxes and tinplate cans are collected by ORWM. Food wastes from the food courts in the Union and International Center go into the general waste stream (Haskell 2005).

4.1.7 Transportation Department

The Transportation Department is responsible for the maintenance of most of the vehicles owned by MSU except for those of the Grounds Department. About 2000 vehicles are serviced by the Transportation Department every year.

The wastes generated are mainly related to servicing of the cars in the garage, and consists predominantly of water-drained waste, used oil filters, and corrugated packaging materials. Water-drained waste from the main garage and the carwash is drained into two underground tanks. The tanks are built with a special oil separator where sludge consisting of oil, grease, sand, dirt and other solids is separated from water. The water is drained into the MSU sewage system and the sludge is pumped out once a year. About 600 gallons of sludge is removed from the two tanks annually; a fee is paid to a contractor for this service. Currently the Transportation Department is not recycling corrugated packaging materials or compacted oil filters (although oil is recovered from the crushed filters). Here, there is opportunity to increase recycling. The department reportedly once had an outside box for corrugated recycling, but stopped collecting it because of problems with material blowing around. The Transportation Dept. should investigate the systems currently in place in the Grounds Dept. for these materials. As a part of the university recycling efforts, the department recycles approximately 6000 gallons of used engine oil annually. The used oil is sold for recycling. About 400 gallons of used antifreeze is generated each year. The department pays a vendor for disposal of the antifreeze. The vendor then recycles the antifreeze and sells it back to the

Transportation Department. As noted below, in the Grounds Dept. section, there appears to be an opportunity for glycol-based antifreeze to be recycled with equipment currently available on campus. There are about 200 batteries disposed of each year. The batteries are collected by the suppliers at no charge, and sent for recycling. Empty aerosol spray cans are collected by ORCBS four times a year. Metal auto parts such as brake drums and rotors and other heavy steel scrap is collected by the MSU Surplus Store for recycling. About 200 used tires are collected every year. The Transportation Department is currently paying for this disposal service (Wolfe 2005).

4.1.8 Grounds Department

The Grounds Department is responsible for the maintenance of turf, trees, walks and streets, directional traffic and informational signs, and general cleanliness of the MSU campus. The department maintains its own fleet of 60 vehicles and equipment and generates primarily transport-related wastes, consisting of residues from cleaning auto parts, used oil filters, and water-drained wastes from the main garage and parking ramps. The department has one floor drain that collects water-drained waste in the garage. The water-drained waste is collected in an underground tank that is built with an oil separator to separate the sludge (oil, dirt and other solids) from water. The water is drained into the MSU sewage system and the sludge is pumped out by an outside contractor twice a year. The department also maintains two floor drains in Shaw and three floor drains in Brody. The tanks are pumped out once a year (Parrott 2005).

The Grounds Department also handles wastes such as street sweepings, general waste, wood, and leaves generated on the campus grounds. Approximately 500 to 600 cubic yards of street sweepings are collected each year. Street sweepings increase when construction activities on the campus increase. The Grounds crew also collects solid waste all around campus. This includes wastes generated after athletics and other events. During athletic events cleanup, the department does not segregate recyclables such as deposit containers and trash, for cost reasons. The Grounds Department tried placing cardboard boxes to collect cans in tailgating areas for recycling a few years ago but was not successful (Parrott 2005). However, in Fall 2005 a new recovery program collecting PET bottles was instituted for the football program and tailgating sites, and has appeared to have good initial success .

As a part of university wide recycling efforts, the department generates and recycles about 800-1,200 gallons of waste oil each year that is sold for recycling. Auto parts are cleaned using the "Safety Clean Machine." The fluid used for cleaning is recycled in the machine and is reused. The separated oil and dirt mixture is transferred to the waste oil tank. Engine oil filters from vehicles and equipment are compacted and recycled. New vehicles are supplied with "Dex-Cool" antifreeze that can be used for 4 to 5 years. The waste Dex-Cool antifreeze is collected by ORCBS. The rest of the fleet uses glycol-based anti-freeze that is recycled in the garage using a "Napa Antifreeze Recycler." There appears to be an opportunity for the Transportation Dept. to send its glycol-based antifreeze to the Grounds Dept. for recycling, since the antifreeze recycler is not currently

being used to its full capacity. This should be explored. Used car batteries are collected by the battery supplier. About 200 used tires are collected for per year. The department is paying for the disposal service. The scrap metal auto parts collected are sent for recycling through MSU Surplus. The department also collects corrugated board from packaging materials for recycling (Parrott 2005).

Wood from tree trimmings, broken pallets, scrap wood and lumber is mulched by an outside contractor twice a year into wood chips for use in campus landscaping. The department also mulches small tree trimmings using their own machine. It is estimated that 2,000 to 2,400 cubic yards of wood chips are generated annually. Some of the lumber is also sold through University Surplus; what cannot be sold is mulched. About 2/3 of the leaves generated on campus are mulched and put back into the soil. The remainder, about 300 cubic yards of leaves per year, is collected and composted (Parrott 2005).

4.1.9 MSU Farms

MSU farms produce both animal and agricultural wastes. Information about agricultural wastes was not obtained. Animal wastes include both liquid and solid manure. The total amount is estimated at 1.7 million gallons per year of liquid wastes, and 8,044 tons per year of solid manure. As a part of university wide recycling efforts, MSU operates a composting facility to convert the animal waste and wood mulch into compost. This is done to ensure compliance with state regulations, as part of the nutrient management program. Composting of manure is not counted in recycling totals (Selke et al. 2006).

4.1.10 Power Plant

The MSU Power Plant supplies electricity and steam to approximately 110 buildings in its service area, enclosed by the following roads: Harrison, Mt. Hope, Hagadorn, Michigan Ave. and Grand River. The plant uses coal and natural gas to produce energy. Coal is the primary fuel and natural gas is used as a backup when the coal system breaks down. The primary wastes generated from the Power Plant operations are coal ash and gypsum.

There are four boiler units, one of which uses circulating fluidized bed combustion (cfb) for sulfur dioxide removal and nitrogen oxide control. Three of the units use fabric filters and one unit uses an electrostatic precipitator for airborne particulate control. The plant consumes approximately 250,000 tons of coal and 200,000 mcf of natural gas in total per year. The 'old technology' boiler units consume 170,000 tons of coal per year, and generate approximately 17,000 tons of ash, about 10% of the coal input. The new cfb boiler unit consumes approximately 80,000 tons of coal and 20,000 tons of limestone and generates approximately 32,000 tons of high pH and calcium-rich ash per year. The coal ash from the 'old technology' units is sold for cement manufacturing. The coal ash/lime from the clean unit is sold for biosolids production. The sales proceeds are used to offset MSU's cost to transport the waste to both buyers. This alternative is less expensive than landfilling the coal ash. Per ton revenue for the ash from the "dirty" units is about 7 times that from the "clean" unit (Ellerhorst 2005).

4.1.11 MSU Laundry

The MSU laundry provides laundry services to various entities at MSU such as the residence hall cafeterias, Kellogg Center, laboratories and farms. The main laundry items are garments such as laboratory coats, uniforms and aprons and linens such as towels and tablecloths. The main types of wastes generated by the MSU laundry include wastewater, cloth lint, bleach containers, and soap containers. The wastewater from the laundry machines is drained into the sewage system after being filtered for residues, which are mainly cloth lint. The lint is collected in a collection bin that is emptied twice a year by an independent contractor. MSU laundry sends back the empty bleach containers to the supplier. Corrugated board and office paper are recycled (MSU Laundry 2005).

4.1.12 MSU Printing Services

The MSU Printing Services is mainly responsible for printing brochures, letterhead paper, business cards, and some course packs for MSU departments. The primary wastes generated are paper, polyester printing plates, mixtures of ink skin and waste ink, solvent, used toner cartridges and ream wrappers. MSU Printing has three offset machines and five digital printers. The offset machines use polyester plates and generate about 50 lbs of non-recyclable polyester plates per month. The department uses solvent based inks for the printing process. Approximately 500 lbs of inks and 94 gallons of solvent were used in fiscal year 2004/2005. This process generates around 200 lbs of an ink skin, waste ink and solvent mixture that is collected by ORCBS. The department uses about 90,000

lbs of white paper and 45,000 lbs of colored paper per year. About 20% of the jobs are sent off campus as mail. As a part of university wide recycling efforts, reusable rags used for cleaning purposes in the printing process are washed at the MSU Laundry and reused. Used toner cartridges are sent back to the suppliers. MSU Printing collects recyclables such as corrugated, white paper, and colored paper that are generated during the printing process, and sends them to ORWM. The ream wrappers cannot be recycled as they contain additives for moisture barrier. To minimize ream wrapper waste, the department has most of their paper supply delivered in a special corrugated box without ream wrappers (Seybert 2005).

4.1.13 University Stores

University Stores is a part of University Services. Materials and items required for daily use in MSU departments, laboratories and housing are sold through the University Stores. Any purchases to be made are processed through the Stores Stock or Non-Stock Order functions. Incoming shipments are received and distributed from the University Stores. The main type of waste generated is general refuse which is handled by ORWM. As a part of recycling efforts, corrugated boxes are reused for circulation. Recycling systems are also in place for junk mail and for pallets. Items with recycled content are generally identified (University Stores 2005).

4.1.14 Construction, Demolition and Renovation Activities

The construction, demolition, and renovation activities are performed by contractors. The wastes may be removed by the contractor or the university

depending on the contract. Generally, contracts do not require any recovery of materials (Purchasing Office 2005).

4.1.15 Special Events

Special events at MSU include the waste generated at sports events such as football and basketball, cultural events such as concerts and theatrical performances, and other types of performances. Wastes from these events are generally handled by the University through normal waste disposal channels. In the 2004 football season, almost 400 cubic yards of waste was generated in every home game. That is about 2400 cubic yards with 6 home games. It was reported that more than 66,000 souvenir cups and almost 57,000 bottles of water were sold by MSU Concessions during the season. Out of the total waste generated, 11% was non-recyclable refuse. The rest were recyclable items that included: 23% souvenir cups, 19% plastic water bottles, 21% cardboard and combo trays, 16% other recoverable paper, 10% foam (Mallett 2004). A recycling program in the 2005 season was intended to reduce the amount of PET water bottles sent for disposal.

Move-out days at the end spring semester in the dormitories can also be regarded as a special event. The "Pack Up, Pitch In, Move Out" program was started in 1999. Furniture, clothing, and other items collected through this program are donated to local nonprofit organizations. In spring 2005, 7,050 pounds of clothing, 1,910 pounds of food, 1,055 rolls of carpet, and a variety of small appliances, furniture, and electronics were collected. In addition, over 1,100 cubic yards of loft lumber was collected for recycling or reuse. During

move-in in the fall, special collection of corrugated is carried out; in fall 2005, 33 tons was collected and recycled through this effort. This program diverts a significant amount of material from the waste stream. Table 3 summarizes the sources of wastes at MSU.

Table 3 Summary of MSU Waste Sources

Sr. No.	Waste Source	Main Types of Waste	Recyclables collected and recycling efforts
1	Lecture Halls, Classrooms and Computer Labs	General refuse and office waste	Office paper, newspapers, plastic bottles, and cans
2	Administrative and Faculty Offices	General refuse and used office appliances and furniture, electronic wastes such as monitors and other computer accessories	Toner cartridges, office paper, newspapers, magazines, and corrugated board, plastic bottles and cans
3	Laboratories and Research Facilities	General refuse and office waste Laboratories are the sources of chemical, biological and radioactive wastes.	
	Meat Laboratory	Non-edibles from animals Bio-hazardous, chemical and radioactive wastes	
	Diagnostic Center for Population and Animal Health (DCPAH)	Bio-hazardous wastes: tissue samples, blood samples, blood stained gauze and swabs, contaminated packaging materials, and sharps; Animal carcasses; and chemical waste	
4	Medical and Veterinary Facilities	Blood-stained gauze, swabs, speculums and items contaminated with human fluid	
5	Residence Halls	General refuse and office waste Wastes from maintenance activities: fluorescent and incandescent tubes, lead acid batteries from emergency lights, light ballasts, and cleaning supplies and paints	Newspaper, white paper, mixed paper, phone books, magazines, corrugated, and loft lumber New furniture delivered wrapped in blankets or in plastic to minimize use of corrugated board Washable cloths used as rags

Table 3 Summary of MSU Waste Sources (continued)

	University Apartments	Household wastes	Newspapers, corrugated board, steel cans, aluminum, clear glass, brown glass, PET and HDPE bottles, magazines, white paper, and mixed paper "Give or Take Center" residents donate various educational materials and household items for other to use
	Kellogg Center	General refuse Grey water Grease, Paints and thinner from maintenance services,	Used oil (collected by Kruger Commodities) Steel cans, aluminum cans, and plastic bottles Fluorescent and incandescent bulbs, aerosol cans, batteries, and light ballasts Washable cloths used as rags Bathroom tissue containing 95% recycled content (10% post-consumer). Paper towels contain 100% recycled content (50% post-consumer)
6	Cafeterias and Other Food Service Facilities	General refuse, food wastes	Napkins with 100% recycled content Used oil (collected by Kruger commodities)
7	Transportation Department	Water-drained waste, corrugated packaging materials, compacted oil filters, empty aerosol cans General refuse and office waste	Used engine oil, anti-freeze, used car batteries, used tires, heavy steel scrap – metal auto parts such as brake drums and rotors
8	Grounds Department	Water-drained waste, street sweepings, wastes after special events	Used oil, auto parts cleaned using "Safety Clean Machine" – fluid used for

Table 3 Summary of MSU Waste Sources (continued)

		General waste	cleaning is filtered and reused Used oil filters and scrap metal, Dex-cool antifreeze, used vehicle batteries, corrugated. Wood from tree trimmings, broken pallets, scrap wood and lumber, leaves.
9	MSU Farms	Agriculture waste, animal waste, liquid wastes	Animal waste converted into compost
10	Power Plant	Fly ash	Coal ash
11	MSU Laundry	Cloth lint (collected by independent contractor), bleach containers, soap containers	Corrugated board and office paper
12	MSU Printing Services	50 lbs of non-recyclable polyester plates per month, 200 lbs of an ink skin, waste ink and solvent mixture,	Washable cloths used as rags Toner cartridges sent back to suppliers Corrugated, white paper, and colored paper. Paper delivered in special corrugated boxes to avoid ream wrapper waste
13	University Stores	General refuse	Corrugated boxes, pallets, junk mail
14	Construction, Demolition and Renovation Activities	Wastes removed by contractor or MSU	
15	Special Events	2400 cubic yards of waste in one 2004 foot ball season at Spartan stadium (11 non recyclable items, rest were recyclable items – bottles, cups, card board and combo trays, paper and foam	"Pack Up, Pitch In, Move Out" (started in 1999. Similar collection during Move In period.

4.2 Michigan State University Waste Management

MSU has 4 departments responsible for management of different waste streams. These departments overlook the waste collection, disposal, and recycling activities and manage the salvage.

1. Office of Recycling and Waste Management (ORWM)
2. Office of Radiation, Chemical & Biological Safety (ORCBS)
3. University Laboratory Animal Resources (ULAR)
4. MSU Surplus.

4.2.1 Office of Recycling and Waste Management (ORWM)

ORWM is responsible for the pick-up of refuse from around the MSU campus, compacting of refuse and transporting it to the landfill. Various recovery programs have been initiated by ORWM. They encourage the University units to participate in the recycling programs and provide special containers for collection of items. ORWM collects the following materials for recycling:

1. Bottles, aluminum and steel cans: academic buildings and residence hall cafeterias, drop-off locations in University Apartments
2. Telephone books are collected seasonally.
3. Corrugated board: special dumpsters at designated sites.
4. Office waste such as paper, magazines, books are collected on request.
5. Newspaper recycling was limited to 14 classroom buildings. Through the Residence Hall Association (RHA) and the Housing office, newspaper collection was provided in dormitories, but required residents to take newspapers to the loading dock. In 2005, container collection of

newspapers was expanded to serve 67 buildings. All residence halls now have container service for newspapers on each floor and in each wing. In addition, centrally placed bins are available in residence halls for recycling of mixed paper, magazines, and corrugated board.

6. Toner cartridge recycling is available at all residence hall reception desks.
7. Wooden pallets and steel scrap are collected at designated locations (Grounds Department, Transportation Department and University Stores) (Pasterz 2005).

4.2.2 Office of Radiation, Chemical and Biological Safety (ORCBS)

ORCBS is responsible for handling the radioactive waste, chemical waste and biological waste generated on the MSU campus, which need strict monitoring and compliance with regulations of a number of agencies such as United States Environmental Protection Agency (USEPA), United States Department of Agriculture (USDA), Michigan Occupational Safety and Health Administration (MIOSHA), United States Department if Transportation (USDOT), National Fire Protection Association (NFPA), and Nuclear Regulatory Commission (NRC). ORCBS has established a protocol for storage, handling and collection of chemical, biological, radioactive and hazardous wastes. ORCBS provides the guidelines as well as containers for collection of chemical wastes, radioactive wastes and sharps (Parmer et al. 2005); (Willard 2005).

ORCBS handles approximately 150 tons of hazardous waste materials from 1500 locations every year. Hazardous waste is disposed off-site by appointed vendors. The hazardous chemical waste generated in the labs is

collected in 5 gallon steel cans or HDPE single use drums or in small bottles; usually glass if the lab personnel do not want the chemicals to be mixed with others. The drums carry a label that contains the details of the chemical waste. The chemicals are then collected in 55 gallon HDPE tanks. 20 filled tanks are sent for disposal every 3 weeks. Open top drums are purchased on a regular basis for the consolidation of solid wastes and semi-solid wastes such as paint. The 55 gallon drums that are removed from campus are taken by the contractor to an off-site facility where the materials are combined with other wastes into bulk tanks for subsequent incineration or treatment as necessary, based on the material composition. A majority of the chemical waste is incinerated and the remainder is compacted. The compacted chemical waste is landfilled in a permitted hazardous waste location. The emptied 55 gallon drums are incinerated (Parmer et al. 2005).

ORCBS oversees the disposal of asbestos and lead from paint by building contractors during renovation or demolition projects. The department also recycles non-alkaline batteries.

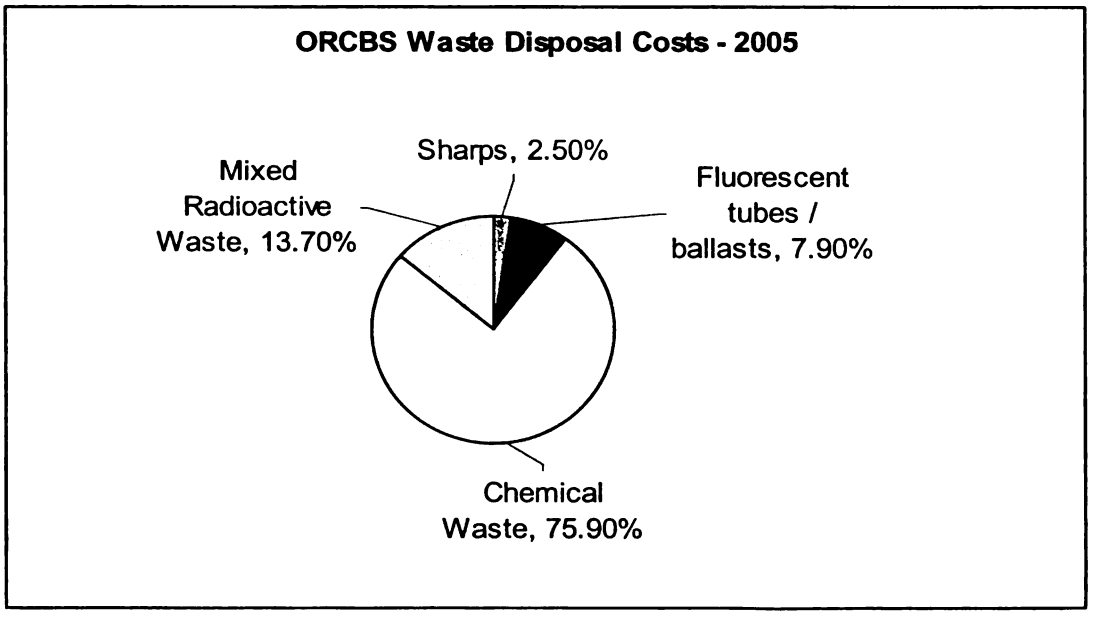
Radioactive materials for use on campus are purchased though ORCBS and are strictly monitored. Radioactive waste is collected and put in sealed containers. It is stored in these containers until it has decayed to safe levels and then is disposed via one of several methods, including disposal as ordinary trash after significant radiation is no longer present, or shipping to a licensed disposal site. Handling of radioactive materials is licensed and regulated by the U.S. Nuclear Regulatory Commission and the State of Michigan. The amount of

radioactivity in a container is controlled according to the volume and type of the container, chemical and physical form of the waste, amount of radioactivity, specific radioisotope and the applicable limits. Most of the decayed waste is incinerated in the Service Road incinerator and the ash, which is no longer radioactive, is landfilled (Erickson 2005).

Insurance for waste handling is managed by the MSU Risk Management Office. ORCBS conducts internal audits to ensure regulatory and safety requirements are met. The unit also conducts safety inspections every three months. As under U.S. law MSU remains responsible for the hazardous wastes it generated, ORCBS constantly evaluates its vendors to ensure compliance and to minimize risks of liability (Parmer et al. 2005).

The total cost of disposal for materials handled by ORCBS in 2004 was $105,337; in 2005 the total was $109,159.

Figure 7 ORCBS Waste Disposal Costs - 2005



4.2.3 University Laboratory Animal Resources (ULAR)

ULAR is mainly responsible for taking care of the live animals required for research around the campus. They maintain their animals (mostly rodents) near the laboratories at 9 different locations. They also provide service for pick up of carcasses from those 9 different locations around the campus such as microbiology, zoology, pharmacology, physiology, neural science, etc. All the rodents that have been used in tests have to be euthanized. If a dog or a cat was used, they generally donate the animal. This service is provided to MSU labs at subsidized rates. The incineration facility is provided free of cost for MSU facilities (Gaymer et al. 2005).

There can be infectious waste or chemical waste from the bedding that may contain dioxin, aldehydes, PBB, etc, depending on the projects, that is collected by ORCBS.

Pathological waste: All human tissues and animal tissues associated with infectious disease or recombinant DNA research is collected by ULAR from 3 consistent locations around campus. An average of 3 barrels are picked up every 3 weeks and incinerated.

ULAR also provides service for incineration of carcasses and remains of animals around Michigan. They receive carcasses of farm animals such as horses, cattle, sheep and pigs, and other animals from zoos. Suspect TB cattle are sent by the Michigan Department of Agriculture and a lot of deer and deer heads are sent by the Michigan Department of Natural Resources. Only 4% of the animal carcasses that are incinerated are from MSU labs.

There are 3 incinerators on campus; 2 of which are being currently used. ULAR maintains the incinerator at Beaumont road owned by DCPAH and the Farm Lane incinerator (the Wilson Road incinerator is not functional). These are gas fired incinerators (natural gas). 17,000 MCF of gas was used in FY 03-04 at a cost of $ 5.65/mcf. The current cost for 05-06 is $7.77/mcf. Around 1 million pounds of carcasses and remains are incinerated every year. Government agencies that use the service are charged 25 cents/lb by ULAR. The incinerator at DCPAH is run for 7-8 hrs a day, 4-5 days a week incinerating 1200 lbs/hr; but all this depends on how busy the incinerators are. The one at Farm Lane is a back-up incinerator. 6 cubic yards of ash is generated every week. The ash generated is considered as non hazardous waste and is landfilled at Granger. It is non-compactable solid waste class 200. Cost of disposal is $15.30 per cubic yard at Granger. ORWM maintains a 10 yard container at DCPAH and services it approximately twice every month (Gaymer et al. 2005).

4.2.4 MSU Surplus Store

The MSU Surplus Store, located at 1344 S. Harrison, is responsible for purchasing and selling used and surplus items from the university dormitories, offices and laboratories. Items sold at the Surplus Store vary from furniture, kitchen appliances, bicycles, laboratory and scientific instruments to computer and electronic items and even automobiles.

In the period July through December of fiscal year 2004/5, the Surplus Store generated $730,799 in sales, compared to $524,169 during the same period in fiscal year 2003/4, and $325,018 in that period of fiscal year 2002/3.

MSU Surplus does not track volume or weight of materials, only their value. Therefore, the amount of avoided waste disposal cannot be precisely quantified, though it is estimated at approximately 1,000 cubic yards per year (Daoust 2005).

4.3 MSU Waste Management and Recycling Operations

The following is an account of the quantities of waste disposed and the recyclables collected on the MSU main campus by the different departments working around campus.

4.3.1 Wastes Handled by ORWM

The following table indicates the volumes of different classes of wastes landfilled in fiscal years 2003-04 and 2004-05.

Table 4 Volume of wastes landfilled (cubic yards)

Waste Type	Fiscal Year 03-04 (cubic yards)	Fiscal Year 04-05 (cubic yards)
Class 100 (compact)	35,600	36,447
Class 200 (non-compact)	6,288	6,054
Class 310 (non-haz sludge)	8	
Class 330 (medical waste)	20	
Class 350 (fly ash)	130	2,300
Class 8 (appliances)	1	
Class 13 (sludge)	20	
Class 17 (asbestos)	20	

The landfill that MSU employs to dispose of its waste is Granger. The landfill fee is on a per cubic yard basis; hence, the records are maintained in cubic yards rather than by weight. We used a factor of 0.2711 ton per cubic yard to estimate the weight. It can be estimated that 9,651 tons of general refuse was

landfilled by MSU in fiscal year 2003-04 and 9,880 tons in fiscal year 2004-05 (Pasterz 2005).

Table 5 ORWM Recycling of Materials

Material	Density factor (lbs/cubic yards)	Density factor (tons/cubic yard)	Fiscal Year 2003-04 (tons)	Fiscal Year 2003-04 (cubic yards)	Fiscal Year 2004-05 (tons)	Fiscal Year 2004-05 (cubic yards)
Confidential shred	800	0.4	33.30	83.25	73.50	183.75
White office paper	800	0.4	351.80	879.50	318.50	796.25
Mixed office paper	800	0.4	145.90	364.75	94.40	236.00
CS/CL/IBM*	800	0.4	68.90	172.25	64.90	162.25
Magazines	800	0.4	57.40	143.50	56.50	141.25
Books	800	0.4	160.50	401.25	103.70	259.25
Newspaper	800	0.4	246.00	615.00	284.00	710.00
Cardboard	820	0.41	529.40	1291.22	546.50	1332.93
Mixed plastic*	355	0.1775	0.90	5.07	2.60	14.65
Plastic #1 (PETE)	355	0.1775	0.80	4.51	0.30	1.69
Plastic #2 (HDPE)	355	0.1775	0.20	1.13	1.20	6.76
Plastic #2 (CHDPE)	355	0.1775	0.20	1.13	0.30	1.69
Clear glass	2800	1.4	1.90	1.36	2.80	2.00
Brown glass	2800	1.4	0.10	0.07	0.00	0.00
Scrap metal	570	0.285	217.00	761.40	157.00	550.88
Coal ash (units I-III)			21,746.80		23362.70	
Coal ash (unit IV)			30,296.60		19114.40	
Total				4725.38		4399.34

Note: Recycling of scrap metal is handled by MSU Surplus Store.

The second column listed as "Density factor (lbs/cubic yards)" is the density of individual materials if they were landfilled. The density factors for various materials have been provided in the EPA's 1997 MSW update (U.S.EPA 1998). The cost of landfilling municipal solid waste categorized as class 100 (compactable) waste is $ 9.95 / cubic yard (Pasterz 2005). The third column is the land density of various materials in tons/cubic yards. The fourth and sixth columns indicate the recycled materials for fiscal years 2003-04 and 2004-05 in tons; this data is recorded by ORWM. The fifth and seventh column is the recycled materials converted to cubic yards from tons using the density factor. Using this cost factor, the landfilling cost avoided by recycling in the fiscal year 2003-04 is $47,017 (4725.38 cubic yards) and in fiscal year 2004-05 is $43,773 (4399.34 cubic yards).

Other materials recycled by ORWM include pallets. 2,351 pallets were recycled in fiscal year 2003-04. 7,019 pallets were collected in fiscal year 2004-05; out of which 3,282 were reusable, and the remaining 3,736 were categorized as "bad pallets" and recycled. Approximately 76 tons of frying grease is recycled each year from the MSU cafeteria. Printer and toner cartridges are recycled by ORWM.

Recycling rates at MSU: In 2003-04, 1,814 tons of materials were recycled and 1,706 tons in 2004-05. Adding the 76 tons of frying grease, the totals are 1,890 tons for 2003-04 and 1,782 tons for 2004-05. Considering the total MSW landfilled in 2003-04 was 11,400 tons and 12,100 tons in 2004-05, a rough estimate of recycling rates is 14.2% for 2003-04 and 12.8% for 2004-05. These

rates are very close to Crawford's (Crawford 1996) estimate of 13.6% for 1994-95.

4.3.2 Wastes Handled by ORCBS

Hazardous wastes generated in laboratories are handled by the Office of Radiation, Chemical and Biological Safety. They also recycle used oil and most non-alkaline batteries. All the other wastes are either incinerated or landfilled. The following table summarizes the wastes handled by ORCBS in the 2004 and 2005 calendar years.

Table 6 ORCBS Hazardous Waste Data

	Calendar Year 2004		**Calendar Year 2005**	
Waste Type	Quantity	Weight (lbs)	Quantity	Weight (lbs)
Bulk hazardous waste liquids	12,325 gal	110,925	13,648 gal	122,832
Lab packed hazardous waste	10,101 lbs	10,101	13,932 lbs	13,932
Mixed radioactive/hazardous waste	6,274 lbs	6,274	4,670 lbs	4,670
Paint in cans as hazardous waste	405 gal	4050	438 gal	4380
Parts washer as hazardous waste	229 gal	2,061		
Solely part 121 liquids	9,222 gal	82,998	7,484 gal	67,356
Used oil	6,580 gal	52,640	7,540 gal	60,320
Ni/Cd-Li ion batteries	200 lbs	200	400 lbs	400
Lead acid batteries	5,500 lbs	5,500	5,800 lbs	5,800
Light ballasts	10,800 lbs	10,800	10,200 lbs	10,200
Used electric lamps	28,369 units	21,277	18,148 units	13,611
Trimethyl benzene removal from cyclotron			4,866 gal	38,928

Radioactive wastes are either disposed of as hazardous waste off site or decayed to a point and disposed of as regular waste or incinerated. In 2005, 14,000 lbs of solid low level radioactive wastes were decayed to non-radioactive and disposed of as regular waste. 1197 gallons of liquid low level wastes were decayed on site and then disposed of as ordinary liquid wastes.

266 gallons of mixed RCRA regulated and radioactive wastes were generated. 15 gallons of these wastes could not be decayed and were shipped off site for disposal. The remaining 251 gallons was disposed of as hazardous wastes after it was decayed to not radioactive. In addition, 3600 gallons of mixed RCRA and radioactive wastes in liquid scintillation vials was disposed off site. About 1 cubic foot/year of solid low level radioactive wastes are disposed off site that cannot be burned or decayed (Selke et al. 2006).

Table 7 ORCBS Non-Hazardous Waste Data

	Calendar Year 2004		**Calendar Year 2005**	
Waste Type	Quantity	Weight (lbs)	Quantity	Weight (lbs)
Empty waste containers	4,398 units	13,194	4,589 units	13,767
Sharps	31,900 lbs	31,900	42,350 lbs	42,350

Table 8 ORCBS Waste Disposal and Recycling Rates

	2004 (lbs)	**2004 (tons)**	**2005 (lbs)**	**2005 (tons)**
Total amount of waste shipped for disposal	351,920	176.0	275,837	137.9
Battery, oil and electric lamps for recycling	79,617	39.8	80,131	40.1

4.4 Analysis of Selected Waste Streams

4.4.1 Classroom and Office Waste

The waste basket sort was done to develop a better understanding of the materials found in the classroom and office waste stream. The waste was collected and sorted as recyclables and non-recyclables. The recyclables were further classified into individual categories – paper (white office, mixed office and junk mail, magazines and other glossy paper, and newspapers), deposit plastic bottles (clear PET, blue PET and green PET), non-deposit plastic bottles (clear PET, blue PET, green PET, natural HDPE, colored HDPE), glass bottles, deposit aluminum cans, non-deposit aluminum cans, and steel cans. Food-contaminated packages were recorded into the non-recyclable category. Some of the potentially recyclable materials (mainly paper) were wet because of coffee, water and other beverages. Residuals were removed from beverage bottles before weighing. Excess moisture in paper could not be easily removed and the moisture content is assumed to be 10% or less. The following is a graphical representation of the data from Waste Basket Sorting.

Figure 8 Wastebasket sort data for classrooms and computer labs

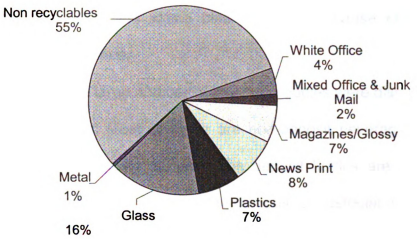
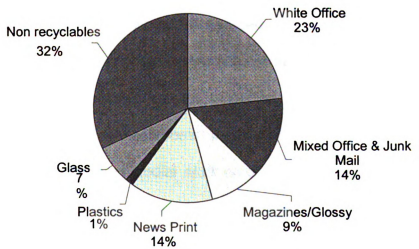


Figure 9 Wastebasket sort data for faculty and administrative offices



It is clearly visible from the above figures that large numbers of recyclable items are dumped in the trash and finally end up in a landfill. These items, if recycled, could not only save the disposal costs but could also generate revenue from recycling.

Paper makes a total of 21% of wastes from class rooms and about 60% from offices. Paper recycling efforts have been undertaken by ORWM. Even so, the high quantity of paper in the waste bins could be because of lack of awareness or lack of convenience.

It was observed that a large number of beverage bottles were discarded in office and classroom wastes. Most of these are non-deposit beverage bottles (especially in the classroom waste stream). The deposit bottles are removed from the main stream by students, visitors to the campus, or custodial personnel. Most of the non-deposit bottles were clear PET water bottles. Currently, MSU sends the PET and HDPE bottles collected from MSU Housing to Granger for recycling. There is no revenue generated, but the university does not have to pay for disposal. If the collection of non-deposit bottles was expanded to class rooms and offices, the disposal costs would be avoided. If large quantities of these materials are collected, a buyer could be found to generate some revenue.

The waste basket sorting indicates a total of 3 deposit containers from academic offices, and 26 from classrooms. It is possible that deposit metal cans are removed by students or custodial staff emptying the waste containers. A small number of non-deposit metal cans were also found. If a convenient collection system is expanded, metal cans could be recovered.

4.4.2 Waste from Transportation and Grounds Departments

Vehicle wastes form a separate category. Some of these are not a part of MSW handled by ORWM or the hazardous waste stream handled by ORCBS. Following is a tabulated account of the vehicle waste.

Table 9 Waste Streams Generated from Vehicle Operation and Maintenance

Waste Type	Source	Annual Quantity	Disposal Method
Oil Filters	Grounds, Transportation	In ORWM total	ORWM - recycle
Engine Oil	Grounds, Transportation	In ORCBS total	ORWM - recycle
Dex-Cool Anti-freeze	Grounds, Transportation	In ORCBS total	ORCBS
Glycol-based Anti-freeze	Grounds, Transportation	Unknown	Recycle - reuse
Scrap Metal	Grounds, Transportation	In ORWM total	MSU Surplus – recycle
Car Batteries	Transportation	200 units	Private company
Aerosol Cans	Transportation	In ORCBS total	ORCBS
Used Tires	Grounds, Transportation	400 units	Private company
Water drained waste	Grounds, Transportation, Brody and Shaw Ramp	Unknown	Private company

The MSW generated by the Transportation and Grounds departments is included in the total MSW quantities reported by ORWM. The used engine oil is not disposed or recycled by ORCBS. The quantities are reported by ORCBS for regulatory reasons. Following is a list of wastes generated at MSU Transportation and Grounds Departments not handled by ORWM or ORCBS.

Table 10 Additional Transportation and Grounds Wastes

Waste Type	Transportation Dept.	Grounds Dept.
Used antifreeze	Approx. 400 gallons/yr – pay vendor to accept & recycle	Dex-Cool – collected by ORCBS Glycol-based – recycled internally
Used oil filters	Recycled	Recycled
Used car batteries	Approx. 200/yr – collected by supplier at no charge	Collected by supplier
Used tires	Approx. 200/yr – pay vendor to accept & recycle	Approx. 200/yr – pay vendor to accept & recycle
Scrap wood		2,000-2,400 cubic yards – mulched for use in landscaping
Leaves		Approx 300 cubic yards/yr collected and composted; remainder mulched in place

4.4.3 Wastes Handled by DCPAH

The incinerator at DCPAH is managed by ULAR. The ash generated from incineration activity is landfilled. The amounts are included in those reported by ORWM. Following are the main types of wastes generated at the Diagnostic Center for Population and Animal Health:

Table 11 Waste Streams Generated from DCPAH

Waste Type	Source	Annual Quantity	Disposal Method
Sharps	DCPAH	Unknown	Autoclave, ORCBS – landfill
Biological Waste	DCPAH	Unknown	ULAR/ORCBS – landfill
Animal Carcasses	DCPAH, Farms and Zoos in Michigan	312 cubic yards/yr	ULAR – incinerate

4.4.4 MSU Farms

Another group is working on nutrient management issues associated with MSU's farm animal operations. The group is co-chaired by Chuck Reid, Bill Bickert, and Karen Plaut. Most of the plant-based wastes are incorporated back into the fields. Exact quantities were not available (Selke et al. 2006).

Table 12 Wastes from MSU Farms

Waste Type	Amount
Agricultural	Unknown
Animal liquids	1.7 million gallons/yr
Animal solids	8,044 tons/yr

4.4.5 Wastewater Treatment Plant

The East Lansing Wastewater Treatment Plant treats about 12.6 million gallons of water a day. The wastewater treatment generates 16,250 wet tons of solids per year, which is approximately 3,250 dry tons. It is estimated that 1/3 of the total is from MSU; i.e. about 1,083 dry tons of solids per year. Based on this calculation, MSU is charged one-third of the total operating costs of the facility (Johnston et al. 2005).

5 RECOMMENDATIONS

The results of the project indicate that there are opportunities in a number of areas for improvements in MSU waste management and recycling activities. These are discussed in the recommendations below. It was noted that in general, some of the departments and facilities on campus do not keep track of waste quantities and the associated disposal costs. This information is important for decision making. Before implementing some of the recommendations below, a reliable economic analysis should be done.

5.1 Increase of recycling activities

The data from ORWM indicate that recycling operations in MSU divert a large amount of materials from the municipal solid waste stream – thus saving a lot of disposal fees and also generating revenue. Previous waste characterization of municipal solid wastes in MSU indicated, and the waste basket sorting indicate that still, recyclables are present in the waste that are being land-filled. There is an opportunity to collect these recyclables, as explained through the examples below.

We have to realize that convenience is a key for every person when it comes to recycling. Collecting the materials according to specific categories makes it difficult, as collection containers for each kind might not be available at every location. In the case of paper, a much larger quantity could be collected. This is possible if all kinds of paper and paper products are collected at all locations and then either sorted or sold as mixed paper. This is being done in a number of other universities, as stated previously.

Plastic containers are collected at very limited locations (ex: School of Packaging) and on certain occasions (football games). Deposit as well as non-deposit containers should be collected around campus. The containers should not be limited to one kind of material; they could be plastic, glass or metal.

In Spartan Village and Cherry Lane, locations for collection of recyclables such as corrugated is limited; while collection of empty milk jugs in Spartan Village and Cherry Lane is limited to single location. In general, increasing the collection centers will increase the recycling activity.

The number of items recycled should be increased – a variety of items are collected at other universities that are not collected at MSU. This will add to the cost savings because of waste reduction.

Currently, students, staff and faculty do not know that inkjet cartridges and toner cartridges can be sent to Surplus and generate revenue for the University. Often, they are sent back with the empty cartridge return package that comes with the new cartridge. The number of cartridges sent to the Surplus Store would increase if this information was provided and reminders were sent periodically.

The Grounds Department uses a Napa Anti-freeze Recycler to recycle glycol based antifreeze. The Transportation Department could use a similar technology for their antifreeze. Also, the Transportation Department should get involved in recycling of corrugated and of compacted oil filters.

3M provides a lot of information online regarding recycling of overhead transparencies and they actually accept the transparencies for recycling. A lot of these transparencies are used in MSU during lectures and seminars. A system

needs to be in place for collection of these transparencies and sending them for recycling. Following is a link to the website 3M website that contains the information about recycling of over-head projector transparencies:

http://solutions.3m.com/wps/portal/3M/en_US/Meetings/Home/Solutions/Product_Catalog/Transparency_Film/RecProg/

The Grounds Department and Transportation Department have significantly different approaches to recycling, despite having similar waste streams. It appears that adoption of some Grounds Department practices by Transportation can increase recycling and reduce disposal.

Another area of interest is recycling of food wastes and leftovers. These are currently sent through the garbarators to join the main sewage line. At Stanford University these food wastes are composted, while at Rutgers University, the food wastes are pulped and are sold as animal feed to a local swine farm. With a large student population and cafeteria facilities, a large quantity of leftovers and prep wastes are generated in MSU; this is an area that needs attention at MSU.

5.2 University wide recycling culture and increased awareness

The students attending the university, as well as the faculty, staff and visitors, need to know why waste reduction and recycling is important for the university. In order to make recycling a core value, it is necessary to continuously remind the students, faculty and staff about the University's commitment to recycling. This publicity about "why and how" can be done in a variety of ways.

One option is to host a recycling awareness module in the freshman orientation as well as the international student orientation and welcome week; this is being done at the University of Colorado at Boulder. An online mandatory section could be introduced in freshman year or the first semester of graduate study about MSU recycling and waste reduction initiatives, (ex: ORCBS mandatory lab safety training available online). The online section should include MSU's success at reducing waste through recycling and the adverse effects it otherwise would have had because of land filling. A positive result always provides an incentive for commitment and further action. It could even bring out new possibilities.

Every piece of communication / document / package circulated around campus such as pay stubs, employment contracts, packaging materials for course packs, and corrugated boxes should carry a message stating MSU is an environmentally conscious university.

In residence halls and university halls, students and residents should be given instructions regarding MSU's recycling efforts and waste reduction. Trash bags are provided by the University Housing Service Center when students move into an apartment or on request; they should also provide receptacles for recyclables, information about the materials that are recycled and the drop-off locations along with maps.

In computer halls and class rooms, notices can be put up about materials that should be recycled and not dumped into the trash can.

An important waste reduction strategy is to reduce paper notices / memo's being circulated. For example, library overdue notices could be made completely electronic reducing paper usage. Double sided printing could be used when submitting reports, assignments, home-works, class papers, lab reports, etc. The default setting on university printers should be double sided so as to encourage double sided printing, thus greatly reducing the large quantity of paper used.

Newspaper waste could be reduced by increasing on-line options rather than having only printed copies.

Electronic display boards should be used in busy areas and major buildings on campus to spread information and details of upcoming events as well as advertisements amongst University members. This would greatly reduce the waste due to paper flyers.

A project should be undertaken to study the waste generated, the quantity of materials / items recycled, and their direct financial and environmental impacts from a building or a department. In other universities, such activities are done on a regular basis and there is a competition – which building is greener. It is not limited to materials recycled and also includes energy and water consumed.

Each department or building should have a recycling coordinator who overlooks the recycling operations. This could be a voluntary job and also a shared responsibility. Also, there should be representation from the student body (ex: a person from the Packaging Graduate Association could speak about the recycling efforts.

RecycleMania is a competition in which schools compete in per person recyclables collected, waste minimization, and other categories. Other universities, including The University of Michigan and Western Michigan University, participate in the competition. This will be a great incentive and will also create a need to quantify the amounts of materials recycled and waste minimized.

5.3 Alterations in recycling and waste management activities

The custodial services, which are a part of the MSU Physical Plant Division, should partner with ORWM to better manage the recycling activities along with their other services. The custodians working in individual buildings could be retrained for collection / sorting of recyclables. Their work routines could be amended to involve emptying and collection of recyclables from receptacle bins for newspaper and beverage containers, which get quickly full. Based on their daily waste collection experience, there could recommendations for improvement in operations, location of bins, etc. They could also write notices / tickets wherever recyclables / waste materials were inappropriately disposed. The custodial staff could participate in a project stated earlier to study the quantity of waste disposed and materials recycled per building.

Currently, the receptacles for recyclable items are requested by the department for their building. It should be made mandatory for each department/building to have receptacles. The dorms, as well as all on-campus housing, should have receptacles for recycling with clear instructions for acceptable materials and centralized locations convenient for collection. The

location and size of the containers could be decided on the basis of the student activity and functions of that building / room. Location of receptacles should be displayed on a map available on every floor near doors, as well online on the MSU campus website.

It is convenient to deposit recyclables in a collect commingled recyclables collection basket. It would encourage a lot more recycling and large quantity of materials could possibly be collected. However, sorted materials get a better price than commingled waste. To get a better price, the commingled materials will have to be separated, which is more expensive than collecting source separated materials. It will be good information to know – with the quantities generated in MSU, whether sorted materials are a better option than commingled materials or not. A materials recover facility (MRF) for sorting of materials is an option but may not be feasible unless partnered with another group such as the City of Lansing.

As per expert opinion, there is lot of cost savings involved in optimization of truck routes used for collection of waste and recyclables. This information needs to be collected and monitored for appropriate decision making at MSU. Also, the local landfill charges fees based on the volume of the container, and containers delivering waste to the landfill are not always completely full. Optimizing sizes of containers is an option to be considered. Also, the contracts with the landfill could be renegotiated, which could result in cost savings.

Out-sourcing of recycling activities such as collection, sorting and marketing is an option that should be considered, as the volumes generated in MSU might be large enough to be of interest to commercial firms.

5.4 Management and disposal of hazardous materials

Other universities such as Pennsylvania State University have a chemical exchange program in place. It involves the exchange between university laboratories of chemicals that might have been bought in excess or are left over from an experiment. MSU can implement such a system that can be supervised by the ORCBS. The chemicals will be listed online with their year of purchase along with the expiration date (set by the ORCBS) and the contact information. This will reduce the high disposal costs of hazardous chemicals that can still be used. Also, as a lower quantity of chemicals is purchased / used, this will decrease the environmental impacts to a certain extent.

Certain substances are extremely toxic and hence expensive to dispose of. ORCBS should have some control over purchase of these chemicals. Anyone interested in purchasing such chemicals should obtain approval from ORCBS and arrange for a disposal fee if necessary. This way, ORCBS can influence the quantity of chemicals purchased. This would not be limited to chemicals but also to biological agents and radioactive materials.

Contracts and Grants should include the disposal costs of general waste as well as chemicals used in research budgets. The ORCBS should be involved in estimating the costs if significant chemical quantities need to be purchased.

In certain cases, less toxic chemicals can be used in place of conventional chemicals. A list of such chemicals should be created by ORCBS and distributed in laboratory training sessions, with the intended chemicals they can replace. This list should also be available on the ORCBS website.

5.5 Environmentally conscious purchasing at Michigan State University

It is better to control the amount of materials getting into the university than to try clean up at the end. The Purchasing Department should play an important role by acting as a gate keeper of materials coming into the university. This can be done by implementing 'environmentally preferred procurement' principles and 'environmentally conscious' contract design and management practices. Currently, recycled paper and few other environmentally better choices are available through the Purchasing office. The Purchasing office should utilize the bargaining power available to MSU to reduce the quantity of wastes to be disposed and the costs of disposal associated with it.

One option is to incorporate waste management clauses in initial purchase contracts such as "takeback" of packaging materials, replaced equipment, and items/equipment at the end of life.

Items such as tires, vehicle fluids, batteries, lamps, lumber, and carpets are commonly used at MSU. The disposal costs of these old and worn out items are borne by MSU. For such large volume items or those that require large disposal costs, the costs should be borne by the supplier.

MSU should acquire information about the items purchased such as end of life disposal costs, environmental impacts of products and product/packaging

ratio. This information should be displayed in the online catalog and should be considered before deciding on a supplier. For bulk purchase of items, the Purchasing Office should provide the information regarding the best disposal technique to ORWM.

In the case of purchasing through departments using credit cards, the departments should have enough information to make "environmentally friendly" purchases. This information should be provided by the Purchasing department to individual departments and should also be made available online on their website. Also, a reminder should be sent at the beginning of each semester to spread awareness amongst as many people as possible.

For large events as such games, the food and beverage vendors should be responsible for disposal costs or take back the wastes or make an effort to collect recyclable beverage containers.

Construction and demolition generate a lot of waste materials that can be recycled in some cases. The contract should include either waste "takeback" or recycling of the materials generated in construction activities. Also, the contracts could include use of recycled items in building design.

The Purchasing Office could partner with local governments, other universities, schools and colleges for bulk purchasing. This gives them the power to bargain on bulk purchases; thus reducing costs of waste disposal and also reducing environmental impacts.

5.6 Improved operation of MSU Surplus Stores

The MSU Surplus Store offers a great service by providing sale of equipment and supplies, and also facilitating the exchange of equipment between departments. The new inventory management system at the MSU Surplus Store will exactly track the items sold by price and quantity, which will help quantify the benefits of the Surplus Store. One of the main recommendations to the Surplus Store will be community outreach, benefitting the people from MSU as well as outside of MSU.

The MSU Surplus Store should have an on-line catalog of items available, similar to that of University Stores – which is regularly updated. Currently, E-Bay is sometimes used to sell products online.

The Surplus Store should initiate an equipment loan service. The MSU surplus store can list the department / people who are willing to share their equipment at a modest price without actually warehousing the equipment at their location. This will help the University as well as community members who want to use the equipment for a short project but don't want to buy it.

The Surplus Store could provide a credit to departments which could be a percentage of the profit generated from the sales of their used / discarded equipment. This will be an incentive to departments to use the services provided by the MSU Surplus Store.

6 CONCLUSION

The aim of this project was to study the waste management activities and recycling efforts at MSU and make recommendations to the university to implement environmentally better practices. The university waste management offices have been listed along with their functions. The university waste sources have been categorized and the types of wastes from that location have been discussed. A waste basket sorting project was conducted to study the class room and office wastes. The results indicated that at MSU, a lot of recyclable materials are disposed of into the solid waste stream and there is an opportunity for improving recycling activities.

As a part of the project, the best practices from other universities were reviewed. Also, the data from other studies was reviewed and summarized. There are practices in other universities that MSU can implement, such as the chemical exchange program, competitions for greener campuses and buildings etc.

The recommendations were made to the university with a focus on environmentally better practices. These recommendations have been covered under the following headings:

1. Increase of recycling activities
2. University wide recycling culture and increased awareness
3. Management and disposal of hazardous materials
4. Environmentally conscious purchasing at Michigan State University
5. Improved operation of MSU Surplus Stores

It can be stated that MSU has implemented lot of environmentally better practices, but there is room for improvement. With commitment from senior management and university wide efforts, MSU can set an example of having a green campus and environmentally better practices.

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