Generic Designs and Projected Performance

For Two Sizes of

Integrated Resource Recovery Facilities

A Report to the

West Virginia Solid Waste Management Board

by

URBAN ORE® INC.

with

Mark Gorrell, Architect

Kathy Evans, Recycling Consultant

Dr. Robert Diener, P.E.

January 9, 1995

Second printing February 1997.

Contents

ACKNOWLEDGEMENTS

Urban Ore's design team wishes to thank the **people of West Virginia, Governor Gaston Caperton,** and the **Solid Waste Management Board** for giving us this opportunity to provide two generic designs for Integrated Resource Recovery Facilities (IRRFs), and to estimate and discuss their costs and revenues. We appreciate the thought and effort that went into selecting our team for this task and feel honored to advance the design of recycling facilities.

Our thanks also go to the following individuals and groups:

To **Charles Jordan,** Director of the Solid Waste Management Board, for framing a key question that this report will answer. Mr. Jordan told us to assume there are developers in West Virginia who are "sold on the concept of an IRRF and what it will accomplish." After creating the site schematics called for in our proposal, he asked us to estimate what such a facility would cost to build and operate.

To **Dr. John Hannon Martin,** recycling enthusiast and former member of the SWMB who served as the Board's designated representative, for helping us clarify the Board's objectives and fit the study to local conditions. Dr. Martin also supplied us with valuable technical papers and reports, including results of a landfill composition study he personally conducted using our categories.

To **Dr. Robert Diener**, Professor of Agricultural Engineering at West Virginia University, and his students and colleagues. They aggressively pushed the recycling envelope with innovative designs that combine plant debris and putrescibles in a single low-cost process that manufactures high-quality topsoil. Dr. Diener also supplied us with technical information and illustrations of key concepts that we have incorporated into the text or included as appendices.

To **Vonnie and Cecil Knapp**, residents of New Martinsville since 1958, who for many years have supplied us with clippings and news about Wetzel County and statewide garbage issues, and who also supplied local activists and opinion leaders with the information about alternatives that we sent in return.

To the **state legislature** for having the wisdom and courage to make West Virginia the second state to ban garbage incineration. This decision favors development of a network of Integrated Resource Recovery Facilities by simplifying the disposal service system choices: recovering materials, landfilling, or some combination of the two.

To the **authors and organizations** who generously granted permission for us to reproduce their reports in the appendices.

And to the **activists around the state,** alert citizens who helped awaken West Virginians to the dangers posed by out-of-state garbage, and, by extension, in-state garbage as well.

Generic Designs and Projected Performance

For Two Sizes of

Integrated Resource Recovery Facilities

Executive Summary

This report to the State of West Virginia describes the functions, operations, and cost of an Intermediate Resource Recovery Facility (IRRF), and it presents two generic designs of different-sized facilities.

Dr. John Hannon Martin, a former Solid Waste Management Board member, defined an IRRF as "a front-end reclamation plant stationed between discard generators and landfills or incinerators. The IRRF is a comprehensive reclamation facility that combines several proven discard management techniques: reusable goods exchange, organics composting, wood chipping, scrap recyclables processing, used oil collection and refining, and soil screening. The innovative aspect of the IRRF lies in the way it coordinates and centralizes these techniques."[1]

In short, an IRRF receives and recovers a comprehensive supply of discards. The IRRF was first conceptualized by Dr. Martin and Professor Robert Diener as a collaboration while Dr. Martin was a doctoral student at West Virginia University.

The two IRRF designs that are the heart of this report are not intended to fit a specific site, or to be built exactly as shown. Instead, they show *in general* how to design an IRRF to recover a comprehensive set of materials. Any real facility would have to be tailored; that is part of the point. Every community or local area produces a slightly different supply, and every site will have different physical characteristics, so to be most efficient, a facility must be designed to fit. This report discusses how to analyze a local supply using a set of twelve master categories – the Clean Dozen™ – to determine the local system requirements. These two generic designs illustrate the general system principles. They show a recovery system for a small rural site handling 25 tons per day and a larger urban site handling 100 tons per day.

As a consequence, the financial figures calculated for the two IRRF designs are only illustrative because they are not derived from real specifications. For example, equipment quoted here at one price might be found less expensively if purchased used, or the operator of a real site might prefer other machinery. Nevertheless, the figures have been calculated to provide a general idea of income and costs.

That idea is important: the IRRF will generate both income and costs. The facility is a productive asset, a mine that doesn't run out of ore, a manufactory that eliminates a major source of pollution *while generating wealth.*

Money will be needed to build and operate an IRRF, but once it is up and running, the facility will generate considerable revenue from two sources: disposal service fees and product sales. Adding up the expected income stream and subtracting the cost of operating provides an estimate of the facility's net operating balance. If the difference is positive, the facility produces a net profit, and if negative, it produces a net cost. This net operating balance is of great interest to West Virginia's Solid Waste Authorities. We believe these facilities can generate a net profit.

The Clean Dozen™

The Clean Dozen™ is a set of twelve master categories of discarded material that are of paramount importance to the reuse and recycling industry. They are: **reusable goods; paper; plant debris; putrescibles; wood; ceramics; soils; metals; glass; plastics; textiles; and chemicals.**

Each master category may be divided into dozens or even hundreds of subcategories by various cleaning and refining processes. But each material ultimately relates to a particular end-use industry, and the master categories do not overlap significantly, except for reusable goods. Reusables can overlap most of the other categories. Any given discarded item might be a candidate for reuse, depending on its condition and utility.

Nearly everything reusable can be scrapped, but once it has been scrapped, it is no longer reusable. To be put back into commerce, it must be transformed by recycling. Once Humpty Dumpty is broken, his best destiny is to become compost.

Value follows this principle of highest and best use. Lumber that is denailed, trimmed to size, and stacked neatly can be sold for ten cents to a dollar per lineal foot. But the same lumber may bring only $10 to $40 per ton if it is instead scrapped by chipping or grinding. This economic hierarchy encourages an efficient receiving and processing system to minimize contamination and to recover materials at the highest level to achieve highest income.

Within the eleven categories of scrap, each category has characteristics that require different processing and generate a different constellation of costs, income opportunities, products, and potential for sharing equipment and labor. Adding the eleven together and combining them with reusables describes all the recoverable components of the discard supply, as well as all the segments of the emerging recovered materials industry. Therefore, the Clean Dozen™ are a complete basis for planning if maximizing recycling is the goal. We make no provision for landfilling unrecoverable materials; that is a different industry and set of problems.

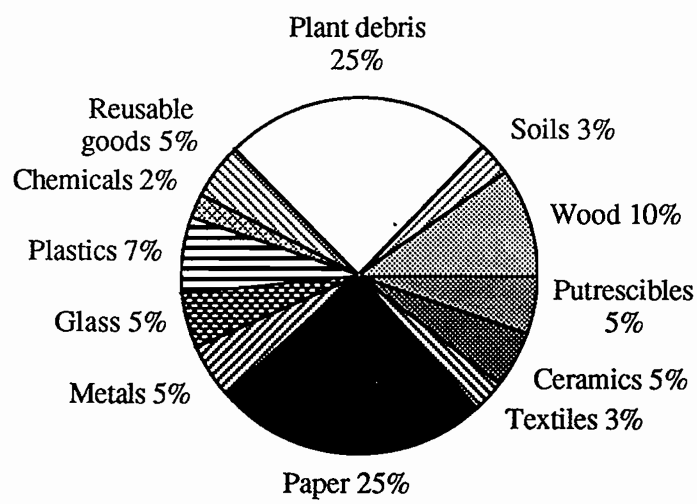
One way to visualize the Clean Dozen™ is to put them into a pie chart that shows the relative proportions of the master categories, expressed as a combination of weight and volume. It is a relatively accurate reflection of the generic national supply as our analysis finds it, *but local conditions will always be different from this generic image*. Again, determining the structure of the local supply is essential to designing a good local system. The value of this generic chart is to show relative proportions.

The practical importance is to permit strategic design. If we want to reduce landfilling fast, some of the biggest categories can be captured quickly. But if our local economy has lots of surplus labor (unemployment and underemployment), then we may go after the most valuable categories first to generate more employment per investment dollar and enough revenue to finance the recovery of less valuable fractions. The two strategies will produce different outcomes in reducing the trash being landfilled.

Supply and Recovery

Using the concepts outlined above, we referred to three supply studies done for West Virginia: "Waste Shed H Study," 1990, done by William F. Cosulich and Associates; the "Mon Plan," 1993, by Nassaux-Hemsley for Monongalia County; and Dr. John Hannon Martin's doctoral dissertation describing a standardized protocol for analyzing the supply, 1993, also for Monongalia County. Dr. Martin's figures are the only available products of observation that use the Clean

The Clean Dozen™
Twelve Master Categories of Discards



Dozen™ categories as their basis.

The analysis of these reports showed that three master categories – paper, plant debris, and wood – make up 50% of the total supply. Composting immediately became very important because for all three categories, supplies that cannot be recycled at a higher level can be composted for full recovery. Therefore these categories alone generate a recovery potential of 50% at the IRRF.

Supplies from three other master categories – soils, putrescibles, and ceramics – can be added to generate a recovery potential of 65% at the IRRF. Other categories can add to these substantial recovery rates.

By another valuable measure, dollars per ton, reusable goods may well provide the consistently highest value.

The actual recovery will depend, however, on specific facilities' design and implementation. Industries that use feedstocks of some recovered materials, such as glass and textiles, are far less tolerant than others of receiving supplies contaminated by out-of-category materials. The more tolerant the IRRF is of receiving mixed materials, usually in the name of convenience for users, the more contamination it can expect in its products. Also, the lower the recovery rate and income are likely to be. Another rule of thumb is that the more the facility separates master categories into subcategories, the more it will maximize its income per ton.

We assumed that the commodities most likely to arrive commingled were newspaper, cardboard, magazines, and mixed paper; glass and plastic bottles; and steel and aluminum cans.

The Facility Designs

Using the figures that this analysis generated, we designed two generic IRRF facilities. One is more suited to a rural area and has a capacity of about 25 tons per day (tpd). The other is more suited to an urban area and has a capacity of about 100 tpd.

We also designed them to cooperate with each other, to encourage urban and rural areas to work synergistically in developing resources and economic structures. For example, urban IRRFs could send rural IRRFs raw compost feedstocks, processing fees, finished goods, and excess reuse items. The rural IRRFs could manufacture compost and sell soil products to agricultural markets to grow products for sale back in the city. Other compost products could be bagged and marketed in the cities as custom topsoils. Truckers that haul raw organics from city to country for composting could return with loads of bagged or bulk soil amendments, or scrap such as baled paper, shredded tires, or metal.

Our designs provide three distinct processing modules at each facility: reuse, recycling, and composting. They closely resemble the areas specified in the engineering drawings and subsequent writings by Drs. Diener and Martin.

In the reuse module, goods are sold as-is or are sorted, dismantled, and cleaned for scrap. In the recycling module, source-separated and some commingled materials are upgraded to serve as feedstocks. In the compost area, organic (carbon-based) and certain inorganic discards are turned into topsoil, sand, and gravel for landscaping, construction, and agriculture.

Each module has a receiving area, a processing area, and a storage and sales area. Haulers have many tipping area choices. To preconfigure the sequence of unloading, they will load their trucks by stratifying different materials into a tipping order. Once inside the facility, they will be free to unload in whatever sequence makes sense to them, so long as they unload clean, separated materials that are acceptable to each operation.

Both sizes of design assume that a complete system has been installed on a single site, and all elements of the system are up and running simultaneously. In practice, however, it may be easier and more efficient to build the system in phases on several sites.

While it might appear that three operators will be needed for the three modules, our experience suggests there could be more. For example, all or part of the IRRF site could be owned by a single entity such as a Solid Waste Authority, which could then lease different parts to specialized operators. This structure could generate substantial income from rents and revenue sharing while maximizing flexibility, recovery, and income by using specialists, externalizing operational difficulties, and providing opportunities to develop partnerships with private developers.

The Flow of Money

The facilities will generate income by charging different fees to receive different materials, even paying for some, such as reusables. Money will flow according to highest and best use; suppliers with the highest-quality materials will be paid, and those with the lowest quality will pay to dump. It will be in suppliers' interest to keep materials as clean as they can. Still, all users will be encouraged to come if the service fees are lower than landfill fees, or if the facility is so clean and appealing that it becomes a preferable destination. They will also come if they are required to because some materials are banned from landfill.

Then the facilities will incur expenses by upgrading and otherwise processing the materials.

Finally, they will generate income again by selling products.

The goal is to generate more dollars in income than are spent in expenses. We believe this goal is achievable, since tipping fees can be adjusted to compensate for fluctuating markets.

Again, because these designs are generic and not specific, the financial figures cannot be applied to a specific facility. But they can indicate the areas the facilities need to focus on to balance the flow. In general, the methods to achieve a favorable balance are to maximize income and minimize expense.

After ten years of operation, and using various assumptions and calculations explained in the text and appendices, we believe the 25 tpd facility could bring in up to $1,105,972 and show a profit of $13,755 per year, and the 100 tpd facility could generate $4,447,289 and show a profit of $749,310.

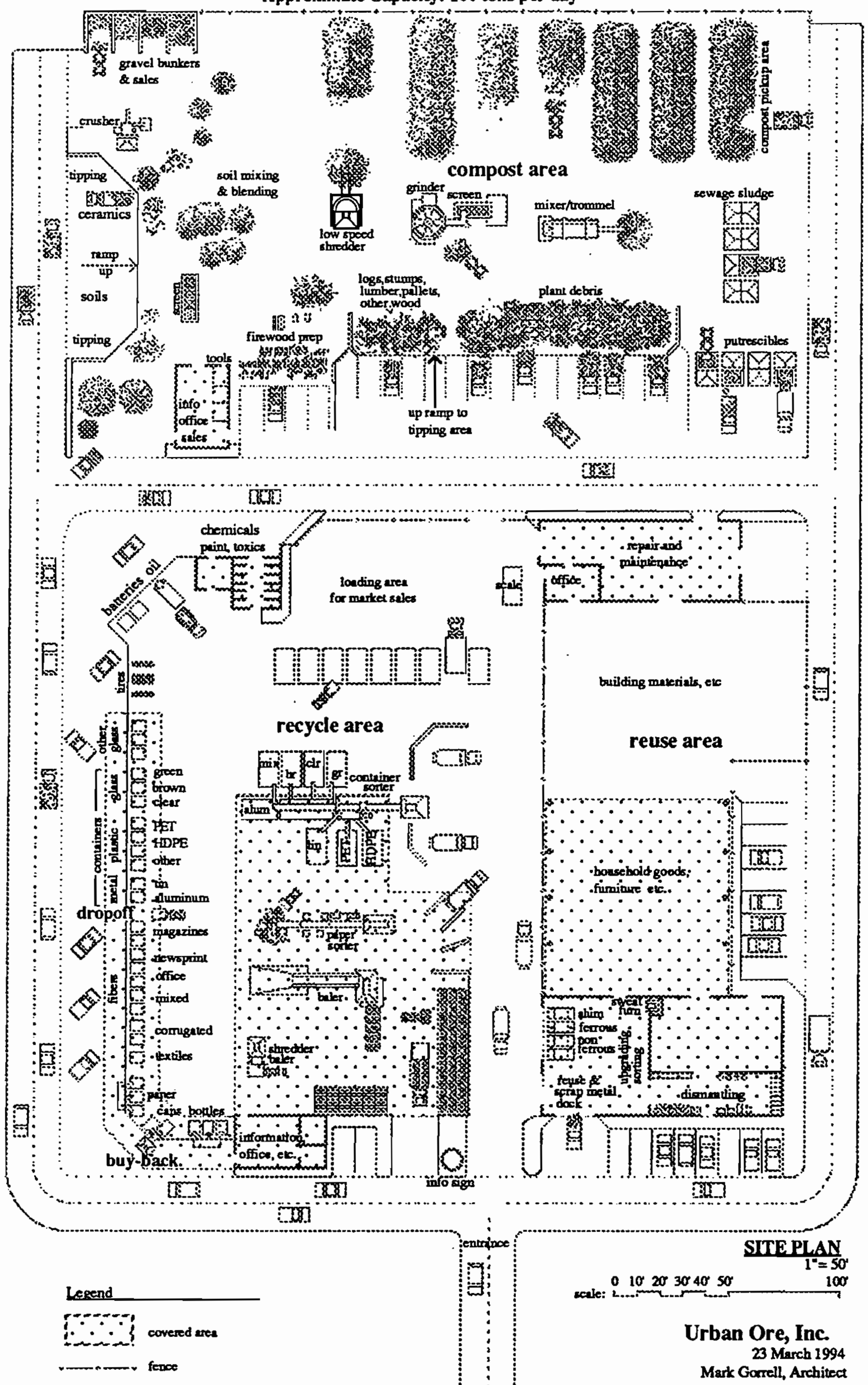
Users will find it in their interest to keep materials clean, and the site will handle a growing proportion of high-quality materials and a shrinking percentage of low-quality supplies. Revenues per ton will then tend to increase.

Conclusion

This design project shows that IRRFs could potentially recover large volumes of West Virginia's supply of discards. In doing so, they could provide jobs and business opportunities, stimulating economic development while developing the state's resources in a non-polluting way. The resources will probably never stop flowing, so these facilities can be regarded as structural elements of long-term, sustainable prosperity.

An Integrated Resource Recovery Facility

Approximate Capacity: 100 tons per day



Generic Designs and Projected Performance

For Two Sizes of

Integrated Resource Recovery Facilities

Generic Designs and Projected Performance

For Two Sizes of

Integrated Resource Recovery Facilities

Cost Is a Complicated Idea

The concept of cost that we apply in this report is not the same as the cost of, say, a bag of potatoes, a pair of pants, or even a landfill. An IRRF is not a consumable item that gets used up. It is a productive asset, a mine that doesn't run out of ore, a manufactory that makes disposal into such an orderly business that it eliminates a major source of pollution *while generating wealth.*

Money will be needed to build and operate an IRRF, but once it is up and running, the facility will generate considerable offsetting revenue from two sources: disposal service fees and product sales. Therefore, the cost to construct such a facility is only the beginning of financial analysis.

Once we add up the expected income stream from receiving and selling various commodities and subtract the cost of processing, we should be able to estimate the facility's net operating balance. Net operating balance is the difference between how much money goes out over, say, a year, and how much comes back in the same period. If the difference is positive, the facility produces a net profit, and if negative, it produces a net cost.

This net operating balance is of great interest to West Virginia's Solid Waste Authorities.

The Basis of the Plan

Writing this report has been similar to writing a business plan. Businesses write plans to gain more control over their futures. They combine current conditions, assumptions, and goals into a performance projection that is the best guess they can manage. The plans reflect reality, but they also shape it. Accurate profiles of existing conditions make planners more confident that their projections will be close to the mark. But the very act of planning is an exercise in peering into the future and is inherently filled with unknowns. Therefore, such plans do not have to be precisely accurate to be useful. They mainly function as a collection of general predictions that can be compared to ever-changing reality.

An inadequate data base does not stop the business planning process any more than black holes will stop the exploration of outer space. One learns to make the best guess possible of sizes and shapes and then navigate accordingly.

Our task is more complicated than an ordinary business plan, however, because we are working with a facility that is generic and conceptual, not real. The Integrated Resource Recovery Facility was first conceptualized by Dr. Martin and Professor Diener as a collaboration while Dr. Martin was a doctoral student at West Virginia University. Illustration 1 on the next page is an early drawing by Drs. Diener and Martin of their concept of such a facility.

This drawing envisions three major handling systems operating in the same facility: a system for source-separated materials (clean loads); a system for commingled post-consumer paper and packaging (commingled = mixed together); and a system for reusable goods. All twelve master categories are represented, although in some cases only subcategories are named. Key processing technologies are identified along with some of the products they would generate.

This IRRF is an imaginary creation, and our consulting task is to carry it a little further by suggesting how it might look and perform if it were built. One reason we are interested in this task is that we have been working independently for fifteen years to develop and understand a parallel and very similar type of facility that we call a Serial MRF (materials recovery facility). Other names we have used are Resource Recovery Depot (1980) and Discard Management Center (1989). All these names – "IRRF," "Serial MRF," "Resource Recovery Depot," and "Discard Management Center" are synonyms. They share these attributes:

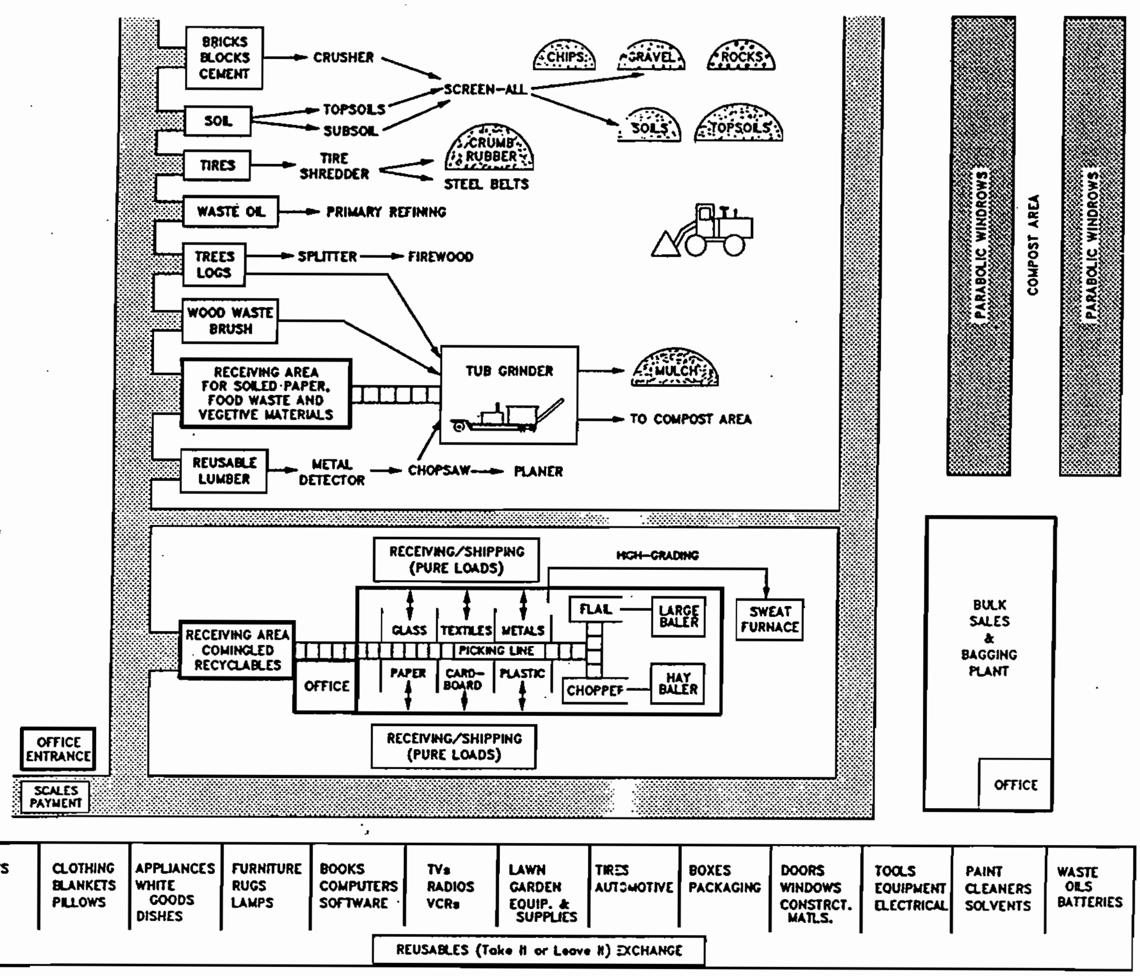
- All are materials recovery facilities that use variable rates instead of separation machinery to create clean, separated flows of discarded material.
- All approach the problem of recycling disposal comprehensively. That is, they assume that nothing recoverable should be lost to landfilling or burning.
- All have a long-term goal of making wasteful forms of disposal unnecessary.
- All are organized around the proven principle of highest and best use.

For more than a decade, the members of Urban Ore's design team have operated businesses that are part of a decentralized but regionally important Serial MRF. Our companies represent some of the kinds of businesses the IRRF concept calls for. Appendix A of this report is our technical paper, recently published by the Center for Neighborhood Technology in Chicago, that describes the Serial MRF phenomenon as it is manifested in Berkeley, California. Over the years during which we have helped develop this facility, we have seen and evaluated the effects of countless alterations, improvements, and new recycling services. Some were undertaken by the businesses we work within;

Illustration 1

Integrated Resource Recovery Facility (IRRF)

As conceptualized by Drs. Diener and Martin



others were created by different companies that complement our efforts. The Berkeley facility is not as complete as it could be, but it is real, and we think it is one of the most complete in the nation.

Nevertheless, our plan for the West Virginia IRRF presents a much more complete configuration of buildings, equipment, and land than the Berkeley Serial MRF has. It is also much more abstract and idealized. Therefore, the two facility designs we will present should be thought of as guides, not blueprints. *Each Solid Waste Authority (SWA) will have to interpret our general model in the light of local conditions.* Further study will be necessary to measure key local variables whose specific magnitudes are impossible for us to predict.

An example is the variable of site conditions. One or more sites may be available in most West Virginia communities that resemble our imagined ones in size and shape. But they may be too costly, or in the wrong zone, or too far from the landfill or transfer station, or bigger than needed because some parts of the IRRF are already up and running on sites of their own. People who read our report carefully should find it easier to identify the critical variables whose specific local configuration will make each local IRRF different from our model.

But there is one major cluster of variables so important that it merits our attention here, at the beginning of the design process. This is the size and shape of the existing reuse and recycling infrastructure. These generic designs do not take account of any existing materials recovery industries, but we believe every community has one or more essential components of an IRRF already present and working at some level. Before proposing any new reuse or recycling services, each SWA should find out what recycling and reuse businesses are already operating in each community, what commodities they handle, and where they are. Efficient implementation and sound community development will be served best by not duplicating existing services. Instead, planners and entrepreneurs are advised to look for what we call service voids: supplies of recoverable materials not currently targeted by any viable businesses.

Not all parts of the IRRF have to be combined on a single piece of property, nor do they have to be built all at once.

Not all parts of the IRRF have to be combined on a single piece of property, nor do they have to be built all at once. Different pieces can be added as communities can afford them or as entrepreneurs pull enough resources together to get something going. This is the way reuse and recycling have developed in Berkeley and in many other communities throughout the nation.

The process of switching from wasteful to conserving disposal has already begun in West Virginia, and it is farther along in some communities than others. To illustrate some different ways people have analyzed the local system, we have reprinted the following local recycling infrastructure studies from outside West Virginia as Appendix B of this report.

- *Economic Development Through Recycling* profiles 25 recycling businesses operating in the Philadelphia area in 1993. Performed in-house by Philadelphia's recycling office, one of the study's most interesting features is that it lists the number of people employed by each business. The study found nearly 600 people in fulltime employment.
- *Opportunities in Recycling for Small Business Entrepreneurs in the Metropolitan Washington (D.C.) Area* evaluates 33 types of recycling enterprises that could potentially design, collect, process, manufacture, or market reusable and recyclable materials. Written for the US Environmental Protection Agency by consultants Nancy Horton and John Snarr, this report discusses some of the technical and capital requirements for each business, and makes recommendations as to whether they should be tried by small entrepreneurs.
- *Small Scale Manufacturing Profiles* by consultant Gainer and Associates describes a select list of 34 businesses that manufacture finished products using recycled feedstocks. The businesses, primarily active in the United States and Canada, illustrate the diversity and originality of the emerging manufacturing sector that uses recycled feedstocks.

These representative studies show that there are already many different recycling and reuse processes that could be bidding for each commodity. For example, yard debris might be made into soil amendments for gardens, animal bedding for farms, or many other products. In a mature materials recovery system, many different processors may compete for the finite supply of each recovered commodity, paying different prices for different quality feedstocks provided by different suppliers. Over the long run, this supply competition will greatly increase the complexity of the disposal marketplace, but it should also lower the overall cost of disposal by converting formerly worthless materials into commodities. At the same time, it directly stimulates community economic development.

Like Drs. Diener and Martin, we have chosen a particular configuration of processes and products for the IRRF we have visualized, but this does not mean we have described all the possiblities. Nevertheless, this design incorporates certain principles that we feel should apply to any real facility; principles like designing for safety and environmental protection, or using competitive disposal rates to reward people who prepare materials so they meet industrial commodity specifications.

Safety is one major consideration that begins in the design, and we have structured in various features to provide it, such as separating processing and machinery from the public areas; and separating big trucks from small public vehicles where possible. Protecting environmental quality is another factor that must be considered in every IRRF. The IRRF inherently protects the environment by preventing landfilling and its attendant pollution, but

Any given discarded item is a candidate for reuse depending on its condition and utility. Nearly everything reusable can be scrapped, but once it has been scrapped, it is no longer reusable. To be put back into commerce, it must be transformed by recycling.

naturally the IRRF itself must be designed carefully. Some protection will be provided only by good operating procedures. For example, runoff from compost windrows should not flow directly into creeks or other water sources without being filtered through the soil. Disease vectors such as rats and flies must be prevented by covering bins that receive putrescibles and by managing windrows well. With good design and management, the IRRF will protect enviromental quality while developing the economy.

With these cautions and caveats, we will move on to discuss the commodities our idealized IRRF is designed to capture.

The Clean Dozen™

The Clean Dozen™ is a set of twelve master categories of discarded material[1] that are of paramount importance to the reuse and recycling industry. They are: **reusable goods; paper; plant debris; putrescibles; wood; ceramics; soils; metals; glass; polymers; textiles; and chemicals.**

Each master category may be divided into dozens or even hundreds of subcategories by various cleaning and refining processes. But each material ultimately relates to a particular industry that uses it, and the master categories do not overlap significantly, except for one: reuse.

Reusables can overlap most of the other categories. Any given discarded item is a candidate for reuse depending on its condition and utility. Nearly everything reusable can be scrapped, but once it has been scrapped, it is no longer reusable. To be put back into commerce, it must be transformed by recycling. Once Humpty Dumpty is broken, his best destiny is to become compost.

Value follows this principle of highest and best use. Lumber that is denailed, trimmed to size, and stacked neatly can be sold for ten cents to a dollar per lineal foot. The same lumber scrapped by chipping or grinding may bring only $10 to $40 per ton, depending on the end-use market. A porcelain sink can be worth $10 to $100 if sold for reuse, but if it is scrapped and made into sand and gravel, the value of its constituent materials may drop to under $20 per ton.

Several master categories of scrap may be present in a single reusable item. A refrigerator, for example, may be a combination of metal (steel, aluminum, brass, copper), plastic (acrylic, rubber), and chemicals (CFCs, HCFCs, ammonia, oil). Recycling a reusable item may require complex dismantling, cleaning, and storage operations.

Fortunately, the payoff for understanding the value of reusable goods is they stand at the top of the hierarchy of income potential.

Illustration 2

The Twelve Master Categories of Discards

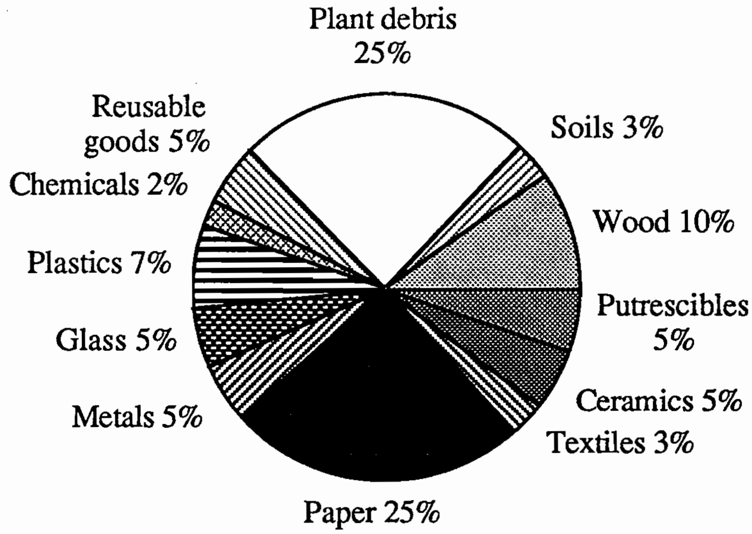


Chart and list of 12 categories ©1991 Daniel Knapp and Mary Lou Van Deventer. May be reproduced with credit.

The Many Faces of Scrap

The other eleven master categories are all scrap categories. Each has characteristics that require different processing and generate a different constellation of costs, income opportunities, products, and potential for sharing equipment and labor. Adding the eleven together and combining them with reusables describes all the recoverable components of the discard supply, as well as all the segments of the emerging recovered materials industry. Therefore, the Clean Dozen™ are a complete basis for planning, where maximizing recycling is the goal.

We have included an article by Daniel Knapp as Appendix C. *The Bay Area's Prospects for Total Recycling* briefly summarizes the development and testing of this category list. First used in a major composition study at a 90,000 ton-per-year refuse transfer station, it has since been adopted and recommended by the Northern California Recycling Association and has been incorporated into the charter of Alameda County, California, a county with about the same number of people as the state of West Virginia. The article goes on to profile a few of the local businesses active in recycling and discusses some of the political issues surrounding the field at the time (1990).

Illustration 2 is reproduced from this article, and from Dr, Knapp's book in progress, *Total Recycling: Realistic Ways to Approach the Ideal,* to be published by the University of California Press.

The pie chart shows the relative proportions of each of the master categories, expressed as a combination of weight and volume. It is a relatively accurate reflection of the supply, *but local conditions will always be different from this generic image.* Its value is to allow us to see intuitively that some categories are far more voluminous than others.

The practical importance of this conceptual understanding is to permit strategic design. If we want to make quick reductions in landfilling, for example, it will be both useful and comforting to know that some of the biggest categories can be captured quickly with the least investment. If we don't have much investment capital, and our local economy has lots of surplus labor (unemployment and underemployment), then we may choose to go after the most valuable categories and subcategories first, because they can generate enough revenue to finance recovering the less valuable fractions. The two strategies will produce different outcomes in reducing the trash being landfilled.

Another way to visualize the twelve categories in an industrial configuration would be to put them into a process flow diagram. Architect Mark Gorrell of the Urban Ore team created such a diagram as preparation for the task of creating his site plans for the two IRRFs. In Illustration 3, shown on pages 14 and 15, the assumption is that most or all of the materials will be delivered or collected separately. No commingling is indicated or planned for, although haulers carrying two or more separated materials can make more than one stop, and site designs can accomodate locally frequent combinations. Each master category of material is divided into its major scrap subcategories by source separation, and these separated materials proceed through different processes toward end markets. Collection from small and large haulers and curbside pickup are illustrated here, along with various key pieces of equipment.

Illustration 4 on page 16, also by Mr. Gorrell, integrates these process flows into a two-dimensional site schematic, where connections between different material clusters are expressed as traffic flows. In this circulation pattern, there are three different kinds of haulers, all of whom follow different paths. The three are: "small haulers," people unloading materials by hand from automobiles and light trucks; "commercial haulers," large trucks such as end dumps and debris box trucks that require substantial maneuvering room, as well as highway haulers that transport densified materials to markets or end users; and "curbside trucks," trucks including packers that collect materials at curbside.

These illustrations show some of the most important of the many variables that have to be coordinated in any site design. But all are alike in that they are highly generalized, so they oversimplify the range of choices in products and processes. In a less graphic but more detailed treatment of the same subject matter, Dr. Martin has written a useful description of some major processes and products, which we include with this report as Appendix D. His listing is valuable because it creates hierarchies of processes and products based on how well they perform these four functions within the local economy:

- Maximize economic benefit;
- Use least cost technology;
- Create a diverse network of enterprises to minimize the effect of market fluctuations in different commodities; and
- Keep recycling's benefits local by reducing cost, retrieving resources, building local markets, and retaining capital.

Using this approach, Dr. Martin was able to identify from three to fifteen feasible technologies and products for each master category, more than a hundred in all. The average number he found was nine per category, providing a wide range of options.

Estimating the Supply of Discards

Having now defined the overall theory, purpose, and operating method of the IRRF, we can begin to conceptualize the facility itself. Our first task will be to reinterpret and adjust Urban Ore's generic Clean Dozen™ pie chart in the light of the actual conditions prevailing in West Virginia's towns and cities.

Unfortunately, there appear to be few composition studies to draw information from, and those that do exist use incomplete category lists, with one exception. Nevertheless, we found relatively good information for Calhoun and Monongalia counties. We were advised that these two counties could also loosely represent the two types of counties that our 25 ton per day (tpd) and 100 tpd IRRFs were designed to fit: a rural county with its population dispersed in villages and along country roads, and a relatively urban county with one or more cities as well as several small towns and a rural hinterland.

We used three primary sources, besides our own experience and our generic estimate, to calculate the two materials recovery profiles. These sources were:

- **Waste Shed H Study, 1990.** This report was commissioned by the West Virginia Solid Waste Management Board and carried out by William F. Cosulich and Associates. *Solid Waste Quantification and Characterization Study: Waste Shed H* summarizes observations and measurements taken at eight landfills near where Calhoun County is located. Measurements and observations covered a one-week period. Currently diverted materials were not factored in, however, so the figures from this study represent only the material landfilled, not the total supply of discards.
- **Mon Plan, 1993.** This study was prepared for the Monongalia County Solid Waste Authority by Nassaux-Hemsley, Inc., in February 1993. The full title of the report is *Monongalia County Recycling Feasibility Study and Comprehensive Recycling Plan.* The consultants did not do any original observational work at Monongalia County landfills. Instead, they imported numbers derived from Cabell, Wayne, and Putnam counties, as reported in the Waste Shed H study referenced above.
- **Martin, 1992.** This original research was done as part of SWMB member John Hannon Martin's doctoral dissertation at West Virginia University. His study, *The Development and Testing of a Standardized Protocol for Analyzing the Waste Stream,* used

Illustration 3
Process Flow Diagram for Materials at an Integrated Resource Recovery Facility
part 1 of 2

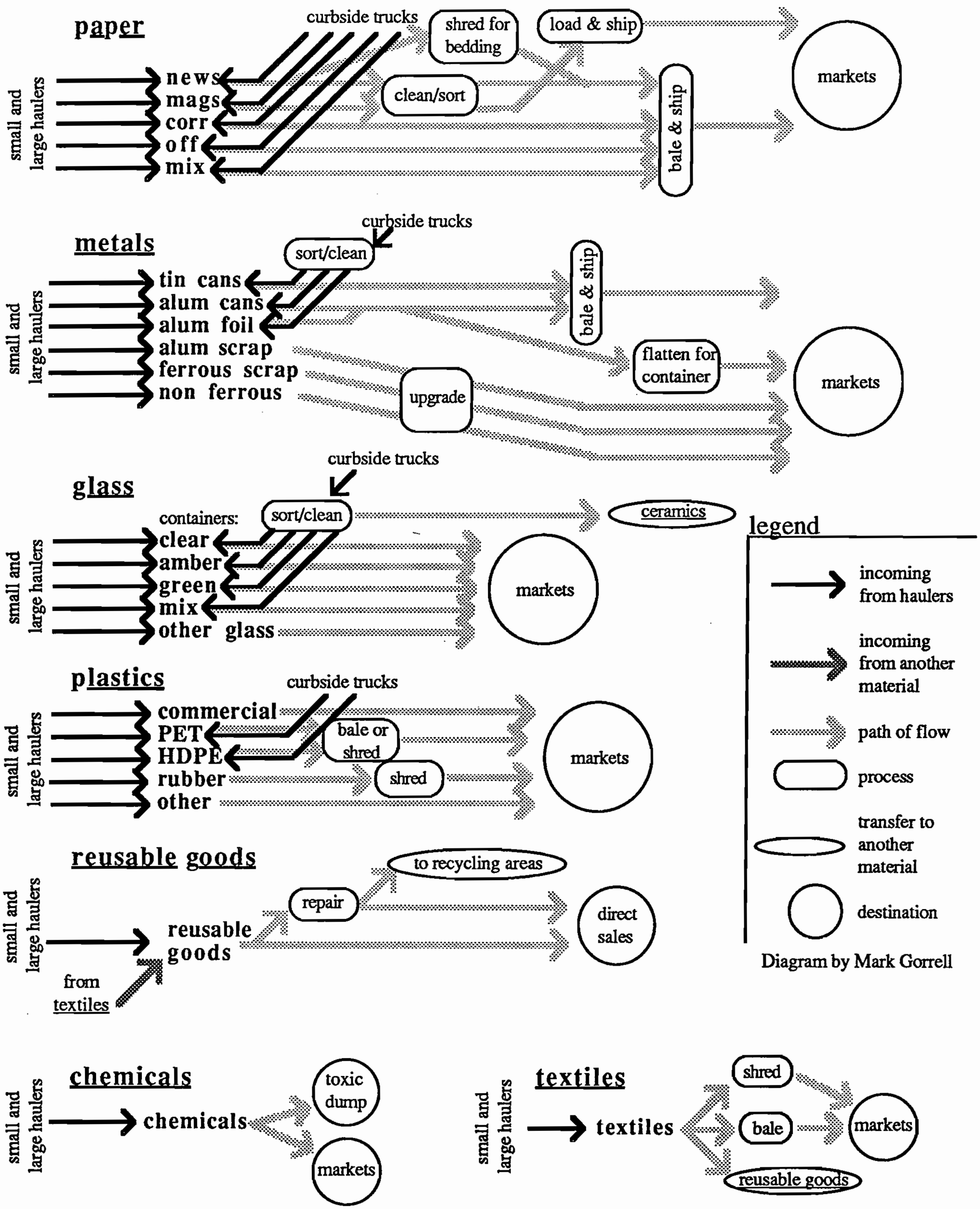


Illustration 3
Process Flow Diagram for Materials at an An Integrated Resource Recovery Facility
part 2 of 2

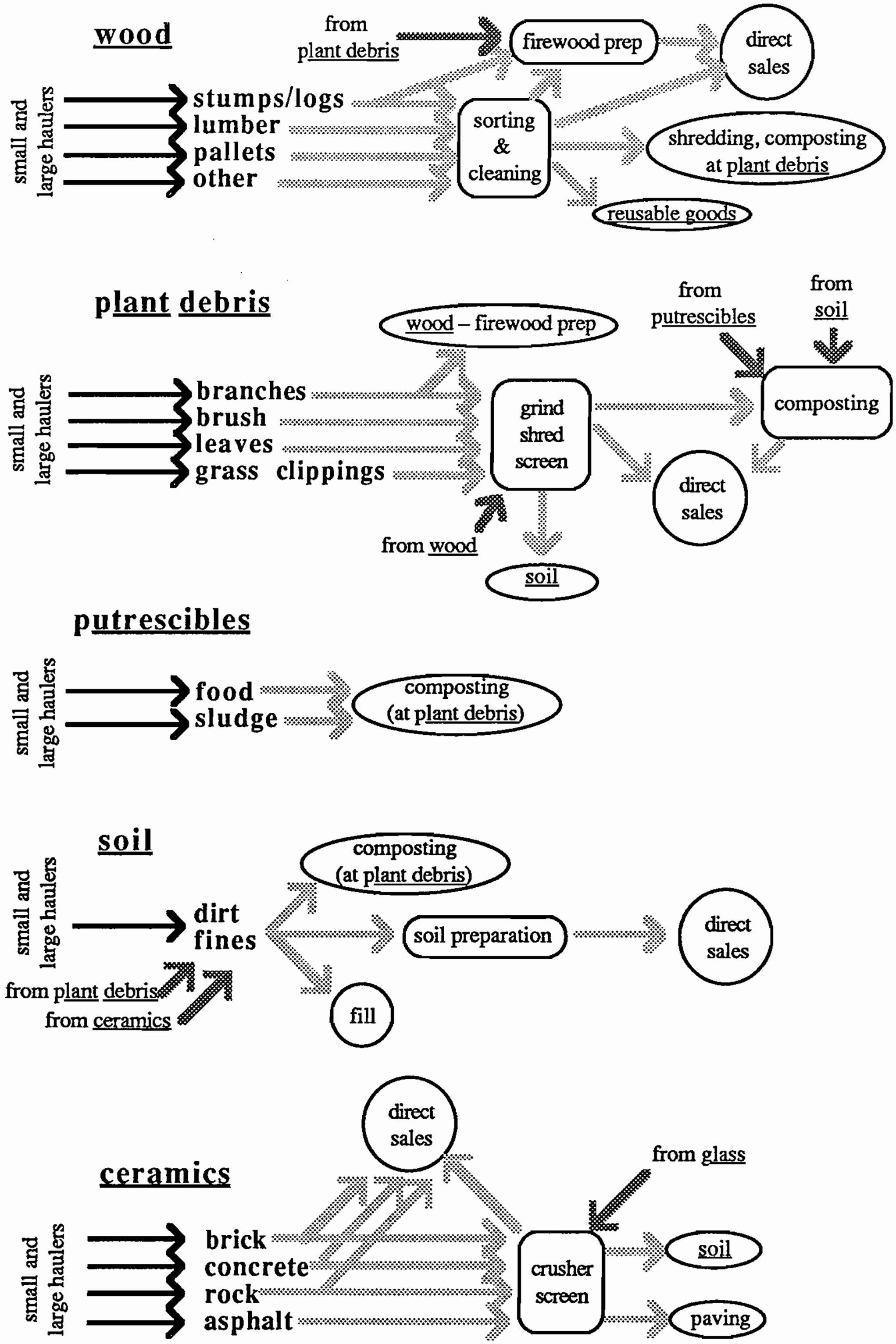
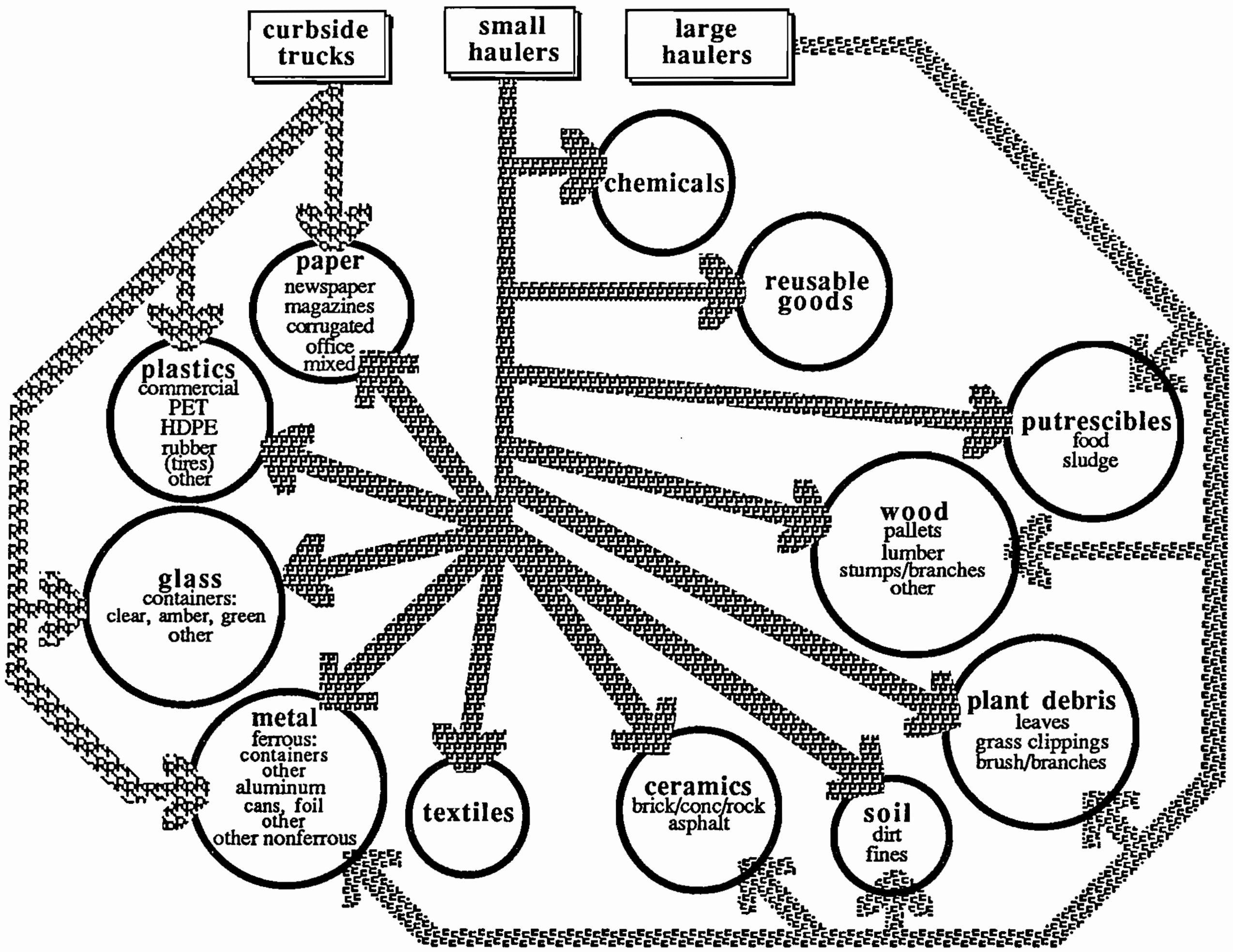


Diagram by Mark Gorrell

Illustration 4
How Materials Arrive at the Site



the Clean Dozen™ as a starting point and featured results of a one-week sampling exercise conducted at Monongalia County's Laurel Point landfill. Again, the figures represent only the total landfilled, not the total generated.

We based the 25 tpd IRRF on the Waste Shed H figures and the 100 tpd IRRF on Dr. Martin's study at the Laurel Point landfill. The discard supply percentages for both IRRFs are shown in Illustration 5 on the next page.

This chart[2] shows that just three categories, paper, plant debris, and wood, make up 50% of the entire supply. Since unrecyclable paper and wood can be composted, the importance of this processing option is strongly underlined for the more rural counties. In fact, adding processing for three more categories that can also feed some materials into composting – soils, putrescibles, and ceramics – would push the IRRF's potential capacity above the 65% mark. With a core technology consisting of a baler, some forklifts and loaders, a shredder, a crusher, and some screens, more than half of the discard supply could be diverted to productive use.

We used Dr. Martin's figures as the starting point[3] for the 100 tpd IRRF because it was a direct observational study, and the only other figures available were extrapolated from three counties in a different part of the state. As with the rural site, paper, plant debris, and wood make up about 50% of the total discard supply, but here paper is nearly 33% all by itself, no doubt reflecting the presence of West Virginia University, which makes Monongalia County its home. Plastics are also a much larger part of the mix, 13% of the total. Otherwise the composition is similar to the 25 tpd facility.

Now we have an image of the gross material composition available to each facility, but to model the economic performance more realistically we would like to recognize at least some of the major subcategories of material. The business of recycling and reuse is all about subcategories; hundreds are in use. Experienced paper brokers, for example, can recognize at least fifty paper grades, each with different uses and different prices. Textile processors may sort more than a hundred. Metal brokers can see about 150 categories of metal where the untrained eye would see only one or two.

An IRRF will not have to recognize so many subcategories in its ordinary practice, but in general, the more subcategories IRRF operators learn to work into their sorting protocols, the more revenue they will earn. In mining terms, the more separations are done, the higher the quality of the "ore."

From the three primary sources supplied us, we were able to estimate separate tonnages for 28 subcategories and four undivided master categories. Illustration 6 on the next page displays these results.

As an additional refinement of the economic model, we decided to assume a small role for commingling in collection and processing, at least for the 100 tpd IRRF. We did this because:

- Some onsite contamination of even the most carefully segregated loads is inevitable. For example, wind can blow paper into other material processing areas. A glass spill could occur near a paper processing area, mixing broken glass in with the paper. A mistake in communications could lead customers to think some materials are recyclable and acceptable when they are not.[4] A speedy and effective process to handle these occasional contaminants would be desirable. This is called "negative sorting" in the trade (removing contaminants from a mostly clean load) to distinguish it from the "positive" sorting that extracts recyclables from mixed garbage. Positive sorting lines are typically much more complicated, space-intensive, and costly than negative sorting lines. One such facility in San Diego County cost $130 million just to build, and its operating expenses are such that it loses money on every ton it processes.
- Some operators may prefer commingled collection over source separation. For organizations willing to sacrifice market potential for "convenience," these materials can still be upgraded to some degree.
- Sorting lines can be designed flexibly to make many different separations for different materials. For example, textiles could be sorted rapidly into several different marketable categories. Mixed paper could be sorted to remove high-value categories such as computer paper. IRRF managers could rent time on sorting lines to many different operators for different purposes, much as many copy shops rent time on computer systems.

We assumed, from our industry experience, that the commodities most likely to arrive commingled were newspaper, cardboard, magazines, and mixed

Illustration 5

Percentages of the Twelve Master Categories Expected at Each Size IRRF

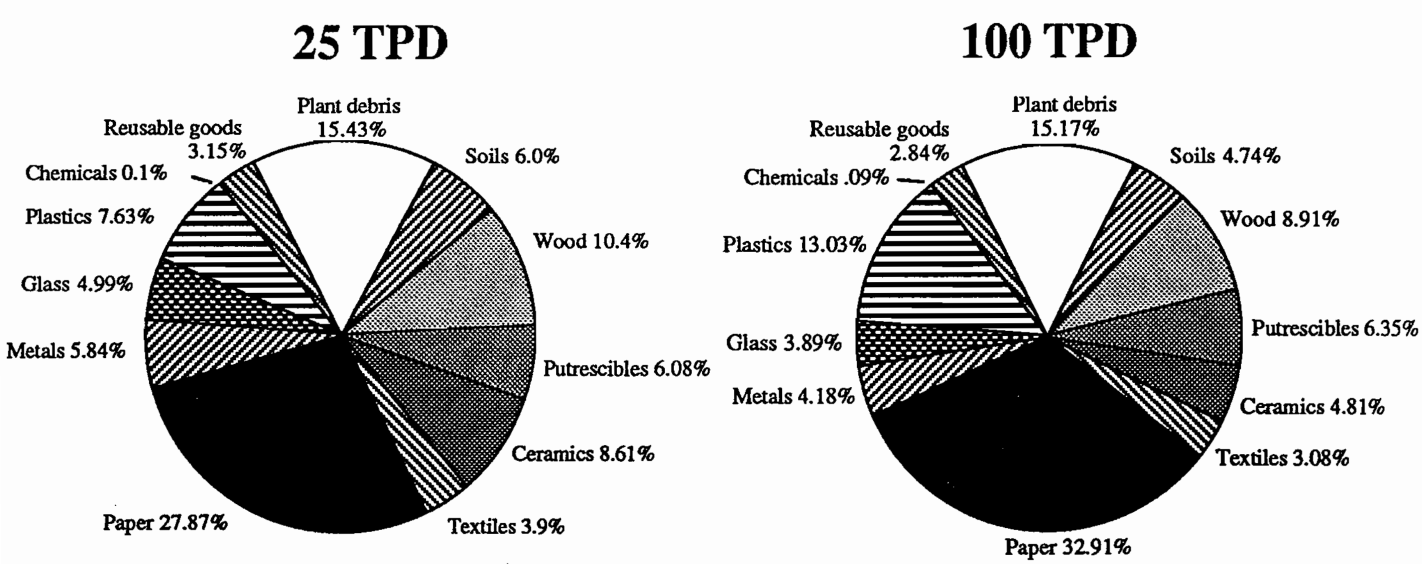


Illustration 6

Estimated Tonnage of 32 Materials Entering IRRFs

	25 tpd		100 tpd	
	tons	%of supply	tons	% of supply
Paper				
Newspaper	1.90	7.61%	7.59	7.59%
Magazines	0.42	1.67%	0.98	0.98%
Corrugated/brown bags	3.02	12.09%	15.75	15.75%
Office paper	0.72	2.89%	0.87	0.87%
Other - books, shredded, paperboards	0.88	3.61%	7.72	7.72%
Subtotal	**6.94**	**27.87%**	**32.91**	**32.91%**
Plastics				
Commercial plastics	1.36	5.45%	9.56	9.56%
PET containers	0.36	1.44%	0.72	0.72%
HDPE	0.16	0.65%	0.56	0.56%
Rubber	0.02	0.09%	2.19	2.19%
Subtotal	**1.91**	**7.63%**	**13.03**	**13.03%**
Putrescibles				
Food	1.10	4.39%	3.73	3.73%
Sludge	0.42	1.69%	2.62	2.62%
Subtotal	**1.52**	**6.08%**	**6.35**	**6.35%**
Textiles	**0.98**	**3.90%**	**3.08**	**3.08**
Metal				
Ferrous containers	0.83	3.32%	1.66	1.66%
Other ferrous	0.22	0.88%	1.51	1.51%
Aluminum cans	0.33	1.31%	0.76	0.76%
Aluminum foil	0.03	0.14%	0.16	0.16%
Other aluminum	0.04	0.18%	0.06	0.06%
Other nonferrous	0.01	0.03%	0.03	0.03%
Subtotal	**1.46**	**5.84%**	**4.17**	**4.1%**
Glass				
Clear containers	1.02	4.09%	0.96	0.96%
Amber containers	0.15	0.61%	0.27	0.27%
Green containers	0.02	0.06%	0.26	0.26%
Other	0.06	0.23%	2.40	2.40%
Subtotal	**1.25**	**4.99%**	**3.89**	**3.89**
Wood	**2.60**	**10.40%**	**8.91**	**8.91%**
Ceramics				
Brick/concrete/rock	2.15	8.60%	4.74	4.74%
Asphalt	0.02	0.07%	0.07	0.07%
Subtotal	**2.17**	**8.61%**	**4.81**	**4.81%**
Soil				
Dirt	1.31	5.24%	4.17	4.17%
Fines	0.19	0.76%	0.57	0.57%
Subtotal	**1.50**	**6.00%**	**4.74**	**4.74%**
Plant debris				
Leaves	1.94	7.76%	9.12	9.12%
Grass clippings	0.03	0.13%	0.76	0.76%
Brush/branches	1.88	7.54%	5.28	5.28%
Subtotal	**3.86**	**15.43%**	**15.17**	**15.17%**
Reusable goods	**0.79**	**3.15%**	**2.84**	**2.84%**
Chemicals	**0.03**	**0.10%**	**0.09**	**0.09%**
Totals	**25.00**	**100.00%**	**100.00**	**100.00%**

paper; glass and plastic bottles; and steel and aluminum cans.

Illustration 7 on page 20 shows how the 13% partially commingled materials break down by subcategory, and the negative effect that handling materials this way has on the supply of source-separated feedstock.

We now have the numerical basis to design the two facilities. Before going on to the designs themselves, however, we want to discuss briefly one important variable left out of our two-dimensional snapshot: time.

Neither our numbers nor the drawings can represent the rhythms common to receiving materials on a day-to-day basis. Material flows vary by volume and mix. There are little trucks that come in occasionally and big ones that may visit the dumpsite every day, even several times a day. There are haulers that make clean loads and haulers that mix everything up; both may believe they are saving time. There are rushes of disposal traffic in early morning, mid-day, and late afternoon. People empty trucks in the morning to prepare for their day's work; they dump at lunchtime because they can combine eating with driving; and they rush in madly during the last half-hour so they can start the next day with an empty truck.

There are variations within the week as well as within each month. On weekdays there are more contractors dumping loads of brush and construction materials, while on the weekends the homeowners and renters come out in force. There are also seasonal variations. A college town, for example, will see a lot of reusable goods at the end of each academic year as graduating seniors clean out their apartments.

Dumping is a social affair in most communities, mixing up all the classes, occupations, sexes, and specialties. Many customers like to talk about the things they are discarding. Operators should plan to spend time with their customers as they bring in their separated materials. It is all part of the competitive edge the IRRF can have over facilities that treat all materials – and people – as though they were the same.

Schematic Site Designs

The full-sized site designs enclosed in this report are two separate legal-sized sheets that should be laid out and referred to while reading this part of the report. For readers' convenience, however, we show reduced views of them here.

Similarities

Here are some general points to keep in mind about both site plans:

- Each has three distinct processing modules: reuse, recycling, and composting. They closely resemble those specified in the engineering drawings and subsequent writings by Drs. Diener and Martin.
- In the reuse module, goods are sold as is or are sorted, dismantled, and cleaned for scrap. In the recycling module, source-separated and some commingled materials are upgraded to serve as feedstocks for manufacturing new products. In the compost area, organic (carbon-based) and certain inorganic discards are turned into topsoil, sand, and gravel for landscaping, construction, and agriculture.
- Each module has a receiving area, a processing area, and a storage and sales area.
- Haulers may choose various tipping areas for the materials they bring to the IRRF. To preconfigure the sequence of unloading, they will load their trucks by stratifying different materials into a tipping order. Once inside the facility, they will be free to unload in whatever sequence makes sense to them, so long as they unload clean, separated materials that are acceptable to each operation. Frequent users will soon grow accustomed to the routine; infrequent users must be instructed by good educational materials distributed to the community, and by good signage onsite. Our experience shows that if people are informed about how to use the system, they will follow the requirements. They would rather conserve than waste, provided the system is easy to use.
- Each module's work area restricts access. Only site employees and experienced truckers are permitted. This restriction keeps machinery, equipment, and big trucks away from customer areas, making the operation more efficient and safer. Safety must be an underlying theme not only in IRRF design, but also in operation, since the public will be using many parts of the facility. A facility that is designed and run with the public in mind can experience a very good safety record with few accidents involving employees or the public. Clear signage to direct the public is important, and if site managers and staff set a tone of careful alertness and con-

Illustration 7

Supply of Source-Separated and Partially Commingled Feedstocks, 100 tpd IRRF

	Source-Separated		Partially Commingled	
	tpd	% of category	tpd	% of category
Paper				
Newspaper	1.90	25%	5.69	75%
Magazines	0.24	25%	0.73	75%
Corrugated/brown bags	14.17	90%	1.57	10%
Office paper	0.87	100%	0.00	0%
Other - books, shredded, paperboards	5.17	67%	2.55	33%
Subtotal	**22.36**		**10.55**	
Plastics				
Commercial plastics	9.56	100%	0.00	0%
PET containers	0.18	25%	0.54	75%
HDPE	0.28	50%	0.28	50%
Rubber	2.19	100%	0.00	0%
Subtotal	**12.21**		**0.82**	
Putrescibles				
Food	3.73	100%	0.00	0%
Sludge	2.62	100%	0.00	0%
Subtotal	**6.35**		**0.00**	
Textiles	**3.08**	**100%**	**0.00**	**0%**
Metal				
Ferrous containers	0.83	50%	0.83	50%
Other ferrous	1.51	100%	0.00	0%
Aluminum cans	0.68	90%	0.08	10%
Aluminum foil	0.12	75%	0.04	25%
Other aluminum	0.06	100%	0.00	0%
Other nonferrous	0.03	100%	0.00	0%
Subtotal	**3.23**		**0.94**	
Glass				
Clear containers	0.24	25%	0.72	75%
Amber containers	0.07	25%	0.20	75%
Green containers	0.07	25%	0.20	75%
Other	2.40	100%	0.00	0%
Subtotal	**2.77**		**1.12**	
Wood	**8.91**	**100%**	**0.00**	**0%**
Ceramics				
Brick/concrete/rock	4.74	100%	0.00	0%
Asphalt	0.07	100%	0.00	0%
Subtotal	**4.81**		**0.00**	
Soil				
Dirt	4.17	100%	0.00	0%
Fines	0.57	100%	0.00	0%
Subtotal	**4.74**		**0.00**	
Plant debris				
Leaves	9.12	100%	0.00	0%
Grass clippings	0.76	100%	0.00	0%
Brush/branches	5.28	100%	0.00	0%
Subtotal	**15.17**		**0.00**	
Reusable goods	**2.84**	**100%**	**0.00**	**0%**
Chemicals	**0.09**	**100%**	**0.00**	**0%**
Totals	**86.57**	**86.57%**	**13.43**	**13.43%**

fident safety, users will tend to follow.

• Postconsumer recyclables are collected from the public in small, uncovered three-yard bins at both sites. As the small bins fill, forklift operators replace them with empties and take the full bins to storage or processing areas. The forklifts are equipped with rotating heads so they can dump the bins. Primary reasons for small bins are to allow more different types of material to be collected, to make it easier to detect and remove contaminants from small loads before the problem becomes large.

• Both designs assume that a complete materials recovery system has been installed on a single site, and all elements of the system are up and running simultaneously. But in a real application, it may be easier and more efficient to build the system in phases using several sites. This kind of development would allow a community to incorporate existing businesses into the system. Also, some materials could be received, processed, stored, and sold on separate sites.

• While it might appear that three operators will be needed for the three modules, our experience suggests there could be more. For example, all or part of the IRRF site could be owned by a single entity such as a Solid Waste Authority, which could then lease different parts to specialized operators. This structure could generate substantial income from rents and revenue sharing and would maximize flexibility, recovery, and total income by using specialists, externalizing operational problems, and setting up public-private partnerships.

• Although these drawings are more realistic than the Diener/Martin drawings because they show various kinds of trucks; a configuration of buildings and paved areas; and equipment hard at work processing materials; they are still highly conceptual and abstract. Also, some parts of the processing system are still undergoing active testing and development, as reported in professional literature.

• There is no refuse area. Our assumption is that if operators are carefully chosen, there will be very little unrecyclable residue – on the order of 1% to 3% per enterprise. Zero residues are possible for some operations, although they increase with commingling. One way different operators will achieve low residues is by supplying scrap to other operators. We assume that this facility will dump unrecyclable residue using existing permitted landfill capacity in the same way as any other organization, and that it will pay the going rate for refuse disposal.

All or part of the IRRF site could be owned by a single entity such as a Solid Waste Authority, which could then lease different parts to specialized operators.

• Since Integrated Resource Recovery Facilities compete with refuse facilities, both for tipping fees and for supplies of materials, legislative support for the IRRF includes requiring mixed-waste disposal to be priced at its full cost, including its environmental and opportunity costs. Subsidies for mixed-waste disposal should be identified, then minimized or eliminated.

Differences

Although the two sites have many similarities, there are some important differences.

• The 100 tpd IRRF's recycling module has a buyback facility for paper, containers, and other recyclables, but the rural IRRF does not. It may be that some rural IRRFs can support a buyback or curbside operation, but we show only the self-haul or dropoff mode. Keep in mind that buyback competes with curbside, although both are probably necessary to achieve high diversion rates. Dropoff is more efficient with low-value commodities because it externalizes labor costs.

• Reuse areas at the two IRRFs treat building materials differently. In one, they are placed under the same roof as other merchandise. In the other, they are arranged in an open yard, with precipitation-sensitive items such as wood windows and doors stored in covered racks.

• The compost receiving and primary processing areas are similar, but the two sites have very different storage, windrowing, and pickup procedures for soil products. In part this is simply to illustrate that two technologies are possible. But this division also shows how the two kinds of site could cooperate to process materials. For example, the higher price and limited availability of urban land may not permit large enough sites to do the land-intensive windrowing called for in the 25 tpd IRRF.

- This difference suggests opportunities for trade between West Virginia's towns and cities. Urban IRRFs could send compost feedstocks and processing fees to rural IRRFs, as well as finished goods and excess reuse items. The rural IRRFs could manufacture soil products for agriculture to grow products to be sold back in the city. Some soil products could also be sold in bulk or in bags to the cities as custom topsoils. Truckers that haul the organics out to the country for composting could return with loads of bagged or bulk soil amendments, or scrap such as baled paper, shredded tires, or metals. This kind of trade would produce a revenue stream both ways, strengthening the economy, particularly the trucking industry.

On the subject of rural recycling, consultant Gretchen Brewer has reported that Pierce County, Wisconsin, a hilly county of 34,000 people in the northwest corner of the state, has achieved 20% recycling five years after startup. The heart of their system is an 8.5 tpd materials recovery facility handling only source-separated materials. Capital costs for the facility (which would be called a recycling module in IRRF terms) were only $120,000. We include Ms. Brewer's article, first published in January, 1994, in *Resource Recycling* magazine, as Appendix E of this report.

A Guided Tour

All traffic enters at the bottom of the site diagrams. At the entrance, visible across the road as people enter, there is a turnout with a large sign telling customers where different parts of the operation are and what they do. Literature about various recycling and reuse options is also available here. Some facilities may wish to use interactive video terminals to show customers how to take advantage of the various opportunities to recycle.

Small vehicles will turn left or right upon entering the facility.

Curbside trucks enter straight ahead through an electric gate. Large trucks picking up bulk materials will have the option to enter through the electric gate, or they may drive around either side of the site to reach another gate at the back side. Immediately inside this upper gate, a scale and scalehouse is provided for weighing trucks either empty or full.

Truckers that haul the organics out to the country for composting could return with loads of bagged or bulk soil amendments, or scrap such as baled paper, shredded tires, or metals.

At the 100 tpd facility, curbside trucks unload by backing into areas designated either for paper or containers. The 25 tpd IRRF does not provide this specialized unloading area. Forklifts pull the bins of source-separated materials from the curbside trucks and either stack them, dump them into larger containers, or feed them directly into processing hoppers. Negative sort lines are provided in the 100 tpd IRRF for lightly commingled containers or paper feedstocks brought in by the curbside trucks. Posting small portable scales near where small bins are unloaded will make it possible to measure the individual contribution of dropoff, curbside, and buyback operations to overall tonnage and sales revenue for the recycle facility. Baled materials ready for hauling to brokers or end users will be stacked. Shredded or crushed upgraded materials will be stored in larger boxes as appropriate.

To the right at the entrance, each IRRF has a reuse facility with two docks where different kinds of reusable goods can be unloaded. All vehicles that turn right will pass these docks on their left, which will be identified by signs. The first dock handles large scrap items such as appliances, as well as a variety of household and office goods. The second specializes in building materials. Most haulers that have reuse items will put reusable goods on top of or at the back of their loads, so if they have reusable goods, one or both of these docks will be their first stop. People who have come to shop for building materials or other reuse items will park near the pedestrian entrance to the reuse retail facility.

Just past the reuse area on the left is a service bay for repair and maintenance of site equipment.

After the service bay, vehicles delivering sewage sludge or picking up compost will go straight to the two areas. Other vehicles will turn left after the service bay, and the putrescibles area will then be on their right. Trucks that haul putrescibles will be carrying them in covered bins, which will be loaded or unloaded by forklift.

After the putrescibles area is a ramped-up tipping platform for plant debris, logs, stumps, pallets, lumber, and other wood. It includes an area for purchasing firewood. The tipping and parking areas are followed by a sales office and information area where people can pay tipping fees or buy bulk materials such as soil amendments, soils, or sand and gravel products.

After the sales office, vehicles may turn right or left. They may turn right to go to the tipping areas for soils and ceramics, or to the gravel sales bunkers. They may turn left to go to the recycling area or the exit.

To the left at the entrance in the 100 tpd IRRF, all vehicles drive past the information station and office and turn right to pass the recycling area on their right, which will be posted with signs that identify each unloading station. If customers have high grade materials prepared correctly, they will find the first option is to stop at a buyback facility and be paid for certain postconsumer packaging and paper. Alternatively, they may continue on to a dropoff facility, which will receive the same materials as well as lower grades. Depending on markets, some commodities may be accepted free for dropoff or may be charged a tipping service fee.

The 25 tpd IRRF has only a dropoff facility and not a buyback, but it might still charge tipping fees as necessary and will collect the same basic categories.

To the customer, the recycling area will appear as a long line of small, low bins under a long roof. As the small bins fill, forklift operators will replace them with empties. Signage will identify each unloading station. Bins will have removable signs identifying their contents.

The first material taken at the dropoff area is textiles. Then come papers, with one bin each for corrugated cardboard and kraft paper; mixed paper; office and computer paper; newsprint; and magazines. Next are bins for seven kinds of source-separated containers: steel cans; aluminum cans; two kinds of rigid plastics; and three colors of glass. Some bins are also provided for mixed glass and ceramics that will be ground into general-purpose sand. Reusable glass containers could also be collected in this area.

Many ... haulers will be carrying stratified loads of two or more of these materials.

Vehicles may also bypass the recycling area to go to the areas for soil, ceramics, wood, or plant debris. Many such haulers will be carrying stratified loads of two or more of these materials. If they proceed straight ahead after passing the dropoff, they will be able to unload their soils or ceramic materials at opposite ends of the ramped-up tipping area. If there is a wood component to any of the loads of soil or ceramics, it can be discarded by making the first stop at the wood unloading area.

Some traffic will pass the soils and ceramics tipping area to pick up bulk sand and gravel products, or various soil products such as topsoil, amended soils, or fill dirt.

Customers with chemicals, batteries, and oil will probably bring their supplies in with other materials, because chemicals are usually discarded in small quantities. After making other stops on the site, haulers can take their residual chemicals to the appropriate receiving area and unload them there. We expect this operation may also receive supplies of chemicals generated onsite from the operators' cleaning and sorting procedures. For example, the chemical-site operator may be able to handle the compressor oils and CFCs from the refrigerant removal program at the reuse dock.

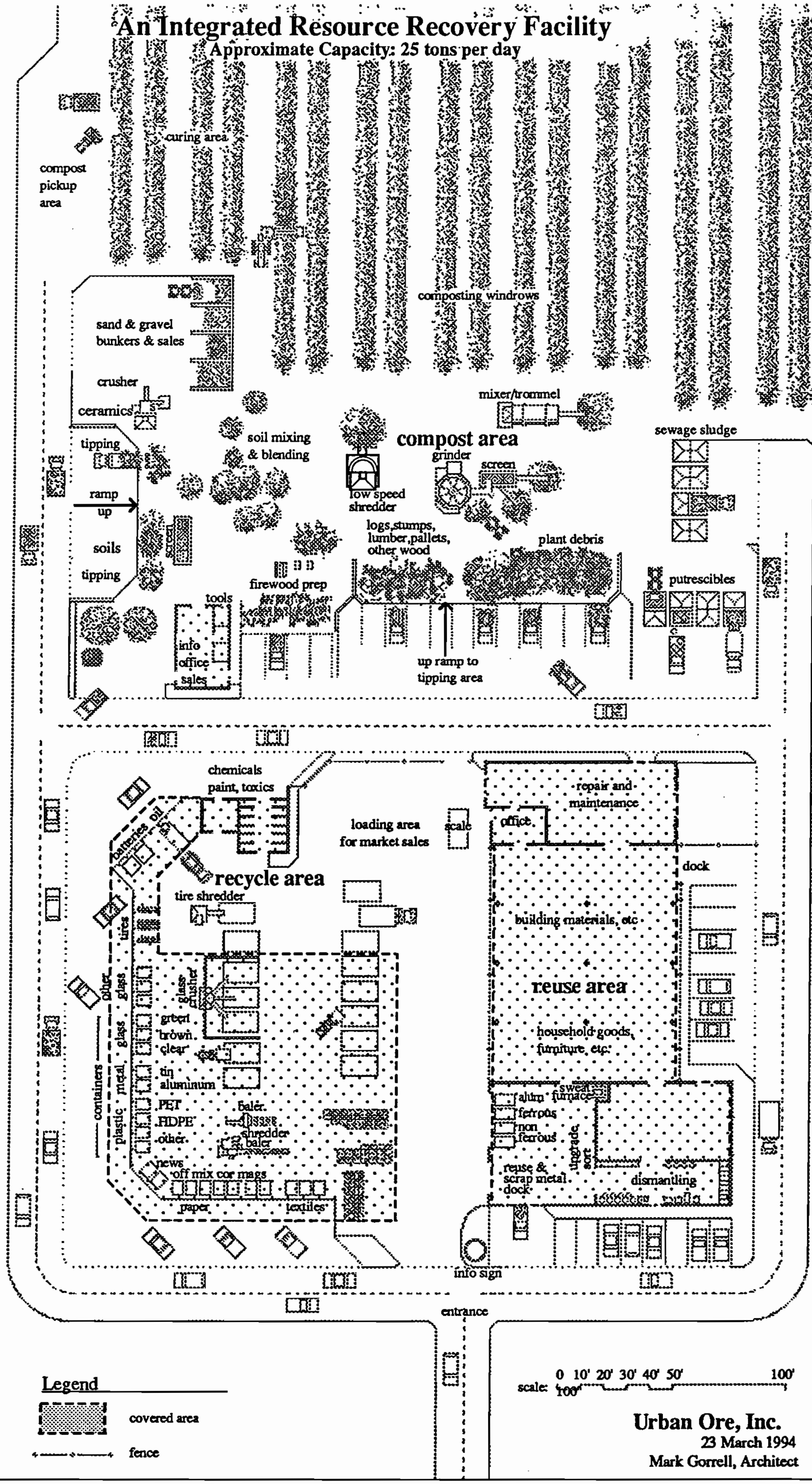
Drivers with no further business will exit the site by either completing the circle or going back the way they came in. Either way, they will be exposed to other tipping options than the ones they used, so signage should be designed to send messages to traffic from both directions.

How materials are handled

Each of the twelve master categories is handled on the sites.

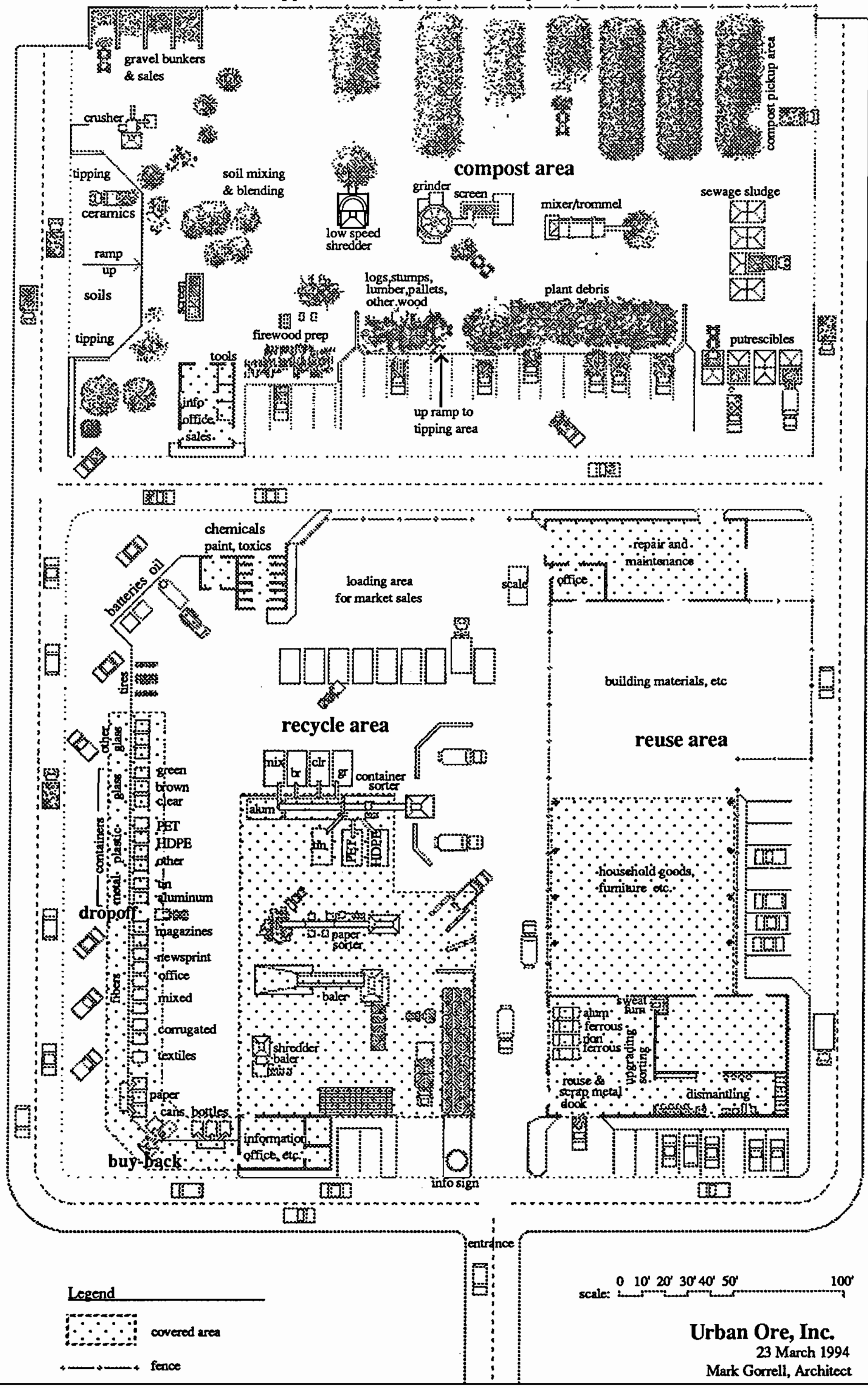
Reusable goods. After reuse loads are purchased, traded, or dropped off for no charge, they are sorted, priced and put out on the retail sales floors. Reuse items that prove unsalable are taken to the scrap cleaning and dismantling area where they are separated into their recyclable parts. The scrap is stored until there are marketable quantities, then hauled to other areas on the IRRF site or to processors. Primary categories of scrap from the reuse facility are wood, glass, ceramics, metals, textiles, and paper. Most types of scrap generated in the reuse area may be disposed of at other IRRF operations.

Plant debris. Live plants can be unloaded at the reuse area, or


An Integrated Resource Recovery Facility
Approximate Capacity: 25 tons per day
curing area
compost pickup area
composting windrows
sand & gravel bunkers & sales
crusher
ceramics
mixer/trommel
sewage sludge
tipping
soil mixing & blending
compost area
grinder
screen
low speed shredder
ramp up
soils tipping
logs,stumps, lumber,pallets, other wood
plant debris
firewood prep
putrescibles
tools
info office sales
up ramp to tipping area
chemicals paint, toxics
loading area for market sales
scale
office
repair and maintenance
batteries oil
recycle area
tire shredder
dock
building materials, etc
reuse area
household goods, furniture, etc.
glass crusher
green
brown
clear
tin
aluminum
PET
HDPE
other
baler
shredder
baler
news
off mix cor mags
paper
textiles
containers
plastic
metal
glass
other
glass
tires
alum
sweat furnace
ferrous
non ferrous
upgrade sort
reuse & scrap metal dock
dismantling
info sign
entrance
Legend
covered area
fence
scale: 0 10' 20' 30' 40' 50' 100'
Urban Ore, Inc.
23 March 1994
Mark Gorrell, Architect

An Integrated Resource Recovery Facility

Approximate Capacity: 100 tons per day

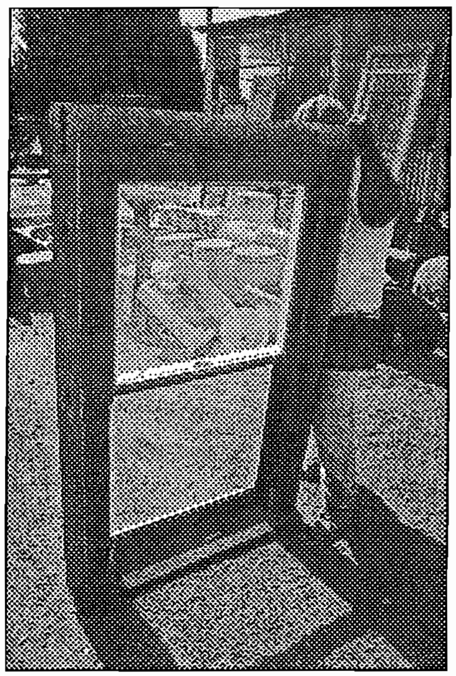


Urban Ore, Inc.
23 March 1994
Mark Gorrell, Architect

set aside at the plant debris tipping area for later pickup by staff from the reuse site. Brush, tree trimmings, and weeds are taken to the compost area. Vehicles back up a low ramp and dump about 3-4 feet down onto a hardened processing floor. The loader operator below uses the vertical tipping face as a pushwall when picking up materials. Large limbs are taken to the firewood area to be cut up into salable lengths. Green material is either shredded or, if space permits, allowed to dry somewhat to facilitate processing. Shredded plant debris is screened immediately into fines and overs. The fine particles that make it through the screen ("fines") are sold as-is or used as soil-blending feedstock. The oversized particles ("overs") are used as a bulking agent in mixtures for composting.

Wood. Wood items that are in a reusable form, such as lumber, plywood, moldings and trim, doors, cabinets, siding, and flooring are dropped off or sold at the building materials part of the reuse area. Alternatively, they may be set aside near the wood-debris tipping area for later pickup by the reuse area crew. Unsalable wood is dumped near the plant-debris tipping platform. Larger pieces are cut into firewood lengths, then split and put into transportable ricks for later sale. Wood that is not suitable for firewood or reuse is shredded, either with plant debris or by itself. Depending on the equipment used, some wood that is shredded separately may be suitable for sale as feedstock for manufacturing chipboard or other products. Shredded wood is screened immediately; the fines are sold as-is or are used in soil blends. The overs are used as a bulking agent in composting, either alone or blended with plant-debris overs. Special handling procedures will be probably be needed for wood that is painted or has been treated with preservatives. The site operator must investigate regulatory requirements.

Ceramics. Common forms of ceramics include stone, china, tile, brick, cement, and asphalt. Reusable ceramic objects such as porcelain sinks, dishes, roof tile,



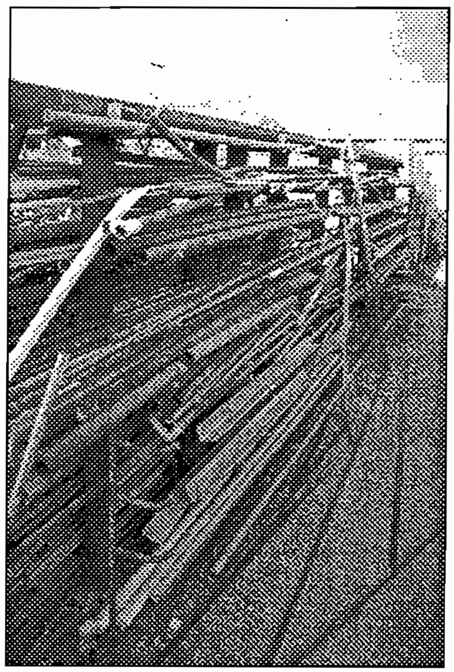
cement blocks, and bricks are delivered to the appropriate dock at the reuse area. Nonreusable ceramics are dumped near soils, off a low wall onto a hardened processing floor. Anything reusable dumped here and not damaged in the tipping can be set aside for pickup or delivery to the reuse area. All nonreusable materials are run through a crusher, either separately to produce colored gravels for landscape use, or together to produce a grey gravel for construction. Other products from the crusher are sand and fine rock powder, which can be blended into compost to make a heavier, more mineralized type of soil. Another product that may be handled at this station is gypsum wallboard (sheetrock). Some of this material can be blended into soils or compost feedstocks, because sheetrock is paper bonded to calcium carbonate, a standard agricultural nutrient.

Soils. Soils are received near ceramics at a separate tipping ramp. An issue that should be decided at the design stage is whether to take soils contaminated with organic chemicals or metals. If soils contaminated with metals will be taken, separate handling procedures will probably be required, because these are mixed materials, and they must be unmixed to be used. Simple screening may work. Nonhazardous soils can be blended, screened, then either sold as-is by the cubic yard or ton, or blended with compost to produce a heavier, more mineralized product closer than unblended plant-debris compost to being topsoil. Hazardous soils may be sent to a bioremediation contractor, if there are any, or otherwise handled as regulatory agencies require.

Putrescibles. Putrescibles are delivered to the site in special covered bins. They are different from other discard supply streams by having high water content and high nutrient levels. Most putrescibles must be processed very speedily to avoid the onset of anaerobic (no oxygen) decomposition, which produces extremely offensive odors and flammable or explosive gases. There are two major incoming substreams: 1) sludges and manures, and 2) food, food trimmings, grease, and food-contaminated paper such as napkins or unrecyclable cardboard. Mixing unrecyclable paper with food residues during collection reduces liquidity and prepares the paper for rapid digestion in the composting process. Plant debris and wood chips are blended with putrescibles in a batch plant, which we have symbolized here as a mixer/trommel but which may take different forms. Then they are windrowed (placed into elongated piles) for composting using high levels of heat. To control odors that may be generated by this feedstock, industry practices include regulating the blending carefully to disperse the putrescibles among other materials higher in carbon, thus achieving optimal ratios of carbon to nitrogen; mixing with bulking agents that allow air to circuluate through the pile; pulling air into the windrows using fans (negative pressure aeration); and blowing the effluent air through a "biofilter" to reduce odor. Many communities may want the facility to contain the processing inside a building.

Paper. Books, magazines, photographs, and "rare paper" that can be sold as-is are dropped off or sold at the reuse area. Paper with no reuse value is received and processed in the recycling area. It may be purchased through the buyback, given away at the dropoff bins, or delivered to the site by curbside trucks or debris boxes whose costs are paid by service fees. Low grades such as mixed paper will probably be dropped off or picked up at curbside rather than purchased at the buyback. Although paper can be sorted into as many as fifty grades to meet the very tight specifications of different end-users, we provide separate bins for only five grades. In spite of the relatively coarse sort, operators who want to maximize income will still need to be very careful to deliver a consistent, clean product. The primary use for the IRRF's paper products will be for fiber reclamation. For off-spec paper, both IRRFs have shredder balers that may be used to make animal bedding or to prepare the paper for co-composting with putrescibles.

Metals. Most metal objects



that are reusable should be dropped off or sold at the reuse area, at either dock depending on the form. A gas stove in good condition would be taken at the household goods dock, while angle iron or lengths of pipe would be handled in the building materials area. Other nonreusable scrap metals unloaded at the reuse area dock are separated initially into refrigerated appliances, ferrous and nonferrous scrap, and container scrap. Refrigerants, compressor oils, and PCBs (if any) are removed, and the refrigerated appliances are further dismantled to recover ferrous and nonferrous components. Other large scrap items are cleaned or dismantled to remove contaminants; size-reduced by cutting, crushing, or melting; then stored in bins or carts for sale to brokers. Container metals such as steel and aluminum cans may be purchased, donated, or picked up at curbside, but they are processed in the recycling area. Lightly contaminated materials can be run through the negative sort line. Densification may be achieved by shredding, briquetting, or baling; we show an all-purpose baler in both site designs.

Glass. Reusable glass such as metal- and wood-frame windows are unloaded at the building materials site. Light fixtures, glass-fronted cabinets, glass cookware, and similar reuse items would be taken to the household goods dock. Container glass is handled at the recycling area. Glass bottles enter the site either through the buyback, the dropoff area, or in collection bins carried by curbside trucks, which may be equipped with side- or rear-dumping features. Forklifts with rotating heads empty small bins into accumulation bins or bunkers. Reusable bottles, if any, are aggregated in wooden boxes. A negative-sort line is provided in the 100 tpd IRRF for commingled or slightly contaminated loads. A sustantial part of the product stream will be color-sorted; some will be mixed. The color-sorted glass will be sold for remelt. The mixed-color glass may be remelted to produce new products such as tiles, or turned into general-purpose sand.

Textiles. Reusable textiles, primarily clothing, may be sold or traded at the household goods dock. Clean textiles suitable for fiber reclamation or for manufacturing into rags or wiping cloths are collected at the dropoff area. Textiles could also be purchased as part of the buyback operation. Curbside collection for textiles is in the experimental stage in some parts of the country. Textiles may be hauled to market either loose or baled.

Plastics. Durable and reusable plastic products such as audio tapes, computers, toys, or pipe would be taken to the reuse area for sale as-is. Recyclable categories of plastic such as rubber tires, certain types of rigid containers, or certain kinds of films are received in the dropoff and buyback portions of the recycling facility. Densification methods that have been used include baling and shredding. We assume the plastics taken by these IRRFs will be baled, with or without shredding. Care must be taken not to let plastics contaminate any of the compost feedstock, because they are very difficult to remove and severely reduce the compost's marketability. Since plastics recycling is still in the formative, expensive, and experimental stages for many forms of plastics, some communities may want to consider bans on certain plastic products as the best near-term way to reduce litter, slow the rate of landfilling, and increase recycling.

Chemicals. A separate station is provided for elements and compounds that would be hazardous if released into the environment. From our experience in the industry, regulated chemicals that the site will likely deal with include paints, oils, chlorofluorocarbons (in refrigerated appliances), encapsulated mercury (in switches and batteries), and encapsulated PCBs (in fluorescent lighting and some appliances). Other subcategories could include solvents, pesticides and herbicides, caustic cleaners, and antifreeze. For the bulk of these materials, the current preferred disposal technology appears to be reuse, either as-is or after cleanup. Some materials such as batteries and used oil are aggregated in special containers, then picked up by reclaimers. Paints in good containers with good labels can be taken to the reuse facility where they are sold as-is or given away. Small quantities of material for which there are no reuse or recycling markets will be stored in a specially designed facility until packaged for approved disposal as hazardous waste. The primary purpose is to keep these chemicals separate and protected until they can be taken offsite for processing. Federal, state, and county governments may have existing specifications for structures such as the one we suggest. Our industry observations suggest that state-of-the-art design includes heavy masonry walls, an open top, and gutters and drains in the floor for collecting spills. We do not show bunkers, however. Special containment barrels and boxes can be purchased for collecting small flows of material.

Money will flow according to the highest and best use of the materials. For the highest-grade materials ... money will flow from the IRRF to the supplier ... For the lowest-grade materials ... the IRRF will charge suppliers a tipping service fee.

The Flow of Money

Money will flow according to the highest and best use of the materials. For the highest-grade materials such as reusables, money will flow from the IRRF to the supplier. For lower-grade materials, IRRF operators will receive supplies free but will not pay. For the lowest-grade materials that require more investment in processing than selling the materials will cover, the IRRF will charge suppliers a tipping service fee.

At the reuse area, various appliances may be taken for a fee to pay for processing to screen the inventory for usability, and for unusable appliances, to remove chemicals such as refrigerants and compressor oils. Putrescibles, soils, ceramics, wood, and plant debris will all be accepted in exchange for various disposal service fees that will reflect the cost of processing and handling. Fees will probably also be necessary in the chemical and hazardous materials receiving area, and to support tire reclamation.

Most reusable items, on the other hand, will be purchased, along with certain higher grades of container scrap and paper at the buyback. Materials with product disposal charges such as legislated deposits may also be redeemed for cash.

Most of the materials accepted free will be taken at the dropoff facility in the recycling area. As an additional service to haulers, individual operators may accept small quantities of material that are processed elsewhere on the site.

Our site designs do not show placement of cash registers, but this is an additional variable that should be thought out carefully in the design of an actual IRRF.

Additional improvements

Some or all of these IRRFs may find it necessary to construct an additional building onsite to house portions of the composting operation devoted to digesting mixtures of putrescibles and plant debris. Dr. Diener has provided specifications and drawings for an inexpensive structure that would probably work well and could be sized to handle incoming supply streams of any size. These drawings and specifications are attached as Appendix E of this report, along with several other valuable technical papers by Dr. Diener and his colleagues at West Virginia University. A deluxe version of the building recommended by Dr. Diener would have its air channels formed into the concrete slab so that negative-pressure aeration could facilitate frequent turning. Cheaper versions would use a solid concrete slab, but the operator would have to lay out plastic perforated hoses that would be destroyed and would have to be disposed of after each compost cycle. The machinery for pumping air through the windrows, and the biofilters used to scrub the exiting gases would be outside the building.

Depending on proximity to a landfill, IRRF developers may want to build a specialized refuse handling facility that aggregates mixed unrecyclable materials for highway transport. We recommend a flat-floor design to permit salvaging.

Financial Projections

Our treatment of IRRF finances is necessarily brief, for reasons covered in the first part of this report. To summarize: we don't have a real site to design and price for; we don't have a real locality; we don't know who will develop the facility and exactly what equipment they will want or how they plan to hire; we don't know what firms or operations already exist.

Our goal in this part of the exercise is only to show interested parties how to begin thinking about the IRRF in financial terms. This is not a real plan for a specific facility or even part of a facility, it cannot accurately predict any specific site's performance, and it does not deal with crucial variables such as how or where financing may be found.

Since the finances of an IRRF could theoretically approach the compexity of the average shopping mall (in terms of the number of niche operators, for example), we wish to emphasize again that there is no substitute for people thinking this type of development through on their own, using their own concrete situation as the source of their data. To facilitate this type of thinking, we include a set of blank forms.

To all the potential IRRF developers, we say: if you don't like our numbers, put in some of your own. If you can't compete with the garbage manufacturing industry on the grand scale we envision, start a smaller piece of it that you most would like to run. That's what we did, and fourteen years later we're still growing.

Our financial discussion consists of three parts. Each part is a series of spreadsheets. **All the spreadsheets are at the end of the report's text and notes, beginning at page 36.**

The first series identifies and estimates some component costs that we used to construct the other spreadsheets. The second one profiles the overall startup costs for the three recovery clusters. The third summarizes the IRRF's financial performance for one year of operations, amortizing startup costs over twenty years and picking an imaginary year that is about ten years after startup with all systems in place and functioning, and selling materials for something like today's prices.

Component Costs

Robert Diener supplied some of the estimates for land and construction costs, but we also relied heavily on Mark Gorrell, a practicing architect who recently designed and supervised construction of a one-million dollar expansion of Berkeley's recycling transfer facility. A site plan of that facility, which is real and operating in 1995, is included as Appendix G.

We used our industry experience with wages, taxes, and benefits. We feel that highly motivated workers who are well-paid are important to the success of such a labor- and knowledge-intensive activity as materials recovery. Many unit costs for the reuse site are also derived from our industry experience. Dr. Diener and Michael Casady of Urban Ore supplied most of the figures used in the compost site equipment estimates, while Kathy Evans and Gretchen Brewer contributed to the list for the recycling area.

We recognize that there may be many opportunities to reduce these costs by renting or leasing land and buildings rather than building them from scratch, and by using or adapting equipment already present in the community. Designing and building recycling equipment has already become a major industry on its own right, as a glance at the advertisements in any of the major trade magazines will show. We have also noticed a tendency for certain real estate and insurance professionals to develop expertise in providing services to reuse and recycling as our industry has grown. Other professionals may soon specialize, too.

As a state known far and wide for its mining experience and expertise, West Virginia may be in a position to profit greatly from the national and international growth of recycling, simply by adapting and redeveloping sites and recovery technologies left over from the mining culture of the past. Innovative uses for old but still serviceable sites and equipment can be tested in local laboratories all over the state. Anywhere an IRRF is under development, the potential exists for testing, developing, and manufacturing new kinds of equipment that people with mining knowledge may adapt or invent.

Startup Costs

This set of spreadsheets shows that the capital requirements for IRRFS are quite modest. The compost site is most expensive in equipment costs, but the least expensive in buildings and paved areas. This investment could be most effectively used by trading with the urban areas as suggested earlier. This kind of trading, however, is not shown on these sheets.

Reuse is most expensive in building and paving costs and cheapest in equipment cost. Interestingly, each of the three modules ends up costing similar amounts, with reuse cheapest.

As a state known far and wide for its mining experience and expertise, West Virginia may be in a position to profit greatly from the national and international growth of recycling.

Most of the upfront expense is site acquisition and buildings; equipment costs are very low for the tonnage handled. Simply by leasing un- or under-used space and adapting it for this purpose, the upfront capital expense we show may be translated into even more affordable monthly rent payments rather than a loan or an infusion of cash. The problem is that there is no equity in such an arrangement, but startup businesses sacrifice equity for timing all the time.

Although a price comparison is beyond the scope of this report, it appears that low upfront cost could help the IRRF compete very effectively with other discard management technologies that may be under consideration. Low facility cost expressed as reasonable rent or amortized payments over a realistic and customary time frame can greatly enhance an operator's ability to pull in the available supply. The instrument they may use is competitive tipping fees, tied to the cost structure typical of the material supplied. Our price estimates are very general, but they are based on our industry experience in our area. From talking with West Virginia residents, we have formed the impression that the fee for disposing of materials treated as wastes is about $50 per ton in West Virginia. This is not so different from here, leading us to believe that the fees we show are competitive. Raising them will tend to cut supply and increase profit. Lowering them will tend to increase supply, but whether profits fall depends on the level of decrease.

Haulers who bring in clean loads of materials, even those that require considerable processing to bring to marketability, will then be rewarded by cash or at least by lower overall disposal expense. Cash in the pocket is also cash that can be spent to get rid of any residual. Many haulers will come who hope only to achieve zero cash out for the disposal service provided. Their reward is an empty truck, ready for the next payload.

One of the direct benefits of such a facility will be to pump money into what might be called the local micro-trucking industry: the people who make part or all of their living from truck ownership. Since this is a local industry, shifting revenue in this direction will tend to keep disposal money cycling in the local economy.

The only technology that may be competitive with the IRRF in terms of upfront cost is transfer with railhaul to a distant mega-landfill, but the problem with railhaul is that the resources are destroyed by mixing and burial, and there is no cash return, only cash outlay. Since the companies participating in railhaul tend to be the large multinational waste companies, much of the money devoted to railhaul is also exported from the local economy to corporate headquarters, wherever that may be. Also, there is a long-term potential liability to railhaul that does not exist with an IRRF. Finally, railhaul succeeds by using a collection technology that has already been rendered obsolete and uncompetitive. Tying a Solid Waste Authority's credit to railhaul facilities when the courts are strking down flow control protections for uncompetitive waste management technologies is probably quite risky. The IRRF is a much more conservative financial approach in a period of changing technologies.

One Year of Income and Expenses

This last series of spreadsheets provides a summary of the income and expenses for the two IRRFs. Essentially, it is the type of statement that in business is called a profit and loss report.

The basic idea is to summarize and state all sources of income on the top half of each spreadsheet, and all expense accounts on the bottom. The difference between the two is the profit or (loss) – a loss is shown numerically in parentheses. The goal of every business, no matter what the ownership structure, must be to show a profit. Businesses can survive losses in the short term, but not on a sustained basis. Since the IRRF is a business, or a collection of businesses, its overall goal is to show a profit.

The form of each of these spreadsheets reflects aspects of business functioning that we have experienced as an operating company in this field. Urban Ore makes or has made income both from charging tipping fees and from selling products. We have ourselves collected and sold many of the commodities listed here. Our focus is on selling reusables, but we also process and sell scrap to a variety of markets. We charge fees to take some things. We buy some things. We also operate in an economic context that includes several other specialized businesses that we communicate with regarding trends, tonnages, and prices.

The effect of the IRRF over time will be gradually to upgrade the resources by shifting them to higher and better uses. ... As this happens, the financial performance of the IRRFs improves.

However, this does not mean that our price estimates are immediately transferable to West Virginia, just that we think our prices are somewhere in the ballpark. A real set of prices would have to be compiled as part of a full-blown business planning process.

In constructing the spreadsheets that model the financial performance of the two IRRFs, we debated whether to use the composition figures straight from Illustration 6, or to modify them in the light of our industry experience. There were two issues: first, it is unlikely that any IRRF will spring fully to life, successfully capturing all tonnage represented by composition studies done before the IRRF is built. It is more likely that the IRRF will grow incrementally. Second, any part of the IRRF that is built will change the composition of the rest of the discard supply.

If planners follow Dr. Diener's recommendations, for example, the composting side of the IRRF will be built first. This will tend to pull materials out of the recycling and even the reuse side into the compost side, since many recyclables and reusables can be composted. On the other hand, if the reuse side is built first, materials that otherwise might be handled in the recycling or compost area will start showing up as reusables, and the supply available to recycling and composting will diminish.

In the end, we decided to model the IRRF's performance as it might appear about ten years after initial development. We adjusted the composition figures obtained from the landfill composition studies to show what might be called "the IRRF effect," a slow but inexorable shift of resources up the hierarchy of value.

As this shift occurs, the financial performance of the IRRF can be expected to improve. Besides increasing income for the operators, the local community will be a big beneficiary because reuse, which will gain tonnage at the expense of recycling and composting, has markets that are almost entirely local.

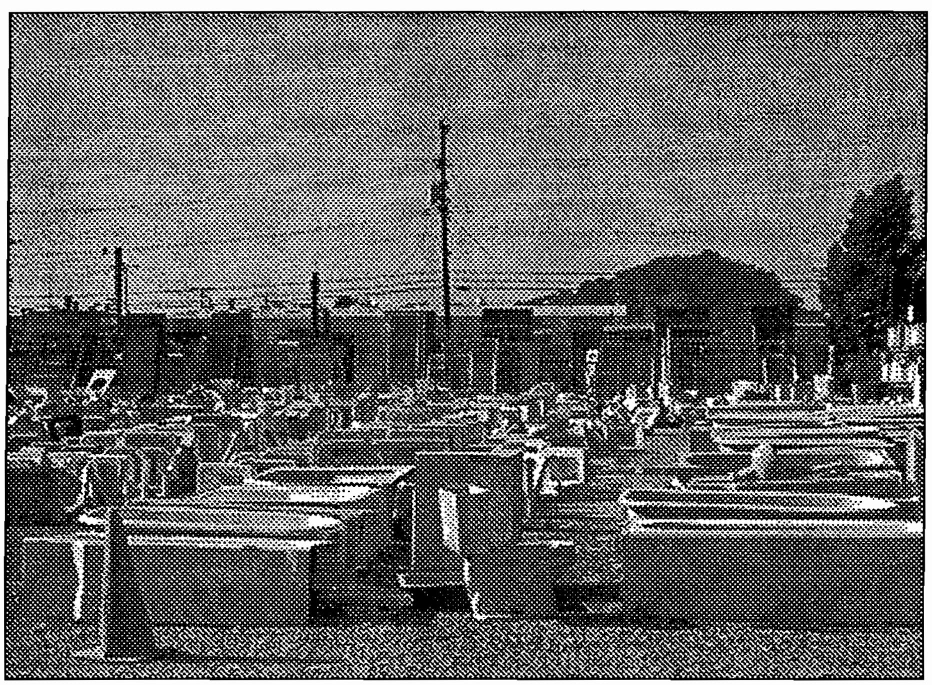
Overall, both mature facilities show a profit. In the 25 TPD model, the profit shown is very small, about 1%. In the larger one, the profit is 17%. The scenarios could plausibly be adjusted to reverse these results, or to increase or decrease profit to any desired level. Then the challenge is actually to create a business that generates whatever result is desired. This process of adjusting reality to fit a plan is the essence of conscious business building.

We have knowingly created a scenario in which four of the six recovery modules operate at a profit, and two lose money; one of them nearly breaks even. We don't think such a configuration is particularly unusual. We ourselves operated a money-losing compost facility for several years, and currently we have a money-losing division that we support with profits from other ones. One reason to continue in a business venture even though it doesn't quite break even would be that doing so accomplishes another goal and is worth the cost. In this case, resources are conserved and pollution prevented.

However, it is worth noting that if the IRRF were not run as a single business under a strong central management structure, there might be no mechanism for transferring profits from one sector to support another. In the pluralistic ownership scenario, therefore, it will be incumbent on each operator to figure out his or her own path to profitability individually. In the case of the compost facility, the imbalance might be helped by the urban-rural commerce discussed earlier.

But although we have suggested that this trade might be profitable, this set of spreadsheets does not record such transactions, nor does it record the amount of tonnage sent to landfill, although it does record the estimated cost.

Again, we encourage readers of this report to refine the numbers to fit their own situation and opportunity, using the blank copies of the forms we have provided. These forms may be distributed to the citizens and agencies of West Virginia, but they must always contain the copyright notice on the bottom, and they may not be sold for more than the cost of reproduction. We hope designers find them useful.



Conclusion

This design project shows that IRRFs could potentially recover large volumes of West Virginia's supply of discards. In doing so, they could provide jobs and business opportunities, stimulating economic development while developing the state's resources in a non-polluting way. The resources in question will probably never stop flowing, so these facilities can be regarded as structural elements of long-term prosperity.

We hope that the design we have presented inspires practical idealists who may have dreamed of better handling systems for their discards to jump into the competitive fray for fun and profit. The more people focus on developing this part of the economy, and the more the industry grows, the more potential people will find in it. There are still a lot of problems to be solved and opportunities to be developed. We hope we have stimulated other people to work on them with us.

Notes

1 The twelve master categories were presented to the public for the first time in West Virginia, at the Governor's Conference on Recycling and Litter Control, Charleston, 1989. The list shown here has been revised slightly. SWMB member Jack Martin has done independent research on the categories; some of his findings are used in this report.

2 For the 25 tpd facility, we revised the Waste Shed H figures because its categories did not fit our processing options. No reliable detailed breakdowns were available, however, so we made adjustments based on our industrial experience as follows:

- We reorganized the Waste Shed H numbers so they fit into the Clean Dozen™ format.
- In a few spots, several subcategories were collapsed into one. For example, "books," "other paperboard," and "other – shredded, etc." became " other – books, shredded, paperboard."
- "Dirt" (6.61%) included sewage sludge, which we consider to be part of putrescibles, so we divided the category into "soil" (5%) and "sludge" (1.61%).
- We reclassified "oversized items" (1.89%) as "reusable goods," then increased the "reusable goods" fraction, for two reasons: (1) most composition studies ignore or underestimate the reusable goods fraction because the researchers are not trained to recognize reusable things; and (2) the supply of reusable goods is elastic, and will increase as more materials recovery businesses go after reusable goods.
- We reduced "other ferrous" and "other wood" by half the amount added to "reusable goods" because many reusable goods are mistakenly listed as metal scrap or wood scrap in composition studies.
- We added a small "chemicals" fraction to make sure the planning process addresses these materials.
- We removed "diapers" from the materials the facility will take, while noting that the main barrier to treating this material by composting is the plastic film exterior of the diaper. Removing the plastic after composting it is technically feasible but adds to the processing cost. Processing fees could be generated by a product disposal charge, otherwise known as an advanced disposal fee, paid as a pass-through at the time the diapers are purchased. But for now, we excluded them as unrecyclable.
- We removed "other plastics" entirely, since we don't know what they are and cannot estimate processing cost.
- We added a minimal amount of "other non-ferrous" because copper, brass, lead, and other nonferrous metals will show up daily at both sizes of IRRF and are easily marketable.
- We added a minimal amount of "asphalt," since it is certain that this material will also show up at the IRRF. We classify asphalt as part of the ceramic family of materials; like the other forms of ceramics, used asphalt is processed by crushing and screening.

3 For the 100 tpd facility, we made the following revisions and adjustments:

- We increased the "plant debris" fraction at Dr. Martin's suggestion that the observations were unseasonably low. We may still be too conservative.
- We reduced "putrescibles" and proportionally increased "plastics" and "paper" because "putrescibles" in Dr. Martin's study were largely paper and plastics contaminated with food and other putrescibles. With some attention to source separation, some of this paper should be recoverable for its fiber. Also, all the plastics need to be kept separate from putrescibles and paper in order to recycle any of them. We assumed that these currently mixed materials would be source separated for the IRRF.
- We increased the "reusable goods" fraction for the reasons described above.
- We removed "diapers" for the reasons described above.
- We reduced the "textiles" fraction, since this study included as textiles some composite materials such as mattresses, which contain wood and metal as well as fabric.
- We used data from the Mon Plan to increase the "soil" fraction and the "ceramics" fraction.
- To generate the necessary level of detail in the "paper," "plastics," "metal," "glass," "ceramic," "soil," and "plant debris" fractions, we followed the Mon Plan's logic by combining data from Cabell, Wayne, and Putnam counties, then applying these subcategory percentages to Dr. Martin's aggregate categories.
- We increased the "newspaper" fraction based on the Mon Plan's comment that 3.9% might be too low.
- We removed "other plastics."
- We increased the "asphalt" category at Dr. Martin's suggestion.

4 A very large and vexatious example of this type of communications mistake was generated back in 1988, when the Society of the Plastics Industry (SPI) developed what it thought was a simple and effective resin identification code consisting of numerals 1 through 7 surrounded by the recycling "chasing arrows" symbol. The code was widely adopted by plastic container and film manufacturers, and by 1993 its use was required in manufacturing by some 39 states. Unfortunately, serious complications developed downstream, as summarized in a report released on July 28, 1993, by the National Recycling Coalition and SPI. One problem was that different resin grades grouped within a single numerical symbol sometimes turned out to be incompatible for recycling purposes. Another was that consumers mistakenly assumed that the chasing arrows meant any item stamped with them was recyclable, leading to countless costly instances of contamination for unfortunate collectors, particularly those operating curbside programs. A joint NRC/SPI task force has been working on the issue for over a year, and the NRC board voted in January 1994 to work on removing the chasing arrows from any future code. It also appears that the code numbers may change or even be abandoned in favor of another code. Anyone interested in pursuing such questions can contact Edgar Miller or Jenny Heumann at the National Recycling Coalition, 1101 30th St. NW, Suite 305, Washington DC 20007.

COSTS OF COMPONENTS – LAND, LABOR, CAPITAL

	Low	High
Land		
Siting, incl hearings	10,000	100,000
Land acquisition	500/acre	500/acre
Labor		
Wages	7.50-20.00/hr	7.50-20.00/hr
Taxes, employer-paid	20%	20%
Benefits	350/mo	350/mo
Capital - buildings		
Construction cost per sq ft		
Building, asphalt floor	5.55	5.55
Pad, asphalt	2.45	2.45
Excavation	1	1
Electrical service	0.64	0.64
Contingency, profit, etc.	3.41	3.41
	13.05	13.05
Capital - equipment		
Reuse Area		
Sheds	250	5,000
Door racks	50	150
Window racks	50	750
Pipe racks	100	1,000
Trucks	2,500	25,000
Forklifts	7,500	25,000
Wood bins	750	2,500
Ceramics bins	250	2,500
Metals bins	1,000	3,000
Carts	100	250
Cash register	2,000	2,000
Radios	1,000	1,000
Computer/printer/software	3,000	3,000
Phone/fax	1,000	1,000
Tools	0	150
Benches	0	150
Sweat furnace	10,000	10,000
Alligator shears (used)	3,500	7,500
Miscellaneous tools	$15 ea	$15 ea
Compost Area		
Wheel loader	15,000	75,000
Track loader	10,000	75,000
Hammermill or tub grinder	50,000	125,000
Screen	15,000	60,000
Cone crusher	100,000	100,000
Conveyor/stacker	20,000	30,000
Windrow turner	10,000	50,000
Tractor	8,000	40,000
Log splitter	1,000	5,000
Chain saws (ea)	500	750
Mixer/batch plant	10,000	30,000
Bagging equipment	2,500	5,000

	Low	High
Covered bins for putrescibles	4,000	5,000
Delivery truck	5,000	20,000
Rolloff bins (ea)	1,500	4,000
Rolloff truck	15,000	50,000
Slow-speed shredder	8,000	10,000
Trailers - tandem-axle dump	5,000	7,000
Bunkers, low-walled 10x10	1,000	2,700
Bunkers, high-walled 10x10	2,000	5,000
Recycle Area		
Bins - 3-yd (ea)	300	400
Debris boxes, various sizes (ea	2,000	4,000
Baler (horizontal stroke), conv	65,000	125,000
Paper chopper, hay baler	8,000	8,000
Baler (downstroke)	2,500	15,000
Glass crusher	1,000	5,000
Tire shredder	150,000	150,000
Rolloff truck	15,000	50,000
Cash register	2,000	2,500
Computer/printer	2,500	5,000
Scales	4,000	50,000
Radios (ea)	500	1,000
Phone and fax	900	900
Scale house	1,000	10,000
Barrels	25	25
Forklifts w rotator	15,000	30,000
Low-speed shredder	20,000	35,000
Magnetic separator	5,000	15,000

Fixtures and Equipment

By Site

REUSE AREA

Item	Cost					
	25 TPD			100 TPD		
	#	Unit Cost	Total cost	#	Unit Cost	Total cost
Alligator shear (used)	1	3,500	3,500	1	7,500	7,500
Benches	4	100	400	4	100	400
Carts	10	100	1,000	20	100	2,000
Cash register	1	2,000	2,000	1	2,000	2,000
Ceramics bins (includes glass)	3	1,000	3,000	3	1,500	4,500
Computer with printer	1	2,500	2,500	1	3,000	3,000
Door racks	15	150	2,250	50	150	7,500
Forklifts (used)	1	7,500	7,500	1	10,000	10,000
Metals bins	2	1,000	2,000	2	2,000	4,000
Miscellaneous tools	50	15	750	50	15	750
Phone and fax	1	1,000	1,000	1	1,000	1,000
Pipe racks	3	500	1,500	6	500	3,000
Radios	4	500	2,000	10	500	5,000
Sheds (not shown on schematic)	1	1,000	1,000	2	3,000	6,000
Sweat furnace			0	1	10,000	10,000
Trucks (used)	1	7,500	7,500	2	7,500	15,000
Window racks	10	400	4,000	20	400	8,000
Wood bins	2	1,000	2,000	3	1,500	4,500
Subtotal			**$43,900**			**$94,150**
Access road, 1/3 share, 12,800 and 15,300 sq ft		$10/sq ft	128,000		$10/sq ft	153,000
Bare land, 1 acre		$500/acre	500		$500/acre	500
Building (incl repair bay), 17,250 sq ft		$35/sq ft	603,750		$35/sq ft	
Paved areas, incl parking, 6,700 sq ft		$10/sq ft	67,000		$10/sq ft	67,000
Paved areas, incl. parking, 17,200 sq ft.					$10/sq ft	172,000
Pole barn, 7,600 sq ft.					$35/sq ft	266,000
Repair bay, 3,300 sq ft.					$50/sq ft	165,000
Scrap bay, 5,600 sq ft.					$50/sq ft	280,000
Subtotal			**$799,250**			**$1,103,500**
Total			**$843,150**			**$1,197,650**

NOTE: If all facilities are integrated on a single site, this facility may share some equipment with others.

Fixtures and Equipment

By Site

RECYCLE AREA

Item	Cost					
	25 TPD			100 TPD		
	#	Unit Cost	Total cost	#	Unit Cost	Total cost
Baler (downstroke) (1 new, 2 used; and 1 used)	3	5,000	15,000	1	7,500	7,500
Baler (horizontal stroke), conveyor			0	1	125,000	125,000
Barrels	10	25	250	20	25	500
Bins - 3 yd	24	300	7,200	50	300	15,000
Cash register	1	2,000	2,000	1	2,500	2,500
Computer and printer	1	2,500	2,500	1	5,000	5,000
Debris boxes, various sizes	6	2,000	12,000	25	2,000	50,000
Forklifts with rotating heads	1	23,000	23,000	3	23,000	69,000
Glass crusher (used)	1	500	500	1	1,000	1,000
Low-speed shredder	1	20,000	20,000	1	35,000	35,000
Magnetic separator	1	5,000	5,000	1	15,000	15,000
Paper chopper	1	8,000	8,000	1	8,000	8,000
Phone and fax	1	900	900	1	900	900
Radios	4	500	2,000	8	500	4,000
Rolloff truck (used)	1	15,000	15,000	1	25,000	25,000
Scales (used)	1	4,000	4,000	1	10,000	10,000
Specialized trucking		contract out			contract out	
Subtotal			**$117,350**			**$373,400**
Access road, 1/3 share, 12,800 and 15,300 sq ft		$10/sq ft	128,000		$10/sq ft	153,000
Bare land, 1 acre		$500/acre	500		$500/acre	500
Buildings, trailer, etc. (used)	1	4,000	4,000			0
Eyewash station (not shown)			500			500
Hazardous materials storage, 625 and 775 sq ft		$25/sq ft	15,625		$25/sq ft	19,375
Office area, 1,125 sq ft					$50/sq ft	56,250
Paved area, 25,250 and 47,350 sq ft		$10/sq ft	252,500		$10/sq ft	473,500
Pole shed (processing), 14,400 and 13,900 sq ft	1	$35/sq ft	504,000		$35/sq ft	486,500
Receiving shed, 2,000 and 5,850 sq ft.		$20/sq ft	40,000		$20/sq ft	117,000
Specialized trucking		contract out			contract out	
Subtotal			**$945,125**			**$1,306,625**
Total			**$1,062,475**			**$1,680,025**

NOTE: If all facilities are integrated on a single site, this facility may share some equipment with others.

Fixtures and Equipment

By Site

COMPOST AREA

Item	Cost					
Some of this equipment may be	25 TPD			100 TPD		
considered optional at a particular facility.	#	Unit Cost	Total cost	#	Unit Cost	Total cost
Bagging equipment	1	2,500	2,500	1	5,000	5,000
Bunkers for bulk products	4	$20/sq ft	20,000	4	$20/sq ft	20,000
Chainsaws	1	500	500	2	500	1,000
Cone crusher (used)	1	50,000	50,000	1	100,000	100,000
Conveyor/stacker (used)	1	20,000	20,000	1	20,000	20,000
Covered bins for putrescibles	4	4,000	16,000	20	4,000	80,000
Delivery truck (used)	1	5,000	5,000	1	20,000	20,000
Hammermill	1	90,000	90,000	1	125,000	125,000
Mixer/batch plant (used)	1	10,000	10,000	1	25,000	25,000
Rolloff bins (for trash)	2	1,500	3,000	4	2,000	8,000
Rolloff truck (used)	1	15,000	15,000	1	30,000	30,000
Screen	1	25,000	25,000	1	35,000	35,000
Slow-speed shredder				1	10,000	10,000
Splitter	1	1,000	1,000	1	2,500	2,500
Track loader (used)			0	1	30,000	30,000
Tractor (used)	1	8,000	8,000			0
Trailers, tandem axle dump	1	5,000	5,000	1	7,000	7,000
Wheel loader, 3 (used)	2	15,000	30,000	3	35,000	105,000
Windrow turner	1	15,000	15,000		Use loader	
Subtotal			**316,000**			**623,500**
Access road, 1/3 share, 12,800 and 15,300 sq ft		$10/sq ft	128,000		$10/sq ft	153,000
Bare land, 8 acres and 2 acres		$500/acre	4,000		$500/acre	1,000
Hardened pad, 22,500 and 30,000 sq ft		$12/sq ft	270,000		$12/sq ft	360,000
Office area, 950 sq ft		$35/sq ft	33,250		$50/sq ft	47,500
Paved area, 18,675 and 27,850 sq ft		$10/sq ft	186,750		$10/sq ft	278,500
Ramped tipping area, 7,500 and 8,700 sq ft		$15/sq ft	112,500		$15/sq ft	130,500
Subtotal			**734,500**			**970,500**
Total			**$1,050,500**			**$1,594,000**

NOTE: If all facilities are integrated on a single site, this facility may share some equipment with others.

ANNUAL PERFORMANCE PROJECTION — 25 TPD, 10 years evolution

	Reuse			Recycling			Compost			Combined	
	Tons	$/T	$	Tons	$/T	$	Tons	$/T	$	Tons	$
INCOME											
Tipping fees											
Appliances	9	$120	$1,080	40	$120	$4,800				49	$5,880
Ceramics							440	$15	$6,600	440	$6,600
Chemicals	5	$100	$500	4	$400	$1,600				9	$2,100
Paper							623	$24	$14,952	623	$14,952
Putrescibles incl sludge							277	$35	$9,695	277	$9,695
Soil							427	$15	$6,405	427	$6,405
Textiles										0	$0
Tires	10	$50	$500	10	$50	$500				20	$1,000
Wood							540	$20	$10,800	540	$10,800
Yard debris							1,365	$24	$32,760	1,365	$32,760
Subtotal	24		$2,080	54		$6,900	3,672		$81,212	3,750	$90,192
Tons in, no tip fee	1,406			3,844			0			5,250	
Product sales											
Animal bedding							398	$30	$11,940	398	$11,940
Compost and soils							899	$35	$31,465	899	$31,465
Glass				203	$25	$5,075				203	$5,075
Gravel and sand							300	$15	$4,500	300	$4,500
Metals				270	$80	$21,600				270	$21,600
Paper				2,250	$100	$225,000				2,250	$225,000
Plastics				900	$150	$135,000				900	$135,000
Reusables	1,430	$400	$572,000							1,430	$572,000
Textiles				135	$20	$2,700				135	$2,700
Wood				140	$25	$3,500	300	$10	$3,000	440	$6,500
Subtotal	1,430		$572,000	3,898		$392,875	1,897		$50,905	7,225	$1,015,780
TOTAL INCOME			$574,080			$399,775			$132,117		$1,105,972
EXPENSES											
Purchases for resale			$75,664			$179,899			$0		$255,563
Labor											$0
Benefits			$22,791			$7,795			$7,795		$38,381
Payroll taxes			$21,585			$6,201			$6,201		$33,987
Wages & salaries			$223,776			$88,357			$88,357		$400,490
Worker's comp insur			$22,159			$7,575			$7,575		$37,309
Subtotal			$290,311			$109,928			$109,928		$510,167
Operations											
Ads & marketing			$9,587			$3,000			$5,000		$17,587
Contract labor			$6,889			$3,000			$1,500		$11,389
Fuel			$2,756			$5,000			$3,000		$10,756
Landfilling @ $50/T			$1,406			$2,000			$2,000		$5,406
Miscellaneous			$8,611			$9,000			$6,000		$23,611
Repair & maintenance			$5,167			$8,000			$10,000		$23,167
Tools & supplies			$4,593			$9,000			$4,000		$17,593
Utilities and phone			$4,707			$2,500			$2,500		$9,707
Subtotal			$43,716			$41,500			$34,000		$119,216
Administration											
Insurance			$15,845			$11,000			$8,000		$34,845
Professional services			$7,635			$6,000			$5,000		$18,635
Taxes and license fees			$2,985			$1,000			$2,000		$5,985
Subtotal			$26,465			$18,000			$15,000		$59,465
OPERATING COSTS			$436,156			$349,327			$158,928		$944,411
Annualized startup costs			$42,158			$53,123			$52,525		$147,806
TOTAL COSTS			$478,314			$402,450			$211,453		$1,092,217
PROFIT/(LOSS)			$95,766			($2,675)			($79,336)		$13,755
Tons/yr, Profit/ton	1,430		$67	3,898		($1)	3,672		($22)	9,000	$2

ANNUAL INCOME PROJECTION — 100 TPD, 10 years evolution

	Reuse			Recycling			Compost			Combined	
	Tons	$/T	$	Tons	$/T	$	Tons	$/T	$	Tons	$
INCOME											
Tipping fees											
Appliances	85	$120	$10,200	200	$120	$24,000				285	$34,200
Ceramics							1,720	$15	$25,800	1,720	$25,800
Chemicals	18	$100	$1,800	14	$400	$5,600				32	$7,400
Paper							1,800	$24	$43,200	1,800	$43,200
Putrescibles, incl. sludge							2,286	$35	$80,010	2,286	$80,010
Soil							1,706	$15	$25,590	1,706	$25,590
Textiles										0	$0
Tires		$50	$0		$50	$0				0	$0
Wood							2,160	$20	$43,200	2,160	$43,200
Yard debris							5,461	$24	$131,064	5,461	$131,064
Subtotal	103		$12,000	214		$29,600	15,133		$348,864	15,450	$390,464
Tons in, no tip fee	5,672			14,878			0			20,550	
Product sales											
Animal bedding							900	$30	$27,000	900	$27,000
Compost and soils							3,715	$35	$130,025	3,715	$130,025
Glass				270	$25	$6,750				270	$6,750
Gravel and sand							1,720	$15	$25,800	1,720	$25,800
Metals				1,080	$80	$86,400				1,080	$86,400
Paper				9,000	$100	$900,000				9,000	$900,000
Plastics				3,600	$150	$540,000				3,600	$540,000
Reusables	5,775	$400	$2,310,000							5,775	$2,310,000
Textiles				540	$20	$10,800				540	$10,800
Wood				602	$25	$15,050	500	$10	$5,000	1,102	$20,050
Subtotal	5,775		$2,310,000	15,092		$1,559,000	6,835		$187,825	27,702	$4,056,825
TOTAL INCOME			$2,322,000			$1,588,600			$536,689		$4,447,289
EXPENSES											
Purchases for resale			$306,040			$714,870			$0		$1,020,910
Labor											$0
Benefits			$92,183			$30,978			$10,465		$133,627
Payroll taxes			$87,307			$24,623			$8,319		$120,249
Wages & salaries			$905,116			$351,081			$118,608		$1,374,804
Worker's comp insur			$89,629			$30,025			$10,143		$129,797
Subtotal			$1,174,235			$436,706			$147,536		$1,758,477
Operations											
Ads & marketing			$38,777			$11,915			$20,287		$70,979
Contract labor			$27,864			$11,915			$6,118		$45,897
Fuel			$11,146			$19,858			$12,183		$43,186
Landfilling @ $50/T			$116			$7,943			$8,104		$16,163
Miscellaneous			$34,830			$35,744			$24,366		$94,939
Repair & maintenance			$20,898			$31,772			$40,627		$93,297
Tools & supplies			$18,576			$35,744			$16,262		$70,581
Utilities and phone			$19,040			$10,008			$10,143		$39,192
Subtotal			$171,247			$164,897			$138,090		$474,234
Administration											
Insurance			$64,087			$43,687			$32,523		$140,297
Professional services			$30,883			$23,829			$20,287		$74,998
Taxes and license fees			$12,074			$3,972			$8,104		$24,150
Subtotal			$107,044			$71,487			$60,914		$239,445
OPERATING COSTS			$1,758,566			$1,387,960			$346,540		$3,493,066
Annualized start-up costs			$59,883			$65,331			$79,700		$204,914
TOTAL COSTS			$1,818,449			$1,453,291			$426,240		$3,697,980
PROFIT/(LOSS)			$503,551			$135,309			$110,449		$749,309
Tons/yr, Profit/ton	5,775		$87	15,092		$9	15,133		$7	36,000	$102,666

ANNUAL INCOME PROJECTION ______ TPD, ___ years evolution

	Reuse			Recycling			Compost			Combined	
	Tons	$/T	$	Tons	$/T	$	Tons	$/T	$	Tons	$
INCOME											
Tipping fees											
Appliances											
Ceramics											
Chemicals											
Paper											
Putrescibles incl sludge											
Soil											
Textiles											
Tires											
Wood											
Yard debris											
Subtotal											
Tons in, no tip fee											
Product sales											
Animal bedding											
Compost and soils											
Glass											
Gravel and sand											
Metals											
Paper											
Plastics											
Reusables											
Textiles											
Wood											
Subtotal											
TOTAL INCOME											
EXPENSES											
Purchases for resale											
Labor											
Benefits											
Payroll taxes											
Wages & salaries											
Worker's comp insur											
Subtotal											
Operations											
Ads & marketing											
Contract labor											
Fuel											
Landfilling @ $50/T											
Miscellaneous											
Repair & maintenance											
Tools & supplies											
Utilities and phone											
Subtotal											
Administration											
Insurance											
Professional services											
Taxes and license fees											
Subtotal											
OPERATING COSTS											
Annualized startup costs											
TOTAL COSTS											
PROFIT/(LOSS)											
Tons/yr, Profit/ton											

Appendices

Appendix A:

Reuse, Recycling, Refuse, and the Local Economy: A Case Study of the Berkeley Serial MRF (Stern, et al, 1994)

Appendix B:

"The Bay Area's Prospects for Total Recycling" (Knapp, 1992)

Appendix C:

"Outline of Processing Options for Materials Handled by an Integrated Resource Recovery Facility" (Martin, 1993)

Appendix D:

Development of Integrated Resource Recovery Facilities (Diener, 1994)

Appendix E:

Berkeley Recycling Center Site Plan (Gorrell, 1993 – constructed and operational as of 1994)

Appendix A

OPPORTUNITIES IN

NEIGHBORHOOD TECHNOLOGY

TO IMPROVE THE ENVIRONMENT AND CREATE JOBS

Number 2, September 1994

REUSE, RECYCLING, REFUSE AND THE LOCAL ECONOMY

A Case Study of the Berkeley Serial MRF

Documented by Urban Ore and the Center for Neighborhood Technology

A RECYCLING PHENOMENON

Berkeley, CA – In the late 1970s, a municipal incinerator was slated to be built in West Berkeley, a mixed residential, commercial, and industrial part of this city of 103,000. Citizens protested, and after a long struggle, a recycling and refuse transfer station preempted the burner. Today, the would-be burn plant site is the epicenter of a regional materials recovery phenomenon: the Berkeley serial materials recovery facility (MRF).

Public policy shifted from building an expensive, centralized facility to encouraging community and private enterprise. Now a network of independent but complementary reuse, recycling, and composting operations receives discards, adds value to them and markets high quality resources. The result: a regional MRF that recovers material, creates jobs, supports local for-profit and non-profit businesses, adds to the tax base and gives haulers a convenient, economical, environmentally sound way to dispose of their payloads.

The Berkeley serial MRF demonstrates how materials recovery can be used as a community development tool. It prompted the Center for Neighborhood Technology (CNT) in Chicago to hire Urban Ore's Information Services division to conduct this study.

CNT and Urban Ore hope the study will help planners, community-based organizations and industry professionals see the full potential of existing serial MRFs

BERKELEY SERIAL MRF AT A GLANCE

City of Berkeley, CA: pop. 103,000.
Alameda County: pop. 1.3 million

City of Berkeley...citywide refuse collection, refuse transfer station with dump-and-pick salvaging and motor oil dropoff...commercial curbside recycling...residential plant debris pickup. **Ecology Center**...non-profit, citywide multi-material residential curbside recycling. **Community Conservation Centers** (CCC)...non-profit, drop-off, buyback, materials highgrading and marketing. **Ohmega Salvage**...for-profit building materials and house parts salvage. **Urban Ore**...for-profit reusable goods salvage and recycling business. **American Soil Products**...for-profit business producing soil amendments, blended soils, and mulches.

Organizations	6
Tipping areas	19
Acres of sites	10
Full time equivalent employees	94
Tons per year diverted	approx. 83,000
Recycling annual cash flow	$8.5 m
Cash budget, 1 ton recycling	$102
Refuse annual cash flow	$11.0 m
Tons per year of refuse to landfill	$90,000

*** Note: much of the refuse and recycling tonnage above is generated outside the City of Berkeley.*

and how their principles might help maximize recovery and community benefit of all discard management facilities.

WHY CALL IT A SERIAL MRF?

The Berkeley configuration recovers materials by diverting them from landfilling, so it operates as a materials recovery facility. Like most MRFs, it had conveyers, magnets and a baler. But it didn't make sense to draw a line around only this equipment and call it a MRF, because the entire network of operations clustered around the transfer station together works as a MRF.

So we drew a line around a core cluster of businesses and programs. We call it a serial MRF because haulers unload at a series of tipping areas.

METHODOLOGY

In late 1993, we sent a list of questions to a highly placed manager in each organization and asked for their best estimates. They responded in writing or in telephone interviews. We made follow-up calls to fill out our database and check facts.

CHRONOLOGY IN BRIEF

The Berkeley serial MRF has grown over time in response to politics, chance, individual activism, legislative mandate and entrepreneurship.

1923: Berkeley landfill opens. Salvaging begins sometime thereafter.
1969: Ecology Center founded.
1971: Precursor to CCC's dropoff opens.
1973: CCC established; Ecology Center curbside newspaper collection begins.
1975: Ohmega Salvage open.
1980: Urban Ore begins at landfill. Ecology Center expands to glass and cans.
1982: Citizens defeat proposed mass burn plant. CCC opens buyback.
1983: Berkeley closes landfill, opens transfer station. Urban Ore opens Compost Farm.
1985: American Soil Products opens.
1986: Urban Ore Compost Farm closes.
1989: Recycled Wood Products opens.
1990: City's commercial recycling collection program begins.
1992: Plant debris program starts citywide.
1993: Recycled Wood Products closes. City's motor oil dropoff opens. Ecology Center takes magazines, OCC, mixed paper.

Supplying the Berkeley MRF

BERKELEY'S HAULING STRUCTURE

The Berkeley MRF feeds its appetite for discards in two ways: by picking them up where generated, and by setting up convenient, cost-effective receiving systems for other haulers to use.

Collection infrastructure: The City of Berkeley picks up residential and commercial refuse in compactor trucks, front loaders and roll-off trucks. It also collects commercial recyclables, residential plant debris and bulky goods at curbside. The Ecology Center picks up residential recyclables at curbside on the same day as trash pickup. The other organizations have a much smaller but still vital truck fleet to reach out and secure supply. American Soil Products subcontracts most of its trucking.

Small and self-haul culture: A lot of material enters the Berkeley MRF through small and self-haulers. Small businesses, contractors, homeowners, scavengers, and a host of other people bring material to the system in automobiles, pickup trucks, vans, trailers, and larger flat bed trucks.

This extensive hauling infrastructure provides several collection tiers—formal and informal—with a wide variety of ways for materials to enter the system.

FEEDSTOCKS

The Berkeley serial MRF handles an astounding array of feedstocks, including organic materials, soils, construction materials and other reusable goods, appliances, glass, plastic and metal containers, scrap metals, scrap ceramics, many grades of paper, motor oil, oil filters, refrigerants, and compressor oils. See the chart on page 12 for a more detailed rendering of the services provided by this comprehensive MRF.

This material comes from homeowners, renters, businesses, institutions, tradespeople, restaurants, landscapers, construction contractors, manufacturers, warehouses, laboratories, the military and more.

SOURCE SEPARATION

The system is geared to handle clean feedstocks. Operators maintain quality by inspecting each incoming load. Haulers learn—enthusiastically or grudgingly—to stratify their loads to pass the quality screens of recyclers' receiving systems. The penalty for failure is high tipping fees later.

The main goal of thorough load screening is to provide a high quality end product without costly mechanical separation equipment. Instead, energies are devoted to upgrading and otherwise adding value.

WHAT IS LEFT OUT

The Berkeley serial MRF is not complete, which means there are service voids.

At this writing, full or partial service voids exist for the following commodities: wood, plant trimmings, putrescibles, soils, ceramics, textiles, plastics and chemicals.

A key missing link appears to be a local, large-scale plant debris composting facility. Since Recycled Wood Products closed early in 1993, landscapers have used a less convenient alternative: tipping their plant debris on a portion of the City's transfer station floor. The material is then trucked to a composter or used as fuel.

The further development of the Berkeley serial MRF may be aided as the West Berkeley Area Plan takes effect. The Berkeley/Oakland Recycling Market Development Zone has already helped finance equipment to increase capacity.

VARIABLE TIPPING FEE

Haulers separate their loads primarily to save money on garbage tipping fees. Tipping fees at local transfer stations range from $49 to $58 per ton. Haulers reduce their costs by tipping clean materials at the other operations, which may charge no tipping fee, a lower tipping fee, or even pay cash for certain materials.

Besides reaping financial benefits, many haulers know their payloads have value and hate to see good stuff wasted. This is especially true for homeowners, contractors, or landscapers, who often buy the MRF's products to use in their projects.

FACE-TO-FACE EDUCATION

When a lower tipping fee or common sense fails to persuade haulers to stratify their loads, a sometimes-cheerful, sometimes-confrontational process of face-to-face education takes place. Operators patiently explain their quality requirements—why they'll accept this door and not that one, or why this load of brush won't produce a clean mulch. At times, the operator has no choice but to reject a load from the most well-intentioned person, sending him or her down the street to pay the going garbage disposal rate.

The good news is that haulers respond well. They know a good thing when they see it: save money, and put things to good use.

REGIONAL DRAW

Much of the material entering the Berkeley MRF comes form within Berkeley, but the system pulls material from the nearby cities of Oakland, Emeryville, El Cerrito, Richmond and Albany. Because of the combination of a lower tipping fee, range of materials accepted, and the sale of attractive retail products, the Berkeley MRF draws people from the Bay Area, and as far away as Southern California and Oregon.

It's possible that this regional pull is responsible for increasing the garbage flow at the Berkeley refuse transfer station when nearby dumps with fewer recycling opportunities are experiencing declining garbage.

Local Economic Development

SUPPLY-SIDE BENEFITS

Local economic benefits start upstream on the supply side, where suppliers save or earn money on the materials they dispose. The Berkeley serial MRF gives haulers an opportunity to increase margins or lower their collection fees, either way making their business more competitive. Homeowners, individuals, business people, and contractors can save or earn money, too. The avoided disposal cost of this MRF is quite large, probably somewhere in the range of $4 million to $5 million annually compared to landfilling.

JOBS, JOBS, JOBS

The MRF puts spending power into the local economy through its 94 employees, many of whom enjoy well-paying, skilled jobs with excellent benefits

Berkeley Serial MRF Jobs
(Full-time equivalent, includes collection)

City of Berkeley	16
CCC dropoff/buyback	15
Ecology Center	18
American Soil Products	18
Ohmega	7
Urban Ore	20
TOTAL	94

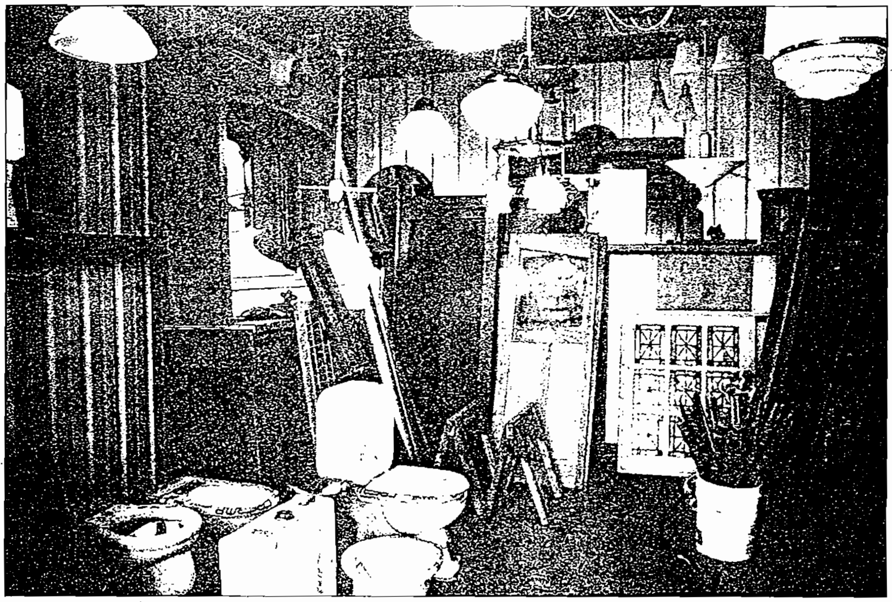
INDEPENDENT CONTRACTORS

The Berkeley serial MRF operators also support many specialized independent contractors vital to the reuse and recycling operations. Urban Ore uses contractors to clean bricks and evacuate refrigerants and appliance oils. Ohmega Salvage uses about a dozen subcontractors to rebuild plumbing, rebuild doors, and make stained glass. American Soil Products contracts out more than $500,000 worth of trucking each year.

DEMAND-SIDE BENEFITS

Local economic benefits flow downstream through

Text continued on page 8



Ohmega Salvage

Ohmega Salvage has found a specialty niche in the building materials business by handling antiques and other high-end discards (left).

Ecology Center

The recycling cartoon characters are used in the education campaign(opposite top left). Sorting and bailing equipment is being added at the Ecology Center to increase its capacity, using county, state and bond financing (opposite top right).

Urban Ore

The core business at Urban Ore is the resale of doors and windows (left). These bins (below left) at the General Store hold nuts, bolts, screws, faucets and other hardware. The store also sells furniture, cabinets, lighting, appliances, art, books, bicycles and lots of oddities — something for everyone.

Leftovers from a garage sale arrive at the Urban Ore Discard Management Center (below).

Berkeley Transfer Station
Yard debris dropped off separately is shredded; some becomes a selected fuel for energy production and some is composted (middle right).

Throughout the MRF
People who work here are familiar with their inventories and are available to help customers find materials to solve their problems (below right).

Community Conservation Centers
The Buyback, run by Community Conservation Centers, sells paper to brokers who ship it to both domestic and export markets (below).

CITY OF BERKELEY TRANSFER STATION COMPLEX

Municipal corporation owns and operates a transfer station, where loads are consolidated for trucking to Vasco Road landfill near Livermore.
Includes several materials recovery activities:

- motor oil dropoff
- scrap metals salvaging
- reusable goods salvaging
- city-wide commercial recyclables pickup
- residential plant debris pickup.

ECOLOGY CENTER

Non-profit corporation runs the City of Berkeley's residential curbside recycling program. Picks up several grades of paper and container glass and metal. Upgrades paper, commercial glass, and metals. Also runs recycling hotline.

URBAN ORE DISCARD MANAGEMENT CENTER

For-profit business runs attended drop-off area for reusable goods, appliances, and scrap metals. Features refrigerant removal and metal upgrading.

COMMUNITY CONSERVATION CENTERS BUY-BACK AND DROP-OFF

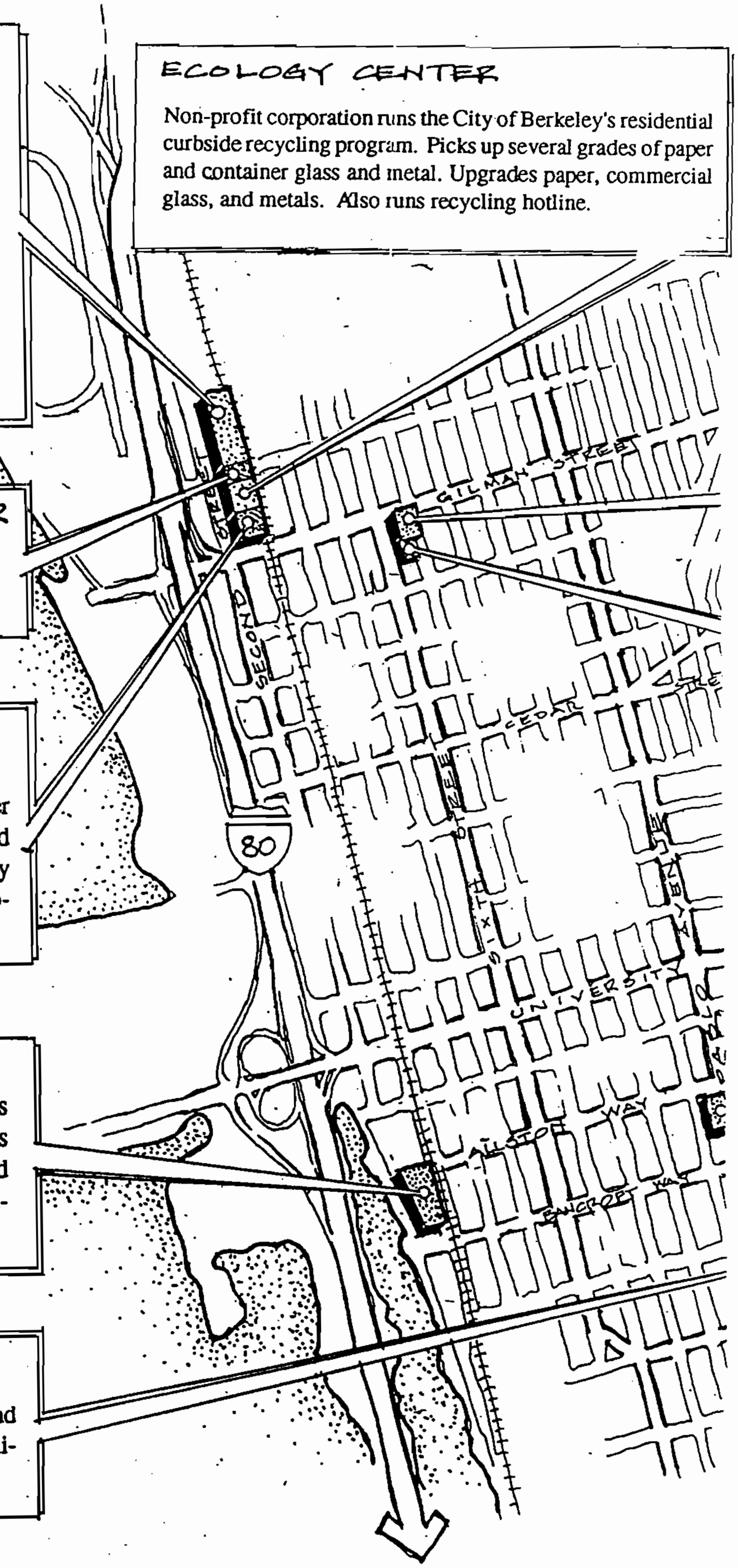
Non-profit corporation runs buyback and drop-off center for several grades of paper, container metal and glass, and scrap metals. Processes some materials collected by Ecology Center and City of Berkleley's commercial program.

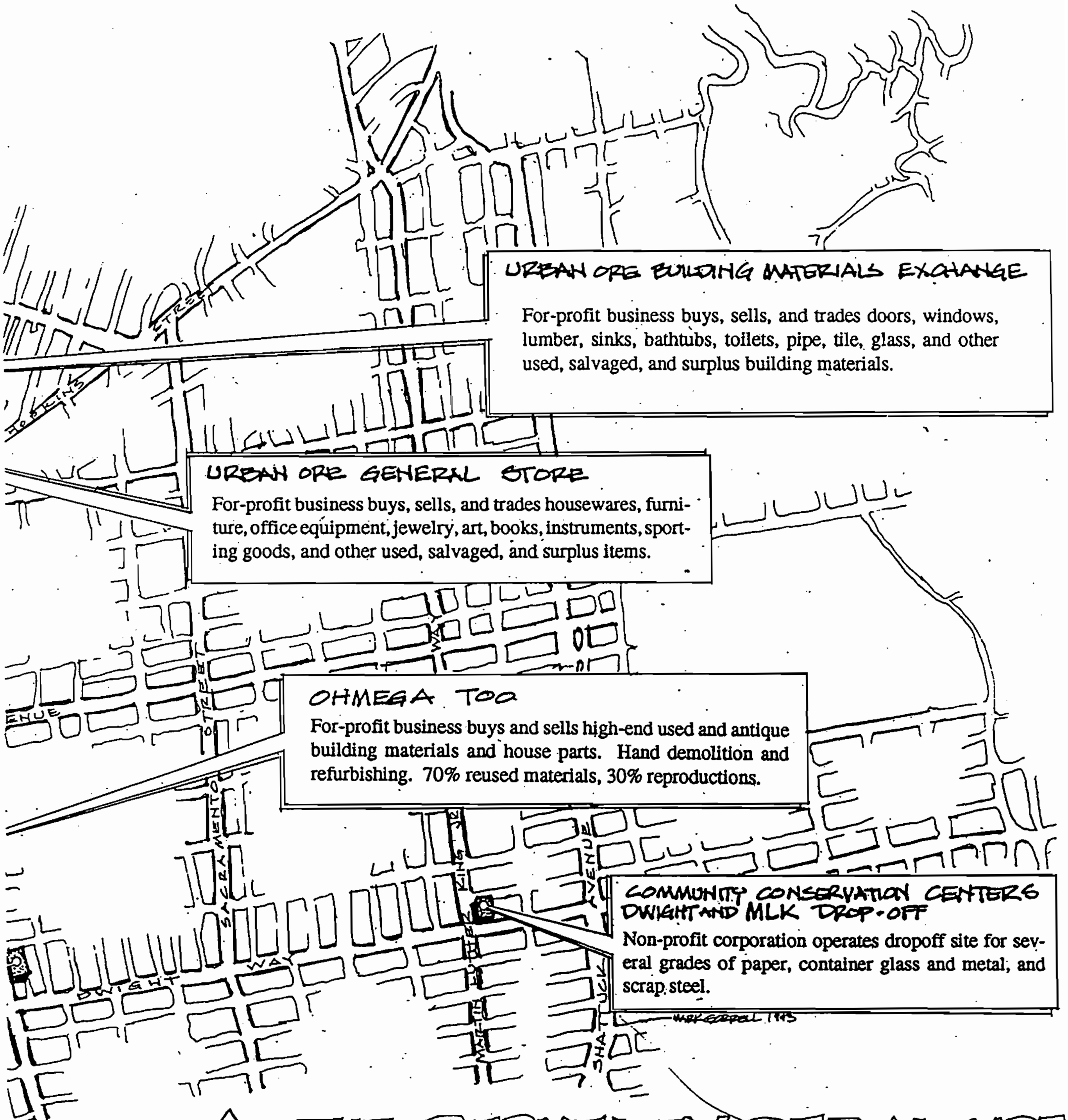
AMERICAN SOIL PRODUCTS

For-profit business receives discarded organic materials and blends, mixes, ages, or resells them as-is. Has developed a wide variety of soil amendments, blended top soils, and mulches for specific agricultural and landscaping applications.

OHMEGA SALVAGE

For-profit business buys and sells medium- to high-end building materials and house parts. Does hand demolition and refurbishing of many items.





THE BERKELEY SERIAL MRF

NORTH

A LOCAL NETWORK OF INDEPENDENT RECYCLING ORGANIZATIONS

Scale: 1" = approx. 2000'

Continued from page 3
demand markets, too. In the reuse business, providing a steady supply of low-priced, authentic house parts enables homeowners, restoration contractors, and property managers to make repairs that might otherwise be unaffordable.

The same is true for the soil amendment business. Beautiful landscaping adds to property values, and good soils are the foundation for landscaping. The effects are felt throughout the real estate industry and eventually raise the tax base.

A substantial number of reuse customers buy things that they resell at flea markets, garage sales, thrift stores and collectibles boutiques. Many do repair and refinishing work; some do considerable research to find the best market for items they purchase. The value they add is reflected in the difference between what they pay for something and what they get when they resell it. The difference, minus any expenses, is their income. For many resellers, this is their primary occupation.

Other reuse customers are contractors who use the MRF's products in their specialized trades. They may upgrade a door by painting or repairing it, then get paid again to install it. Landscapers and gardeners use bricks, stones, soils and scrap lumber to create pleasant outdoor spaces for homes and businesses.

ANNUAL CASH FLOW OF THE BERKELEY SERIAL MRF (includes collection costs)

City of Berkeley	$2.2 million*
Non-profits	$2.5 million**
For-profits	$3.8 million***
TOTAL	$8.5 million

* Expense budget, FY 1993-1994
** Projected 1993 revenues; incl. City of Berkeley service fees not counted above.
*** Estimated 1992 revenues

ECONOMIC POWERHOUSE

The Berkeley serial MRF circulates a substantial amount of money through the local economy.

The money circulates through the local economy by way of employees, contractors, suppliers, customers, public tax coffers, and owners' profits.

TAX REVENUES

In an age of tight budgets, this serial MRF adds directly to the public revenue in the form of business license taxes, and state and local sales taxes. While data were not available for every business, aggregate estimates were available, and are presented below:

THE BERKELEY SERIAL MRF'S ANNUAL CONTRIBUTION TO THE TAX BASE*

City license fees	$5,700
City's share of sales taxes	$38,000
Balance of sales taxes	$292,000
TOTAL	$335,700

* taxes paid on revenues only, not taxes paid on supplies and equipment purchases.

SPACE: THE MISSING FRONTIER

The flip side of the robust and cosmopolitan economy of the Bay Area is the limit to growth imposed by dense settlement. Lack of affordable space for recycling has long plagued Berkeley serial MRF operators.

The City of Berkeley operates and leases about three acres to recyclers, but this land was originally acquired as a site for burning garbage and has proven to be far too small for maximally effective recycling.

Urban Ore lost its compost site in 1986, and in 1991 it vacated one of its retail sites to make room for other recycling operators. Recycled Wood Products lost its site in early 1993. Today, American Soil Products' site is threatened by complaints about odors and dust.

It is ironic that the citizens of Berkeley united to oppose a mass burn plant in the early 1980s but have not been able to solve the land problem for their recyclers.

Highest and Best Use

CONSERVING VALUE

The Berkeley serial MRF implements the principle of highest and best use. The founders who started each business, program, or service had to find a practical way to take one or more discarded materials up a few notches on the scale of worth.

- Ecology Center started as an information center, then added its collection service to demonstrate the effectiveness of curbside recycling and to give the public a chance to do something for the environment that had immediate perceivable results. The nonprofit has collected ever-increasing tonnages for two decades.
- Community Conservation Centers incorporated in 1973 to operate two dropoff centers supported by City funding, then added the buyback later. The resulting

Estimated Throughput

OPERATION	MATERIALS	THROUGHPUT (tons/year)	LANDFILLED (tons/year)
City of Berkeley			
Curbside Plant Debris	Grass clippings, leaves, brush	2,000	n/a
Commercial Recycling	Paper, container metal and glass	1,200	n/a
Transfer Station Recovery:			
Oil dropoff	Motor oil and oil filters	n/a	n/a
Scrap Metal	Ferrous and non-ferrous metals	764	n/a
Ecology Center Citywide Residential Curbside	Glass Containers, Steel Cans, Aluminum Cans and Foil, Newspaper, Mixed Paper, Cardboard, and Magazines	5,784	Avg. 0.6%
Community Conservation Centers	Glass containers, steel cans and scrap newspaper, mixed paper, cardboard, magazines and white ledger, PET redemption containers		
Dwight and MLK dropoff		1,848	Avg. 0.6%
2nd/Gilman dropoff		1,860	Avg. 0.6%
2nd/Gilman buyback		3,480	Avg. 0.6%
American Soil Products	Mixes, blends, and ages a variety of soils and organics, sells soil amendments, blended top soils, and mulch in bulk or by the bag	62,293 *(Most generated outside Berkeley)*	< 1%
Ohmega Salvage, Ohmega Too	Building materials, house parts and fixtures—*Mid-range to high-end*	1,250	< 1%
Urban Ore Discard Management Center	Appliance recycling *(refrigerants, oils, metals)*	n/a	< 1%
	Scrap metals,batteries,cardboard, reusable goods dropoff/	447	< 1%
	transfer station salvage	325	< 3%
Urban Ore General Store and Building Materials Exchange	*Reusables*: Building materials, household and office contents, antiques, collectibles, appliances	1,664	< 3%
	Recyclables: Ceramics, metals, wood, textiles	373	< 3%
	TOTAL MATERIALS RECOVERY	83,288	n/a = not available

Not included: Until it lost its lease in 1993, Recycled Wood Products chipped, shredded and screened wood, limbs, leaves, and grass, then sold the products as mulch or as fuel for cogeneration. Recycled Wood Products processed approximately 12,000 tons of material per year, and reported residues landfilled of well under 1% of total throughput.

configuration maximizes tonnage and quality control, while offering thousands of small collectors a chance to augment their incomes.

- The Ecology Center started a bottle-washing business to demonstrate reuse. The spinoff, called Encore!, has grown into a $2 million per year concern operating in a nearby city.
- Urban Ore's retail sales business for reusable goods replaced an earlier landfill scrap recovery operation.
- American Soil Products started as a spinoff from Urban Ore's Compost Farm, taking bulk agricultural materials from a variety of sources and producing custom soil blends with specific nutrient levels, textures and even colors.
- The City of Berkeley's curbside plant debris collection program uses special compostable paper bags for its customers. When Recycled Wood Products lost its processing site, the city found an alternative out-of-town compost processor that is still much closer than its landfill, and is continuing its source separated service for plant debris.

PRODUCT DEVELOPMENT

Each processor has seen its products proliferate as markets are developed.

- American Soil Products sells five major categories of recycled organic products, and these are further broken down into 34 subcategories.
- Urban Ore's cash registers collect sales information daily on 41 categories of reusable goods, from doors to hardware to toys.
- The City's refuse transfer station produces more than refuse: four categories of metal scrap; bulk loads of clean plant debris; recycled motor oil; and nearly a ton of reusable goods each day.
- Berkeley's two nonprofit recyclers sell four grades of paper, five types of glass containers, two types of metal containers, and mixed metal scrap.

Many of these products are sold locally, for local use. One manager calls these "handshake markets," because they are friendly and personal.

QUALITY

Recycling obeys the laws of the mining economy: high-quality products generate the most revenue. The enterprises that make up Berkeley's serial MRF have generally been able to keep materials moving despite market fluctuations.

Variable disposal fees drive the system. Fluctuations in demand markets can be countered with fluctuations in rates.

Source separation pays off downstream. Processors get away with minimal sorting because materials arrive in a fairly pure state.

Each operator who was able to estimate their tonnages estimated residues of less than 3 percent of total throughput!

FRONT-END SCREEN

The principle of highest and best use creates a huge differential in prices among products. At the low end are broken toilets and broken bricks, given away to a local quarry. Soils and soil blends at American Soil Products are worth $18 to $42 per cubic yard, or $50 to $150 per ton. Studies Urban Ore has done show its overall materials are worth $400 to $500 per ton. At the high end, Ohmega Too takes the prize for the most valuable finished product—a floral terra cotta bathtub, vanity sink, and foot stool worth $48,000!

The reuse operators serve as a value filter for recycling. What doesn't sell for reuse generates clean recycling feedstocks from dismantling, cleaning, and quality control. Materials recovery facilities that put reuse ahead of recycling will enjoy higher incomes, and their residue will be less.

WHAT THE CUSTOMER SEES

Customers entering West Berkeley encounter a thriving mixed industrial, commercial, and residential district with thousands of people on the streets in trucks, vans, cars, and on foot, transporting supplies or hauling things for hire.

Home enhancement and enjoyment is a major theme in the area. Restoration-oriented businesses and bulk suppliers like lumberyards and sand and gravel companies abound, along with upscale eateries and specialty shopping boutiques. One of the city's largest homeless shelters is here, too.

The disposal businesses that make up the Berkeley serial MRF conform to local zoning, energy and sign regulations. They try to make their premises efficient and enjoyable for the customers. They educate the public every day, teaching people how to take advantage of all the recycling opportunities.

The Berkeley serial MRF extends the notion of value-added services. By increasing the information content of the entire disposal and reclamation system, it maximizes value conserved and value received.

Helping the Local Economy Grow

SERIAL MRFS HELP LOCAL GROWTH

Serial MRFs such as Berkeley's offer the local economy opportunities to grow. Participating organizations may have various backgrounds. In Berkeley's case, non-profit businesses run drop-off, buyback, and residential curbside collection programs. Locally owned for-profit businesses salvage for reuse and blend soils. All help the community by serving local buyers and suppliers, creating jobs, hiring local contractors, and supplying low-cost materials to upgrade housing and businesses.

Operators work together informally, refer customers to one another, and occasionally form working groups.

PUBLIC/PRIVATE PARTNERSHIPS

The City of Berkeley has shaped the Berkeley serial MRF by devoting land around and in its transfer station to recycling. It lets contracts with the Ecology Center and CCC for curbside, dropoff, buyback, and processing services. It contracts with Urban Ore for reusable goods salvaging and appliance recycling. Recently, the City signed a long-term contract with the Ecology Center that guarantees a rate of return sufficient for them to make major capital investments in trucks and machinery with confidence.

Communities can do a lot to help serial MRFs grow. For example, they can ask businesses to interview people from local placement programs. They can purchase the programs' products to repair City property. They can coordinate requests for state or federal financing. They can help with siting. They can insert information about services into municipal mailings to all residents. They can use the existing programs' success to attract more businesses.

ENTREPRENEURIAL ZEAL

The structures of the Berkeley serial MRF organizations are different: a municipal corporation, two for-profit corporations, two non-profit corporations and a sole proprietorship. A common theme among them, however, is that leaders have stepped forward to start and grow each program. Some leaders took the personal risk of the entrepreneur. Most of the leaders have the power to make quick decisions as necessary. Some are deeply motivated to help the planet, conserve resources, and build the community. All must be sensitive to diverse interests to do business in Berkeley.

Many of the Berkeley serial MRF operations owe their survival to an individual or two willing to fight passionately for the survival and expansion of a vision. Aspiring participants may need such able champions to survive and prosper.

TIPS FOR SUCCESS

Focus on a niche. The Berkeley serial MRF works well partly because each operator occupies a different niche, resulting in superior service yet minimal local competition.

Focus on your customers. Whether a supplier or purchaser, their satisfaction is the foundation of your success. For suppliers, charge a lower tipping fee for well-prepared materials; pay cash to some people; pick up materials if you can. For buyers, accept cash, check, or credit cards. Keep a list of what people want; develop products to match wants. Stay open seven days a week.

Add a fourth 'R'—*reduce, reuse, recycle, and RETAIL.* Expand your merchandising concepts. Get ideas from thrift stores, junk yards, warehouse clubs,boutiques, hardware stores, mail order catalogs. . .anywhere! Sell, sell, sell!

Be there for your politicians. Give your officials accurate information regularly, not just when a big decision is pending. Help educate the public. Go to important meetings. Explain industrial issues in plain English. Cultivate long-term relationships. The Berkeley serial MRF was put together through two decades of political give and take.

Find a good long-term site. Moving costs money and sales. If the area is likely to gentrify around you, be careful; you may be priced out of the market.

LEVERAGE THE GRASSROOTS

Community support may be a recyclers' greatest asset. Remember that in negotiating joint ventures with other companies, your community presence is part of your "goodwill," and can be expressed in dollars. Use your history of community service to increase your clout in the fishbowl atmosphere of discard management, where public officials can win or lose elections over recycling issues

Many of the Berkeley serial MRF operators came together initially in a grassroots campaign to defeat a mass burn plant. This coalition powerfully shaped the future by passing three initiatives in ten years that paved the way for the MRF's development. The citizens of Berkeley voted for recycling.

RELEVANCE TO CHICAGO AND OTHER CITIES

The experience in Berkeley is valuable to anyone who seeks alternatives to big systems for solid waste management in their city. Citizens defeated plans for an incinerator that would have foreclosed opportunities for jobs in materials reuse and recycling. They persisted until city officials supported a transfer station on the incinerator site. Individuals and organizations used the availability of materials to create enterprises that reuse and recycle specific materials. And public policy and local enthusiasm still combine to nurture evolution of activities that increase the value of discarded materials and benefit the local economy.

This report was prepared by David Stern and Daniel Knapp, Urban Ore. Map by Mark Gorrell. Edited by Bill Eyring, CNT; Mary Lou Van Deventer and Michael Casady, Urban Ore; Kathy Evans, consultant; Jim Liljenwall, City of Berkeley.

FOR MORE INFORMATION

Urban Ore, Inc 510/559-4454
The City of Berkeley,
Department of Public Works ... 510/644-8892
American Soil Products, Inc 510/540-8011
Ohmega Salvage, Ohmega Too .. 510/843-7368
Community Conservation
Centers, Inc 510/524-0113
Ecology Center, Inc 510/527-2580
Center for
Neighborhood Technology.........312/278-4800

RELATED CENTER PUBLICATIONS

To order call Bridget Torres (312)278-4800, Ext. 140 or write *The Neighborhood Works*, 2125 W. North Ave., Chicago, IL 60647.

An Alternative to the City of Chicago's Northwest Incinerator: Reducing Waste, Stimulating Economic Development and Creating Jobs Instead of Pollution, by Bill Eyring, Kevin Greene and Franklin Lomax. $5 + $2.50 handling.

Opportunities in Neighborhood Technology to Improve the Environment and Create Jobs, Number 1: Reusing and Recycling Tires, by Bill Eyring and Stephenie Lowe.

Beyond Recycling: Materials Reprocessing in Chicago's Economy, by Nina Sandlin and Bill Eyring Examines the scope, economic possibilities and barriers to broad-scale materials reprocessing as an environmental and economic development strategy. $10 + $2.50 handling.

Successful Community Based Recycling, by Bill Eyring and Christina Scheidt Analysis of what makes a community recycling program work. $5 + 2.50 handling

No Time to Waste: How Communities Reap Economic Benefits from the Shift to Recycling, by Patrick Barry Demonstrates how recycling can become an economic development opportunity for cities and low-income neighborhoods. $5 + 2.50 handling

The Neighborhood Works: Building Alternative Visions for the City, Award-winning, bi-monthly magazine brings news on community approaches to housing, energy, environment, transportation and economic development. six issues. $30.

Opportunities in Neighborhood Technology is published occasionally by the Center for Neighborhood Technology to inform others who are seeking ways simultaneously to improve the environment and create jobs.

AT&T This issue of Opportunities in Neighborhood Technology was written and produced with the special assistance of AT&T. Additional support was provided by The Prince Charitable Trusts and the Moriah Fund.

Center for Neighborhood Technology
2125 W. North Avenue
Chicago, Illinois 60647

NON-PROFIT ORG.
U.S. POSTAGE PAID
PERMIT NO. 9665
CHICAGO, IL 60647

215 WBE Certified
Printed with soy ink on chlorine free 100% post consumer waste recycled paper.

Appendix B

URBAN ORE, INC.

1333 Sixth Street • Berkeley • CA 94710

General Store (510) 559-4450 **Building Materials Exchange** (510) 559-4460
Information Services (510) 559-4454 **Administration** (510) 235-0172

The Bay Area's Prospects For Total Recycling

by Daniel Knapp

(This article was first published in the Bay Area Green Pages, *Stephen C. Evans, Ed., Green Media Group, PO Box 11314, Berkeley, CA 94701, 1990.)*

Thanks to more than a hundred healthy and growing recycling enterprises, Bay Area cities are replacing unpopular landfills with a comprehensive recycling system. Many elements of this system are already in place. How long it takes to supplant the garbage manufacturing industry will depend on complex factors such as how high and how fast garbage user fees rise; how aggressively recycling entrepreneurs compete for scarce land and financing; and how successfully current attempts reform the overall legal and regulatory structures.

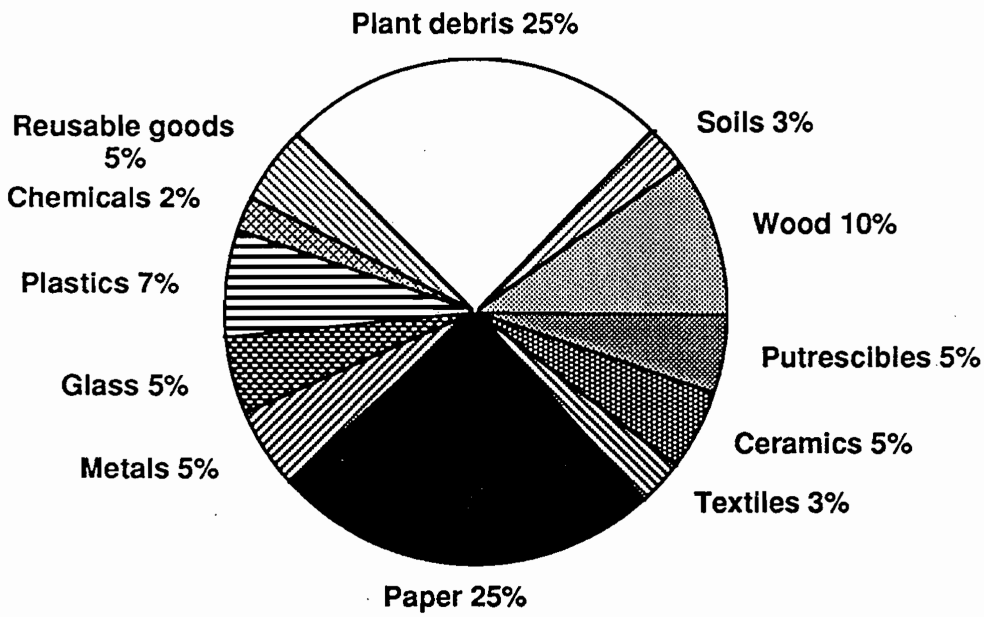
Garbage is not one of nature's own products. A well-capitalized industry manufactures it by routinely mixing all discards together, thus degrading them. Recyclers are developing an increasingly competitive disposal technology that keeps discarded materials separate by category, then classifies, processes, and upgrades them. The garbage system organizes its efforts according to the lowest common denominator, while the recycling system organizes by the highest and best use.

Recycling works because, underlying the chaos, mystery, and even taboo of garbage, there is an order. The Bay Area can take some of the credit for discovering its true profile. Part of the process has required looking at everything that arrives at the landfill or transfer station. The City of Berkeley, for example, commissioned five increasingly sophisticated garbage composition studies over the last three decades.

But a study can report only what its categories let it see. The early ones left out a lot of recyclable categories. That omission propped up the myth that we throw away a lot of undefinable "miscellaneous" stuff, and therefore the curse of garbage will always be with us. In fact, this incompleteness was an underlying factor in the incinerator battles that raged in Berkeley during the early 1980s. Burner backers reasoned that studies showed recycling couldn't handle everything, so the city needed a dump-equivalent, or we would have garbage in the streets. But Berkeley voters rejected the incinerator and called for intensive recycling.

Then in 1988-89, Berkeley commissioned a year-long composition study using a set of categories that covered everything. When the results were published, the garbage fraction simply disappeared. It was replaced by twelve clearly-defined categories of material that are wholly or partially recyclable right now. This development has already allowed Berkeley planners to shift their attention away from creating a higher-tech garbage system and to focus on designing its replacement

What are these categories? What proportion of what we waste does each represent? The answer for any particular locality can be given only after careful study of local discards. But in 1988 I proposed a generic picture that has proven very useful and versatile in various applications, including the Berkeley study mentioned above.



This version of the chart ©1989 Daniel Knapp and Mary Lou Van Deventer. Excerpted from *Total Recycling: Realistic Ways to Approach the Ideal,* in progress; to be published by the University of California Press.

Recycling the Twelve Master Categories

Only two of the twelve master categories — plastics and chemicals — pose any great technical difficulties for recycling, and they amount to less than ten percent of the total volume now wasted. All the rest are eminently recyclable given relatively modest investments of time, energy, land, and money.

Yard debris and putrescibles (such as food) are recycling soul-mates, completely recyclable if composted. Together they make up about one-third of what currently goes into our landfills.

Composting is the largest single disposal technology, because in addition to handling yard debris and putrescibles, it can take parts of the ceramics fraction (mineralized dust and sand); soils; paper recycling residues; and most otherwise unrecyclable organics, as long as they are nontoxic. Capital requirements are low. The limiting factor is land, although here, too, there is a solution if we have the political will and courage to use it.

Metals recycling has probably the best-developed industry of all the categories, and virtually all of the metals fraction is recyclable. About 60% of the steel produced in the US is made from scrap, and the metal scrap industry has been around for centuries.

Paper recycling is increasing rapidly as manufacturers invest in more fiber reclamation plants, responding to increased supplies of postconsumer paper and demand for recycled paper.

Glass manufacturers claim their product is totally recyclable as long as the batches contain no ceramic contamination. But even contaminated glass can be treated as lower-grade ceramic and made into sand and gravel for use in cement or asphalt.

Ceramics, which by molecular structure include rock, brick, crockery, cement, and even asphalt, are 100% recyclable using conventional quarry equipment. The crushed products are suitable for various uses, including road beds and landscaping components.

The ten-year experience of my company, Urban Ore, demonstrates that reusable goods are virtually 100% recyclable, since the amount we spend on discarding our wares as unsalable is a miniscule half-percent of our annual gross income. We have also learned that virtually any piece of wood that is whole and denailed can be sold. What can't be sold for reuse can be ground up and composted.

Textiles have a substantial reusable component, but those that can't be sold for reuse can be fed into fiber reclamation systems. As a last resort, natural-fiber textiles can be composted.

Even the hard-to-handle categories of plastics and chemicals are currently the subject of intense research and development. The key players here are the manufacturers, who want to keep producing, and progressive politicians, who are banning products and increasing regulatory pressure on industries that willfully go on producing things that are troublesome or impossible to recycle.

A comprehensive system that recycles everything and wastes nothing — a total recycling system — will handle all (or nearly all) the discarded materials from every category. No place to my knowledge contains a fully developed system. But in the Bay Area, we have key elements already in place. Many businesses exist whose purpose is to recover discards and convert them into resources, and they have already formed a network.

One of the best ways to find these businesses is to participate in the Northern California Recycling Association, a trade association. NCRA membership is open to anyone for just $35 a year. People who want to join can mail a check for $35 to NCRA Treasurer, PO Box 5581, Berkeley, CA 94705. Anyone can also come to the monthly meetings to see what the group is like before joining.

Recycling businesses take many forms. There are sole proprietorships, partnerships, and nonprofit and for-profit corporations. There are municipal enterprises and privately-owned ones. There are businesses that collect and haul recyclables; that process and upgrade them; that manufacture new products using recycled feedstocks; and that sell the finished products. Some businesses combine two, three, or even all of these functions. There are garbage companies that are converting themselves as rapidly as they can to become recycling companies.

The Golden Gate Disposal Company, the Sunset Scavenger Corporation, and Marin Sanitary Service are three large garbage companies that are innovators in the recycling field. They operate materials recovery facilities (MRFs), which handle feedstocks of mixed materials. The cities of El Cerrito, Berkeley, San Francisco, Palo Alto, Mountain View, and San Jose are noted for their strong commitment to recycling. Berkeley and El Cerrito even operate recycling businesses themselves.

Berkeley's Ecology Center and Community Conservation Center are nonprofit curbside and buyback programs that helped pioneer the field in cans, bottles, and paper, and are notable for outstanding promotion of recycling and educating the public on how and where to do it. Other nonprofits handling similar materials include San Francisco's Richmond Environmental Action and Haight-Ashbury Recycling Centers and the San Francisco Community Recyclers; Tri-City Ecology Center of Fremont; Contra Costa Community Recyclers; and Sonoma Community Recyclers. There are too many more to include here.

Urban Ore, Encore!, West Coast Salvage and Recycling, and Pacific Rim Recycling are some of the better-known for-profit corporations, but there are many others. Standard Metals and Levin Metals Corporation buy metals and upgrade them. American Soil Products blends and sells bulk soils, compost, and soil amendments. American Rock and Asphalt operates several quarries that accept cement, asphalt, and other ceramics that the company turns into various sand and gravel products. In 1989 they handled 350,000 tons of these materials, a large contribution to a growing recycling rate.

The list could go on, but the point is clear. All of the twelve categories are being recycled in some proportion right now in our area. The prospects for total recycling are excellent, as far as underlying business structure goes.

Legal and Regulatory Changes Would Help

Legislative underpinnings are another matter. Recycling is not structured into disposal rates, for example, so recyclers are expected to finance their entire businesses by selling materials. They are also frequently given short-term contracts with cities. Meanwhile, garbage companies performing inferior disposal services and creating long-term liabilities are entirely financed by long-term exclusive franchises that provide them with comfortable profits. Recycling could use a little leveling of the playing field.

To outline the resources available to recyclers, more cities need to do composition studies that measure all twelve master categories. Too much of our local information about garbage and recycling is simply imported from national studies. Those studies extrapolate from manufacturing data instead of measuring actual discards, and they use limited or poorly defined categories. There is no substitute for actually going out and measuring what is happening. Lacking good empirical work, we must guess at quantities. Serious mistakes are inevitable. And expensive.

Recycling needs room, too. A compost operation takes acres, but it produces valuable humus. The surfaces of closed landfills are now devoted to becoming parks while recycling industries cry for low-cost land. They should be opened for use as comprehensive recycling centers. An environmentally responsible concept of park development would let some parts of these lands be recycled into a solution to the garbage crisis. Visitors to such an environmental park would be told that garbage created the land, but using it for land-intensive recycling systems can slow or stop the march of landfills into unspoiled rural areas.

These ideas involve changes in legislative and regulatory structures. That means new laws.

One proposed law, the Alameda Recycling Initiative, was written by Bay Area recyclers and environmentalists to accomplish many of the purposes outlined above. The initiative will be on the November 1990 ballot. It adopts the twelve master categories as its conceptual base. It proposes a surcharge on garbage dumped in landfills, and the proceeds would fund recycling systems for any or all of the twelve categories. By driving up the cost of dumping mixed garbage, it makes landfilling less competitive. At the same time, it recommends that cities provide different sized containers and charge garbage-user fees based on actual volumes wasted, so people who waste the most pay the most.

But although this homegrown measure is innovative, California as a whole has fallen far behind other states in legislation. Illinois, for example, banned plant debris from its landfills starting in July, 1990, and for three years has been collecting a garbage surcharge earmarked for recycling. Wisconsin passed a law last year that is even more ambitious. By 1995, yard debris, metal, glass, paper, and several other materials amounting to over 60% of the total discard supply will be banned from landfills. The same law appropriated almost $20 million for recycling development.

Obviously, good laws can stimulate recycling and help build a thriving industry. Other states have found that their people's interests lie in bold legislation. California passed AB 939, which has been highly touted, but it fails to provide the fundamental economic restructuring and incorporation that recycling deserves. Its concepts of recyclable materials are also seriously flawed.

But legislation is the map, not the territory. It is not the same as business development. California has always been a place where innovative businesses take root and prosper, and the overall climate for recycling businesses has never been better.

Even if the state's legislative development remains sluggish, recycling businesses have an enormous competitive advantage over garbage businesses. Whether they are helped or hindered by laws, they will find ways to go after the ever-more-attractive supply of discards. From small and large niches, they will whittle away at the supply. As they do, they will generate jobs, produce income, and pay taxes. Recycling provides a superb industrial frontier for people who want to make a living in an environmentally sound way.

Appendix C

Outline of Processing Options for Materials Handled by an Integrated Resource Recovery Facility

by John Hannon Martin, Ph.D.

CRITERIA FOR LOCAL COMMUNITY ECONOMIC DEVELOPMENT:

1. maximize economic benefit
2. use least cost technology
3. provide a diverse economic base to limit dislocations caused by changing market conditions
4. keep recycling local - to reduce cost, retrieve resources, build local markets, and retain capital.

HIERARCHY OF DISCARD MANAGEMENT OPTIONS:

1. reduce
   - encourage manufacturers to reduce packaging and product materials, design and produce for durability.
   - educate citizens to selectively shop, buy quality and durability, don't buy what they don't really need, repair and properly maintain products to extend life cycle. ("Fix it up, wear it out, make it do, do without.")
2. reuse, repair, remanufacture
3. recycle
4. compost
5. minimal landfilling
6. no incineration

RECOVERY OPTIONS BY MATERIAL TYPE

PAPER

Paper products make up a significant part of the discard supply. Paper fibers degrade over a period of time and cannot always be recycled into more paper products. Paper products can be contaminated, often by foodstuffs, limiting options for fiber recovery. Historic market fluctuations force us to investigate possibilities for more local uses, such as in agriculture.

Hierarchy of products and processing methods:

- reuse as -is (rare paper, art objects)
- reuse as art materials (handmade paper, collages, school supplies)
- packing material - shred for use as-is
  Example: Eco-Pak, Kent, WA
- cellulosic insulation - shred, add borax as fire and insect retardant
  (generic cellulosic insulation plant costs $500,000-750,000)
- pulped paper products - shred, blend and form egg cartons. trays, planting pots
  Example: Fibreform Containers, Inc., Germantown, WI - $150,000[1]
  Example: Molded Fiber Technology, Westbrook, ME - $ 1.5 million
- mixed paper and agricultural straw thermal/acoustical panels
  Example: Pan Terre - [1]
- sell to fiber recycling markets - bale/ship all grades with positive market value
- cattle feed - shred and bale clean overrun paper from printers
- animal bedding - shred and bale newspaper stock
  (OCC has also tested well for this)
- spray mulch - shred, bale and dip paper and card stock
  Example: 181 roadside hydroseed project, VA Highway Dept[1]
- compost - all paper and card stocks, shredded
- vermiculture - composted to create worm castings, a valuable soil builder
- shred and densify newsprint and OCC to replace cordwood or fuel cubes
- shred and hydrolyze wood byproducts to make methanol

Processing equipment:

- shred - paper shredder, tub grinder
- bale - hay baler, conventional paper baler
- composting - windrow method, tractorloader, manure fork, compost turner
- vermiculture - worm culture
- paper molding - paper pulping/molding machine
- making fuel cubes - lease commercial portable densifier/cuber
- hydrolyzing - destructive distillation equipment
- multi-use - forklift, screener, manure spreader

PUTRESCIBLES

Putrescibles are a portion of the discard supply consisting mainly of food, manures, and other nutrient-rich biodegradable materials, together with enough water to cause them to start decomposing immediately.

Hierarchy of products and processing methods:

- make fresh food discards into animal feed - cook to sterilize
- at-home compost and vermicompost - reduced; withheld from waste stream and converted to products for at-home use
- source separated food and sludges - collected separately to prevent cross-contamination with other materials
- commercial compost - residential putrescibles mixed with plant debris, wood, and sludge
- land application - sludge, other liquids.

Processing equipment:

- shred - forage chopper, tub grinder
- compost - windrow method, tractorloader, manure fork, compost turner
- vermiculture - bins, greenhouse or shed
- densify - commerciual portable densifier/filter press
- hydrolyze - destructive distillation equipment
- multi-use - screen, trommel, manure spreader

WOOD

Dimension lumber and plywood often comes in pure loads from construction and demolition projects. Source separation could be encouraged by differential tip fees, including purchasing, and by educating contractors in non-destructive disassembly and materials handling.

Hierarchy of products and processing methods:

- reusable goods - salvage and sell (or trade or give away) products like furniture, pallets, lumber, etc., that can be used as-is
- repairable products - do minor repair or clean-up of similar products for sale, trade, or give-away
- reusable products - create a community fix-it shop where people can utilize shared tool pool and receive guidance to do their own repairs or reconditioning of items such as furniture.
- reclaim component parts and sell
- mulch - grind
- compost - grind and blend with other compostables
- wood product feedstock - grind and sell chips for particleboard production, or chips or sawdust for paper production
- livestock or poultry bedding - grind or chip
- livestock feed - wood without paint or chemical treatment
- firewood - cut, split, bundle into cords or smaller lots
- fuel cubes - grind, then compress
- methanol - hydrolyze (destructive distillation)

Processing equipment

- hand tools
- log splitter
- tub grinder
- shredder
- composting equipment similar to that listed for paper
- densifying equipment for fuel cubes or "logs"

PLASTICS

Plastics range from 7% to 9% of residential discards by weight, and from 16% to 21% by volume. Figures are not available for discard rates from commercial, institutional, and industrial sources, but they vary widely by regional economic base. For instance, university towns generate higher amounts of durable plastic discards such as computers and electronics, while agricultural areas may produce large quantities of mulching film, chemical containers, and the like. As a general rule, the plastics discard stream is roughly 45% film products, 45% rigid products, and 10% other forms, such as foam, fibers, and composites.

Most plastics do not decompose readily and should be carefully separated from other materials destined for processes such as composting. Plastics recycling markets are still quite limited, and most types will still have to be routed to landfill, at least for the next few years. Plastics most likely to be marketable currently in West Virginia are PET containers such as soft drink bottles, peanut butter jars, etc., and both pigmented and unpigmented HDPE, such as detergent bottles and milk jugs

Until markets improve, the recommended strategy is to encourage source reduction by manufacturers, and educated shopping by citizens. For example:

Manufacturers

- encourage packaging producers to utilize easily recycled resins such as PET and HDPE
- encourage manufacturers to reduce or avoid additives, blends, pigments, and multi-layers of different resins.
- encourage lightweighting of containers, design for reusable and returnable containers, and design for recycling-friendly packaging
- encourage use of less complex resins and simpler package designs that eliminate overwraps and multi-components.

Citizens

- educate consumers to select alternative products, such as paper plates and cups, glass and metal packaging
- generally foster shopping for goods made of reusable, compostable, and recyclable materials
- encourage the public to refuse extra packaging such as plastic produce bags
- encourage the reuse of plastic packages such as margarine tubs suitable for food storage.

Hierarchy of products and processing methods:

- feedstocks for PET markets - separate softdrink bottles from other PET containers, color-sort, bale
- feedstocks for HDPE markets - separate bottle grade from other types of HDPE (tubs, other wide-mouth items) and from other resins, sort into natural and pigmented, bale
- other easily segregated plastics for which markets exist - source separation of plastic grocery bags and pallet stretch wrap collected from stores, and baled on-site or at IRRF
- shredded or cut plastic strips - to give tensile strength to concrete, to be woven into mats
- floor covering - shred to small pieces, then remanufacture
- mixed plastic molded products - extruded "lumber" for outdoor and agricultural uses, floor slabs, large, bulky, or thick products such as cable reels, pallets, grates, and litter receptacles.

Processing equipment:

- simple sorting line
- conveyor-fed rear-loading vertical baler
- shredder
- granulator
- mixed plastic molding system and peripherals
- forklift and other material handling equipment , such as bins

TEXTILES

Hierarchy of products and processing methods:

- buy quality
- extend life cycle with proper maintenance
- sell or donate for reuse
- bale and ship to textile processor
- cut into rags
- make filtration media
- byproducts such as lint to high-grade paper; cotton or linen rags can also go for paper-making
- compost
- for synthetics, see "plastics"

Processing equipment

- industrial cutting machines
- industrial washers and driers
- baling or boxing equipment for shipping
- composting – see equipment under "putrescibles"
- vermiculture – see equipment under "putrescibles"

METALS

Hierarchy of products and processing methods:

- repair for reuse; sell
- discarded reusable items such as tools, bicycles, appliances – sell as-is in store atmosphere
- discarded reusable items such as angle, bar, plate, pipe - to building material yard.
- mixed scrap metal feedstocks - sort, dismantle and clean to identify reusables, remove contaminants, and upgrade to recycling industry specifications
- demolition debris – use labor or magnets to separate scrap metal; further sort onsite into ferrous and nonferrous
- container metal feedstocks - citizens source separate or collect commingled and separate at IRRF using magnets
- convert irony aluminum to pigs onsite using sweat furnace
- use machinery to strip coatings off wire
- recover rare metals such as mercury (switches, electrical) and gold (computer scrap)

Processing equipment:

- hand tools
- magnetic separator (cheap), eddy current separator (expensive)
- conveyor systems
- metal shredders and cutters
- sweat furnace
- biscuiting equipment for aluminum cans
- industrial baler for aluminum scrap and steel cans
- forklift

PLANT DEBRIS

Hierarchy of products and processing methods:
- live plants - resell
- chip very coarse for sludge bulking agent
- grind coarse for mulch – spread for erosion control
- grind, chip, or shred – compost in windrows
- sheet compost – spread on land and till in
- silage - grind
- grind and pelletize for livestock feed

Processing equipment:
- forage chopper or tub grinder
- baler
- loaders
- bins for worm culture
- densifier/cuber
- destructive distillation equipment
- screen or trommel
- manure spreader

GLASS

Hierarchy of products and processing methods:
- reusable bottles and jars, returnable bottles - sort, pack, and sell
- furnace ready cullet - color-sort, crush, ship to glass container markets
- aggregate - crush, tumble, and screen
- aggregate fill tubes for drainage - crush and tumble
  Example: Glass Aggregate Corp., Grand Rapids, MI [1]
- glassphalt - crush and tumble to make aggregate
- abrasives (for sand-blasting, etc.) - crush fine and screen
- glass blocks, tiles - color sort, crush, screen, melt, and mold
- sand - crush fine, screen

Processing equipment:
- sorting table or line
- racks
- screens
- glass crushers
- tumbler
- small scale glass furnace
- molding equipment
- hard tire forklift/loader
- safety gear
- material handling containers

CERAMICS

Hierarchy of products and processing methods:
- sinks, dishes, toilets – sell as-is
- reusable stones - palletize or containerize for landscaping or building walls
- tile, bricks, roofing, steppingstones – clean, palletize, sell as-is

- demolition debris – put into tank of water to separate wood and paper from ceramics and metals
- landscape gravel or sand – color separate to red (brick), gray (concrete), black (asphalt), and white (china), then crush and screen
- roadbuilding – crush and screen coarse
- clean fill - mix all types, then crush
- general-purpose aggregate - mix all types, then crush and screen

Processing equipment:
- hammermill, cone crusher
- screen
- tumbler
- stacker
- loaders
- forklifts

SOIL

Hierarchy of products and processing methods:
- clean topsoil - reuse as is
- contaminated soils – accept for tipping fee; clean up using bioremediation, screening, other methods
- graded subsoils and rock - pulverize and screen
- compost - blend with humus to produce a mineralized soil blend

Processing equipment:
- hammermill
- screen or trommel
- tumbler
- wheel or track loader
- manure fork-compost turner
- manure spreader

REUSABLES

Hierarchy of products and processing methods:
- reusables, repairables - grade and market via different types of resale stores
  Examples: ReStore, Montpelier, VT; Urban Ore, Berkeley, CA
- reusable building materials - sort, grade, resell
  Examples: Wastebusters, Staten Island, NY;Loading Dock, Baltimore, MD; Urban Ore, Berkeley, CA
- reusables that don't sell – dismantle, sort for parts
- reusable parts that don't sell – scrap as appropriate

Processing equipment:
- hand and power tools appropriate to materials
- computer to track materials
- cash registers
- racks, shelving, display cases
- forklifts and trucks
- full range of recycling and composting equipment, as above

CHEMICALS

Hierarchy of products and processing methods:

- eliminate
- replace nonbiodegradable chemicals with biodegradable substitutes
- reduce toxicity
- reuse
  - Example: Sonoma Community Recyclers Recycletown (paint)
- recycle
  - Example: CRT, Bridgewater, MA (oil filters)
  - Example: Central Texas Diesel Injection Service, Austin, TX (oil filters)
  - Example: Eco System, Thomasville, GA (paint)
- bioremediate
- bury in hazardous waste landfill
- burn

Appendix D

DEVELOPMENT OF INTEGRATED RESOURCE RECOVERY FACILITIES

By Robert Diener, P.E.
Professor of Agricultural Engineering
West Virginia University

Recovery of materials is critical to reducing demand for more landfill space in the United States. Reuse, recycling and composting can divert up to 90% of the discards from landfills in an ideal situation (Diener et. al, 1993). However, recovery rates this high will require public education and commitment, and economic pressure.

The West Virginia population is generally committed to reuse, recycling and composting so long as there are convenient, economical, and dependable collection facilities. The economic basis for reusing, recycling, and composting increases as tipping fees approach $50/T in some parts of the state. This rise in the tipping fee pushes recycling because by delivering reusables, recyclables, and compostables to a local IRRF, part or all of the high cost of disposal as waste can be avoided.

Discards such as plant debris that have a low value to volume ratio cannot be economically hauled long distances to large regional IRRF's, but first have to be processed or high-graded at a local IRRF. **A local IRRF for a 25T/D waste stream may not be able to process every discard category but may merely store some in containers/trailers for shipment to a large regional IRRF.** Such a regional IRRF would be in the 100 T/D capacity range, similar to that required for counties having large populations.

BREAKDOWN OF DISCARD CATEGORIES

In order to develop the IRRF concept, discard categories need to be identified and then further broken down into recovery subcategories. Table I shows expected composition, by weight, entering IRRFs.

TABLE I - Composition of Discards Entering IRRF's with 100 T/D and 25 T/D Capacity

Discard Category	25 T/D IRRF	100 T/D IRRF
Compostable (T/D)		
Paper	6.9	32.9
Plant Debris	3.9	15.2
Wood	2.6	8.9
Reusables	0.8	2.8
Putrescibles[a]	1.5	6.4
Soil	1.5	4.7
Textiles	1.0	3.1
Chemicals	0.03	0.1
Non-compostables (T/D)		
Plastics	1.9	13.0
Glass	1.2	3.9
Metals	1.4	4.2
Ceramics[b]	2.27	4.8
TOTALS (T/D)	25	100

[a]Food, sludge
[b]Bricks, concrete, rock, asphalt

BREAKDOWN OF RECOVERY CATEGORIES

The discards presented in Table I are not useful in the analysis of an IRRF until they are presented in recovery categories that the IRRF is designed to process. Three recovery categories used in this study are:

REUSE - *Materials which can be reused as-is or after refurbishing.* For example, used books have a high reuse potential. Many materials such as furniture, appliances, etc. left at curbside or delivered to landfills have reuse potential if that option is made available. No national data is available as to the percent of discards which might be diverted to reuse. A nominal value of 20% developed by Diener et. al, (1993) is used in this study. This value assumes a functioning reuse center is available of the IRRF and that a collection system is operating which recognizes reusables and saves them from damage during handling.

RECYCLING - Recyclable materials are *materials which can be broken down into this* *basic structural or elemental components and made into identical or different products.*

The amount of materials which may be recycled is variable. Markets, contamination and economics all play a factor. For example, paper, depending on a variety of factors could be reused, recycled, composted or landfilled.

When combined with composting, residential recycling programs have been shown to divert an average of 12% (for voluntary programs) to 21% (for mandatory programs) of the MSW stream (Folz, 1991). Diversion of up to 70% of the residential waste stream is possible when all recyclable and compostable materials are removed (Beyea et al., 1992).

The nominal value of 25% used for IRRF's in this study was developed by Diener et al., (1993) and assumes a functioning recycling center is available at the IRRF.

COMPOSTING - A process in which *organic materials are broken down by aerobic microbial action into a humus material.* When starting an IRRF, composting should be the first option developed because there is always a market for the end product.

Up to 45% of the waste stream can be realistically diverted by composting (Diener et al., 1993). This value was realistically determined by evaluating reuse, recycle and landfill options with respect to composting. As an example, paper can be reused or recycled, but if markets are not favorable or the paper is contaminated, then composting or landfilling become options of choice. Municipalities in West Virginia over 10,000 population should be able to implement a plant debris composting program as part or all of their effort to comply with state mandated curbside recycling standards. To use composting in this manner, municipalities must specify plant debris as a recyclable material, and their recycling plan must receive approval from the SWMB. The SWMB has indicated a willingness to favorably consider this option.

As a priority investment, concentrating on composting has a number of advantages compared to conventional curbside recycling programs. Collection and processing costs for composting tend to be lower. Plant debris collection and compost processing costs have been shown to range from $15 to $60 per ton (Derr 1988, Taylor and Kashmanian 1988, Spielman 1988). Curbside recycling costs for collection and processing, including revenue from recyclable materials, have ranged from $40 to $150 (Minnesota Project 1987; Curless and Das 1991). Stucky and Tyner (1991) computed slightly lower costs for the collection of compostables as part of MSW management as compared to curbside recycling. Additional advantages of composting include:

(a) fluctuating national markets are less a problem for composting since local markets exist. Examples are nurseries, top soil distributors, applications on municipal parks, roadsides and farmlands;

(b) plant debris will be banned from landfill disposal as of June 1, 1994, and composting provides a disposal outlet for this material;

(c) separation of plant debris by residents should be easier than other recyclable materials (glass, aluminum, paper, etc.) since it is commonly kept separate from other household discards when placed at curbside for collection; and

(d) diversion of plant debris (leaves, grass and brush) from the landfill can result in a substantial (15%-20%) reduction in the material being landfilled (U.S. Congress 1989).

TABLE III - 100 T/D IRRF[1] INPUT VS RECOVERY POTENTIAL

DISCARD CATEGORY	INPUT TOTAL (T/D)	RECOVERY POTENTIAL			
		REUSABLES (T/D)	RECYCLABLES (T/D)	COMPOSTABLES (T/D)	LANDFILLS (T/D)
COMPOSTABLES					
PAPER	32.9	3.1	8.2[2]	18.3	3.3
PLANT DEBRIS	15.2	0.1	-	13.6	1.5
WOOD	8.9	3.5	-	4.5	0.9
REUSABLE/SALVAGE	2.8	1.9	-	.6	0.3
PUTRESCIBLES	6.4	-	-	5.8	0.6
SOIL	4.7	1.8	-	2.4	0.5
TEXTILES	3.1	1.3[3]	0.3	1.2	0.3
CHEMICALS	0.1	0.05[4]	-	-	0.05
SUB-TOTAL	74.1	11.75	8.5	46.4	7.45
NON-COMPOSTABLES					
PLASTIC	13.0	3.3[5]	8.4	-	1.3
GLASS	3.9	1.6[6]	2.3	-	0.4
METALS	4.4	0.8	3.0	-	0.4
CERAMICS	4.8	1.4	2.9[7]	-	0.45
SUB-TOTAL	25.9	6.75	16.6	-	2.55
TOTAL	100	18.5	25.1	46.4	10

[1]If sludge is considered, add 10 T/D for 100 T/D facility and 2.5 T/D for 25 T/D facility.

[2]Magazines are now in demand because clay can be removed from "slick" pages by floatation techniques and used to floatate newspaper pulp. Computer paper is in demand for recycling because of its long fibers. Demand for office paper is diminished because of the plastic windows in envelopes.

[3]Clothing, rags

[4]Paint, cleansers, solvents, etc.

[5]Chairs, baskets, toys, etc.

[6]Deposit bottles, etc.

[7]When crushed into gravel

TABLE IV. INPUT VS RECOVERY FOR A 25 T/D IRRF

DISCARD CATEGORY	INPUT TOTAL (T/D)	RECOVERY POTENTIAL			
		REUSABLES (T/D)	RECYCLABLES (T/D)	COMPOSTABLES (T/D)	LANDFILLS (T/D)
COMPOSTABLES					
PAPER	6.9	0.7	1.7	3.8	0.7
PLANT DEBRIS	3.9	0.1	-	3.4	0.4
WOOD	2.6	1.0	-	1.3	0.3
REUSABLE/SALVAGE	0.8	0.4	-	0.2	0.2
PUTRESCIBLES	1.5	-	-	1.3	0.2
SOIL	1.5	0.5	-	0.8	0.2
TEXTILES	1.0	0.4	0.2	0.3	0.1
CHEMICALS	0.03	0.02	-	-	0.01
SUB-TOTAL	18.23	3.12	1.9	11.1	2.11
NON-COMPOSTABLES					
PLASTIC	1.9	0.5	1.2	-	0.2
GLASS	1.2	0.4	0.7	-	0.1
METALS	1.4	0.2	1.0	-	0.2
CERAMICS	2.27	0.27	1.8	-	0.2
SUB-TOTAL	6.77	1.37	4.7	-	0.7
TOTAL	25	4.49	6.6	11.1	2.81

SOME DESIGN PARAMETERS FOR COMPOST FACILITIES IN WEST VIRGINIA

By Dr. Robert Diener, P.E.
Professor of Agricultural Engineering
West Virginia University

West Virginia produces about 4,200 tons[1] of MSW (municipal solid waste) and an estimated 430 tons[2] of sewage/septage sludge daily.

Facility designs are presented for both 100 T/D and 25 T/D IRRFs with consideration for local sludge added.

ASSUMPTIONS:

Assumptions for the design exercise are:

1. Sludge tonnage entering the IRRF is based on the state average of 10% of MSW by weight. Use 20% solids for sludge.
2. Uncompacted density of MSW organics is 350 lb/CY. Sludge cake density is 1500 lb/CY.
3. MSW organics are reduced 50% by volume during grinding and mixing.
4. Moisture content of incoming MSW organics is 30% w.b.
5. Organics are composted in windrows that are parabolic in shape with a cross-sectional area of 2/3 base x height and an average moisture content of 40% w.b. Use 12' base, 6' height and 12' aisles between windrows. See Figure 1.
6. A 50% volume reduction occurs during composting and a 25% volume reduction occurs during curing.
7. A 40% loss of volatile solids occurs during the composting process.

---

[1] Diener, R.G., A.R. Collins and J.H. Martin. West Virginia Solid Waste Management: A 1993 Status Report and Blueprint for the Future.

[2] Based on 0.24 T/D sludge w.b./1000 capita and 4.68 MSW/person/day.

8. A 50% weight reduction occurs during the composting process.

9. The composting process is started at 50% moisture content w.b. with added moisture as required.

10. Windrows are aerated using a down-draft negative pressure sized at 25 CFM/T of dry matter[3]. Exhaust pipe is limited to 80 feet maximum length and sized for 2,000 FPM maximum velocity. Inlet holes are double row spaced at 12 inches on center. Area of the holes is twice area of the pipe.

11. Air exchange in the compost facilities is sized at 8 exchanges/hour (winter) and 16 exchanges/hour (summer).

12. Curing area is static pile design with positive pressure at 2 CFM/TDM.

13. Use 30 days retention in windrows and 30 days retention in curing area. Use 8' height for curing area. See Figure 2.

FACILITY DESIGN:

Compost faciility designs are based on 100 T/D and 25 T/D IRRFs with 10% local waste water treatment sludge by weight additional.

A compost facility is divided into four distinct sections according to function:

1. receiving, grinding, mixing
2. composting
3. curing
4. finishing - screening, packaging, shipping

Composting (Figure 1) and curing (Figure 2) require designers to determine size/volume requirements of the composting windrows and curing pile, aeration requirements and other considerations. A summary of these requirements is given in Table 1.

---

[3] The value of 25 CFM/T of dry matter is used for windrows composed primarily of yard waste, paper, wood, manures with small amounts of food waste, sludge and other volatile materials added. This value assumes the windrows are mechanically agitated and that the blowers operate in a 1/3 ON-2/3 OFF sequence. If air flow alone is used for cooling with mechanical agitation, then a higher level of air flow is required. If the windrows are primarily composed of sewage sludge or food waste,e specific values of air flow will need to be determined on a case-by-case basis.

FIGURE I
AERATED WINDROW LAYOUT

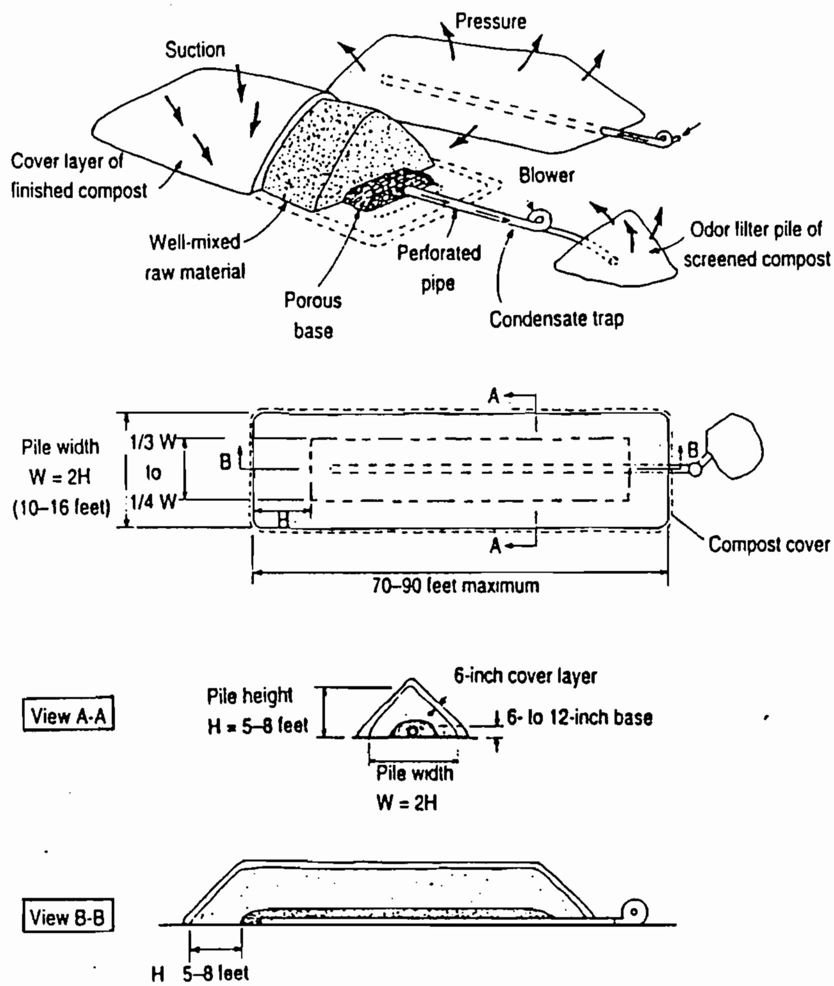


Figure 1. Layout of Aerated windrows showing dimensions, location of aeration pipe (negative pressure) and elementary bio-filtering of odors (6'x12' windrows/12' w.b.). (On-Farm Composting Handbook, Cooperative Extension, Ithaca, NY 14853-5701).

FIGURE 2
DESIGN OF AERATED STATIC CURING PILES

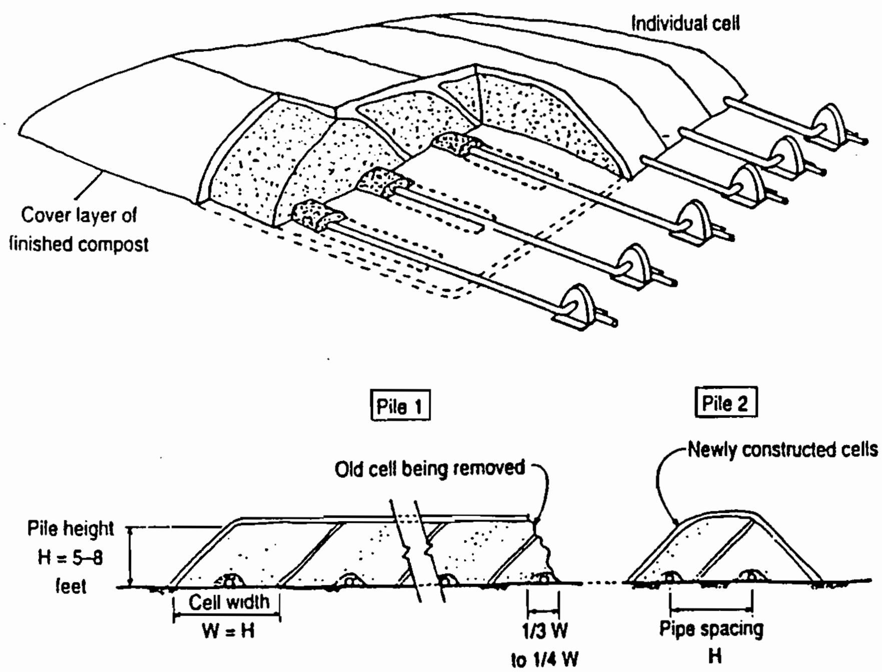


Figure 2. Static curing pile using 8' height with positive pressure aeration pipes located on 12' centers. (On-Farm Composting Handbook, Cooperative Extension, Ithaca, NY 14853-5701).

TABLE 1
DESIGN PARAMETERS FOR COMPOST FACILITIES
(Assumes composting in aerated windrows with 30 day retention moving to aerated curing pile with additional 30 day retention)

	Building Width/ Length [1]	Number of Composting Windrows (6'x12'x160')	Aeration for/Composting Windrows CFM[4]	Biofilter requirement per windrow Area[5]	Curing Area Static Pile[6]	Aeration for curing cell[7] (58.4'x12')
100 T/D IRRF	126'/520'	12[2] (6x12x160)	1255	816 ft^2	102' wide 58.4' long	101.4 CFM
25 T/D IRRF	74'	3[3]	1255		25.5' wide 58.4' long	101.4 CFM

---

[1]Includes 12'interior and outside aisles along the walls.

[2]Build approximately 80' of windrow/working day.

[3]Build approximately 20' of windrow/working day.

[4]Based on 25 CFM/TDM.

[5]Use two minute retention and 3' depth.

[6]8' high, static pile.

[7]Based in 2 CFM/TDM continuous aeration.

CONSTRUCTING INEXPENSIVE IRRF BUILDINGS

by Dr. Robert Diener, P.E.]
Professor of Agricultural Engineering
West Virginia University

If buildings are available disused or can be converted from other uses considerable cost advantage can be gained compared to new construction.

However, new construction may be necessary to meet pad requirements and odor control requirements for composting.

Thus costs can be estimated from specifications 1-13 listed below*:

1. State grading of plus or minus 4 feet of excavatable, compactable earth for building footprint plus 20 feet perimeter. Excavation of and installation of pool type liner for bio-filters.

2. Building to be sectionalized to 60 foot maximum clear span wood frame structure having metal roof, walls, and gable ends.

3. Interior clear height to be 16 feet.

4. All sides are supported by 6" X 6" posts, 10 feet center to center.

5. Interior walls will have 2" X 12" X 2 feet high knee walls constructed of pressure treated lumber to prevent material from being pushed against the building's metal wall panels.

6. The floor will have a 12" base of 1 1/2" crush or run limestone compacted on top of Miraffi 55 ground stabilization cloth. This will be topped with 3" of base course asphalt. Finally, the surface will be topped with 2" of hydraulic base asphalt in order to meet state requirements.

7. Electrical 480/277 volt 3 phase main service wired to all equipment and 240/120 volt lighting service including lighting for main part of building and offices and rest rooms.

8. HVAC through the wall heating and cooling heat pumps for the office areas only.

9. Exhaust fans for rest rooms, intake louvers, main building fans (6) and bio-filter shed fans (4).

*Freelance Technical Services, 207 Fairmont Avenue, Fairmont, WV 26554, (304) 366-6295.

10. All plumbing fixtures for restrooms

11. Two 10 x 12 office areas with drop ceilings, lights and outlets.

12. Two 6 x 6 rest rooms with drop ceilings, lights and outlets.

13. All engineering design, construction inspection and field supervision is included for all items listed above.

Excluded items:

Waste disposal systems, utilities from building to supply source, access roads, parking lots, all machinery, blowers for compost windrows, piping, biofilter, liner and fill material.

ESTIMATED COSTS*

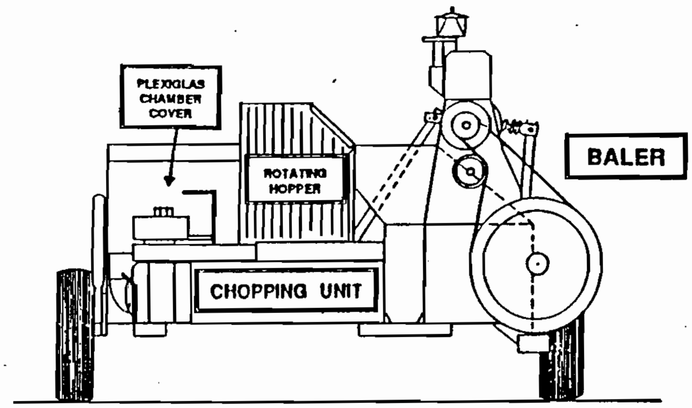
100 T/D RECYCLING OR COMPOSTING BUILDING

1. Building Costs -	$5.55/ft^2
2. Pad -	$2.45/ft^2
3. Ceiling Vent Systems -	$0.16/ft^2
4. Excavation -	$1.00/ft^2
5. Electrical service -	$0.43/ft^2
6. Balance (contingency, design, inspection, profit)	$1.91/ft^2
TOTAL	$11.50/ft^2

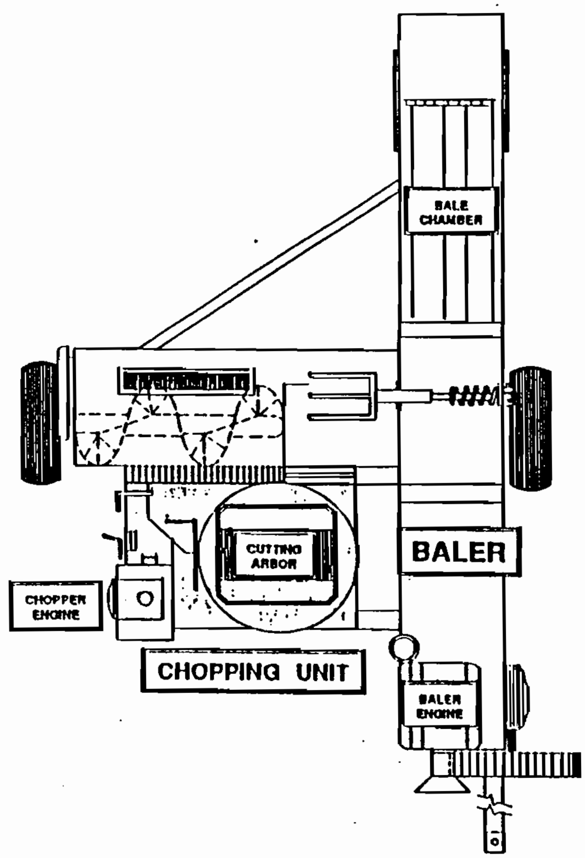
25 T/D RECYCLING OR COMPOSTING BUILDING

1. Building Costs -	$5.55/ft^2
2. Pad -	$2.45/ft^2
3. Ceiling Vent Systems -	$0.16/ft^2
4. Excavation -	$1.00/ft^2
5. Electrical service -	$0.64/ft^2
6. Balance (contingency, design, inspection, profit)	$3.41/ft^2
TOTAL	$13.84/ft^2

*New construction



Front view of the Ross Chopper showing the compact arrangement of components and ease of front loading



Top view of the Ross Chpper showing the "straight through" path of materials from the chopper through the bale chamber

Figure 3. Paper Chopper/Baler Machine*

*Ross Tractor Sales, 52 Windland Avenue, Waynesburg, PA 15370, (412) 627-4950.

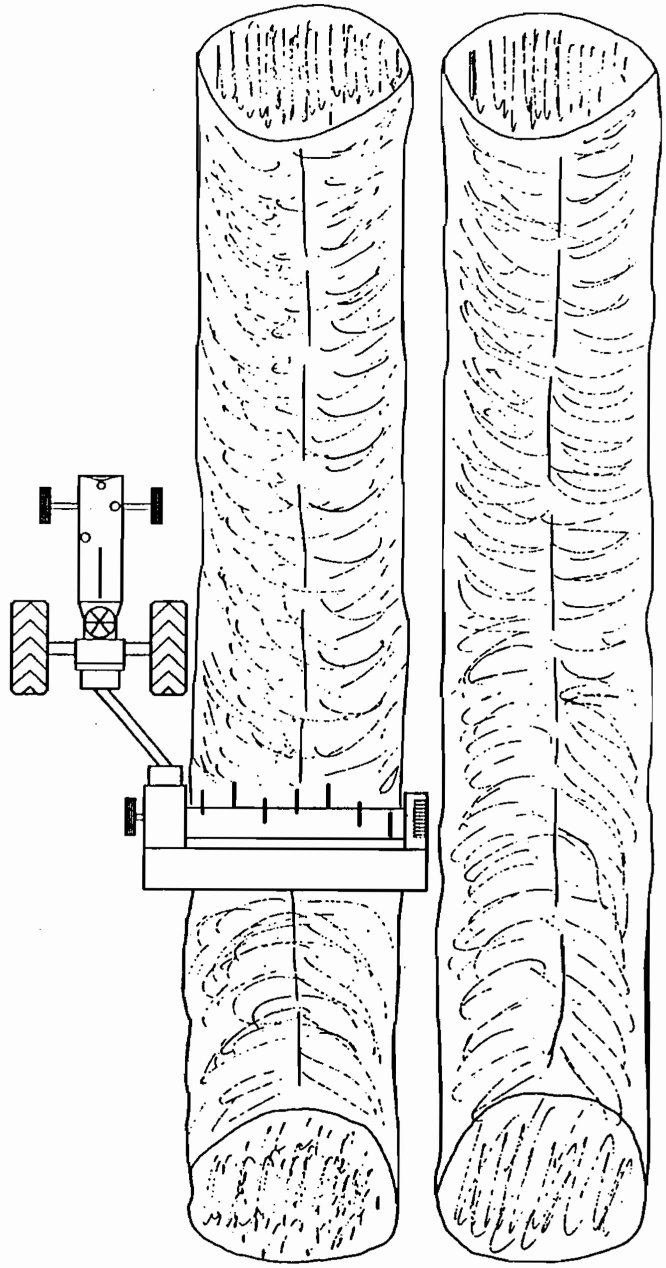


Figure 3. Turning Pre-formed Windrows Inside a Compost Facility Using a Sittler #1012 Compost Turner* Powered by a IHC Hydro-100 Tractor

*Distributed by Valoraction Inc., P.B. 892, Sherbrooke, Quebec (Canada), 1H5LI, (819) 864-7942.

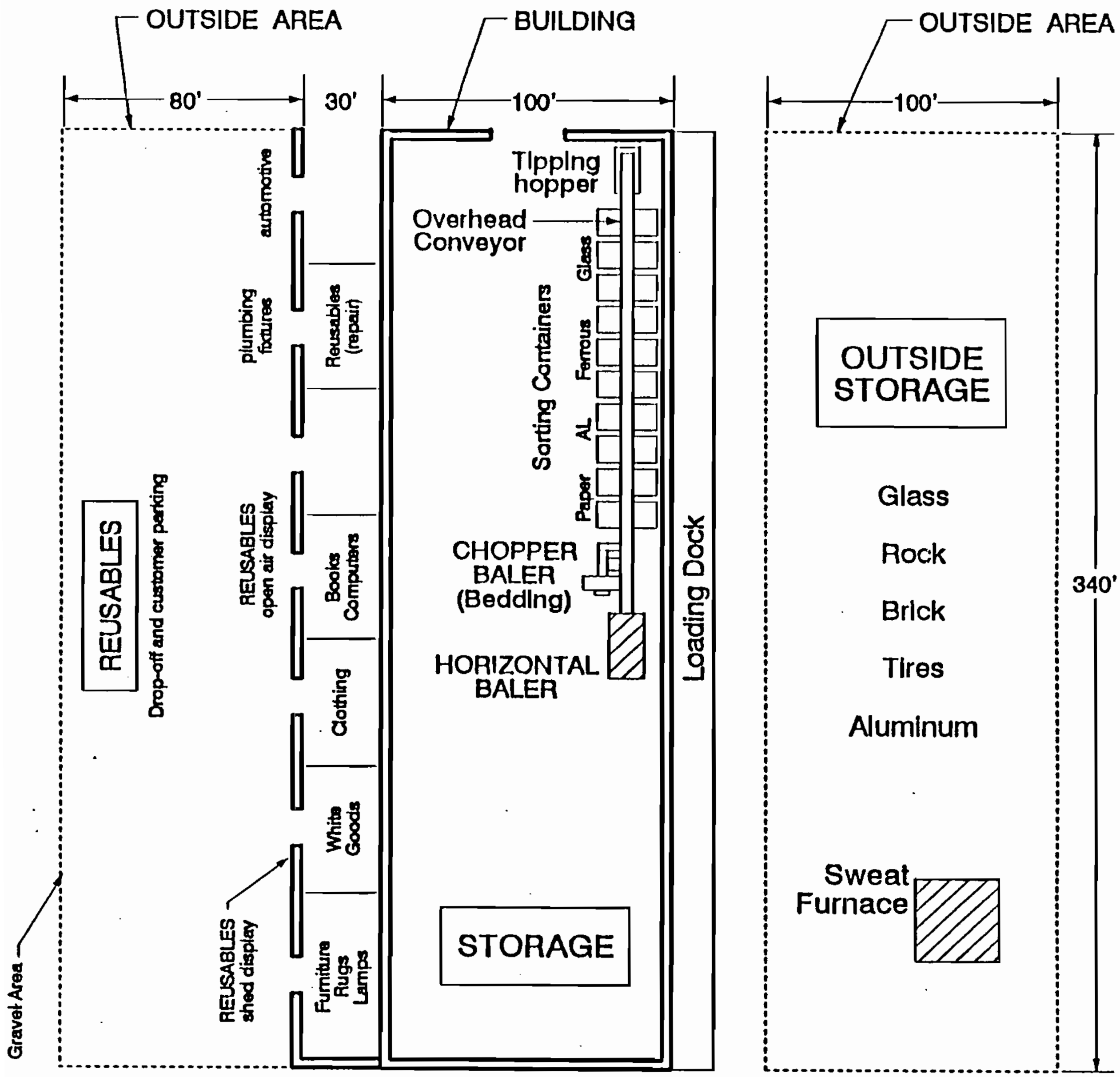
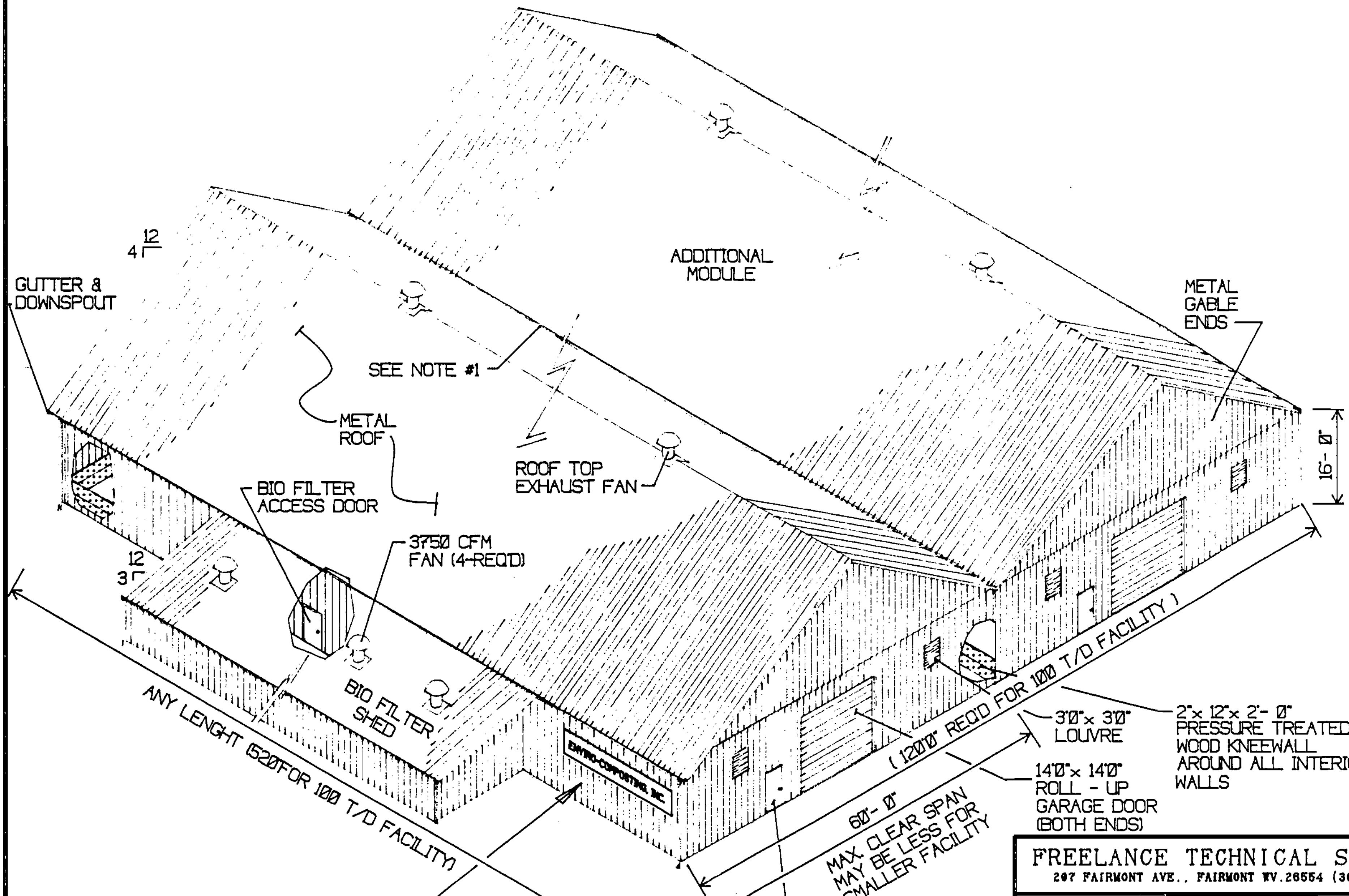


Figure 3-a. Recycling - Reuse Facility for a 100 T/D IRRF



NOTES

(1) WHEN MULTIPLE MODULES ARE USED. VALLEY DRAINS AND DOWNSPOUTS WILL BE USED AT APPROPIATE INTERVALS.

FREELANCE TECHNICAL SERVICES
207 FAIRMONT AVE., FAIRMONT WV.26554 (304) 366-6288

MODULAR COMPOSTING PLANT

HYDRAULIC ASPHALT PAD COMPLETELY ENCLOSED WITH NEGATIVE PRESSURE AIR SYSTEM

SCALE	DATE	DRAWN	CHECKED	REVISED	DRAWING NUMBER
NTS	1-20-94	AJ		0	COMPOST1

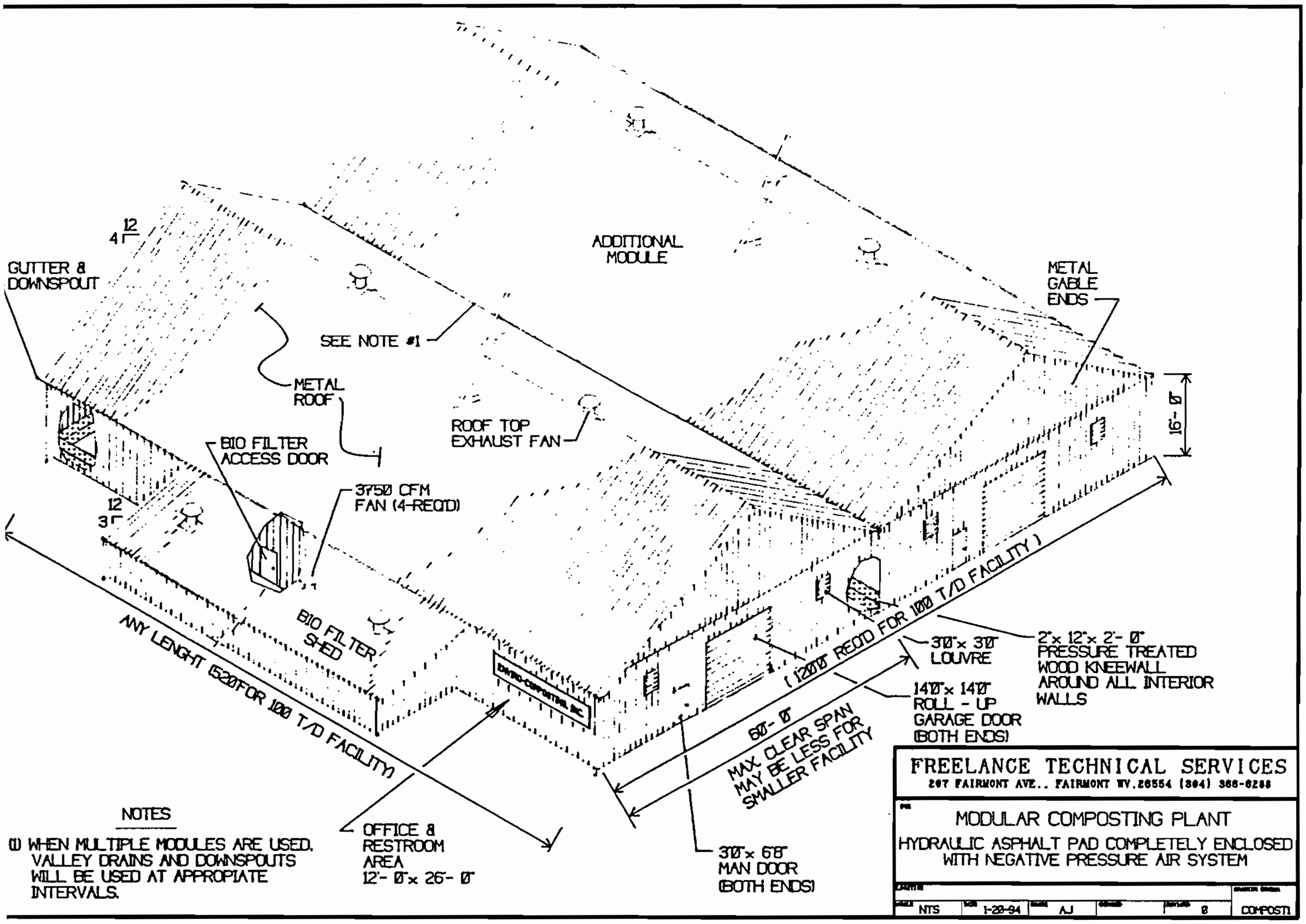


Figure 4. Modular pole buildings in modular widths of sixty feet and length as required. These buildings are suitable for recycling and composting facilities.

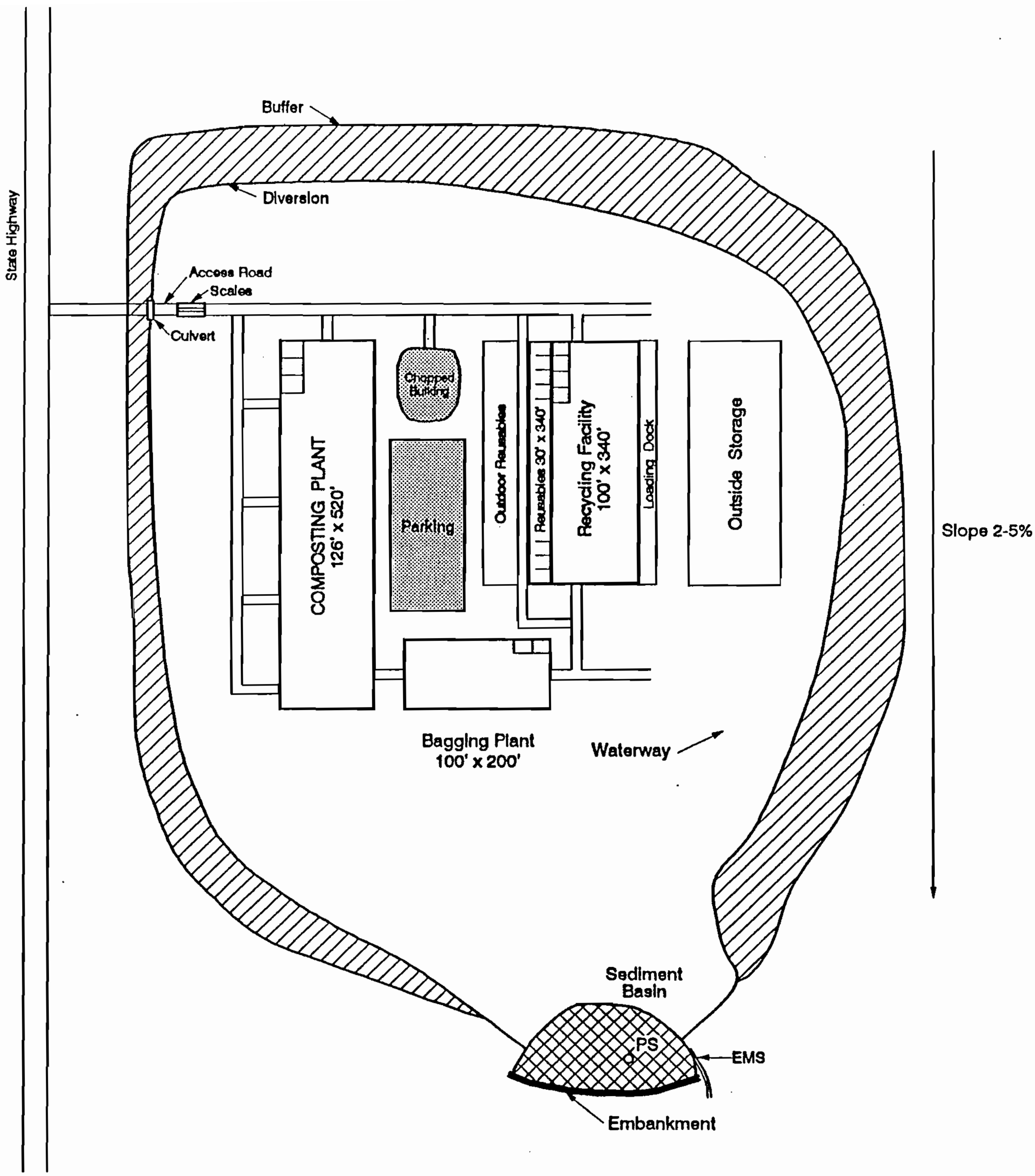


Figure 5. Conceptual Layout for an Integrated Resource Recovery Facility (IRRF) showing Facilities for Reuse, Recycling and Composting.

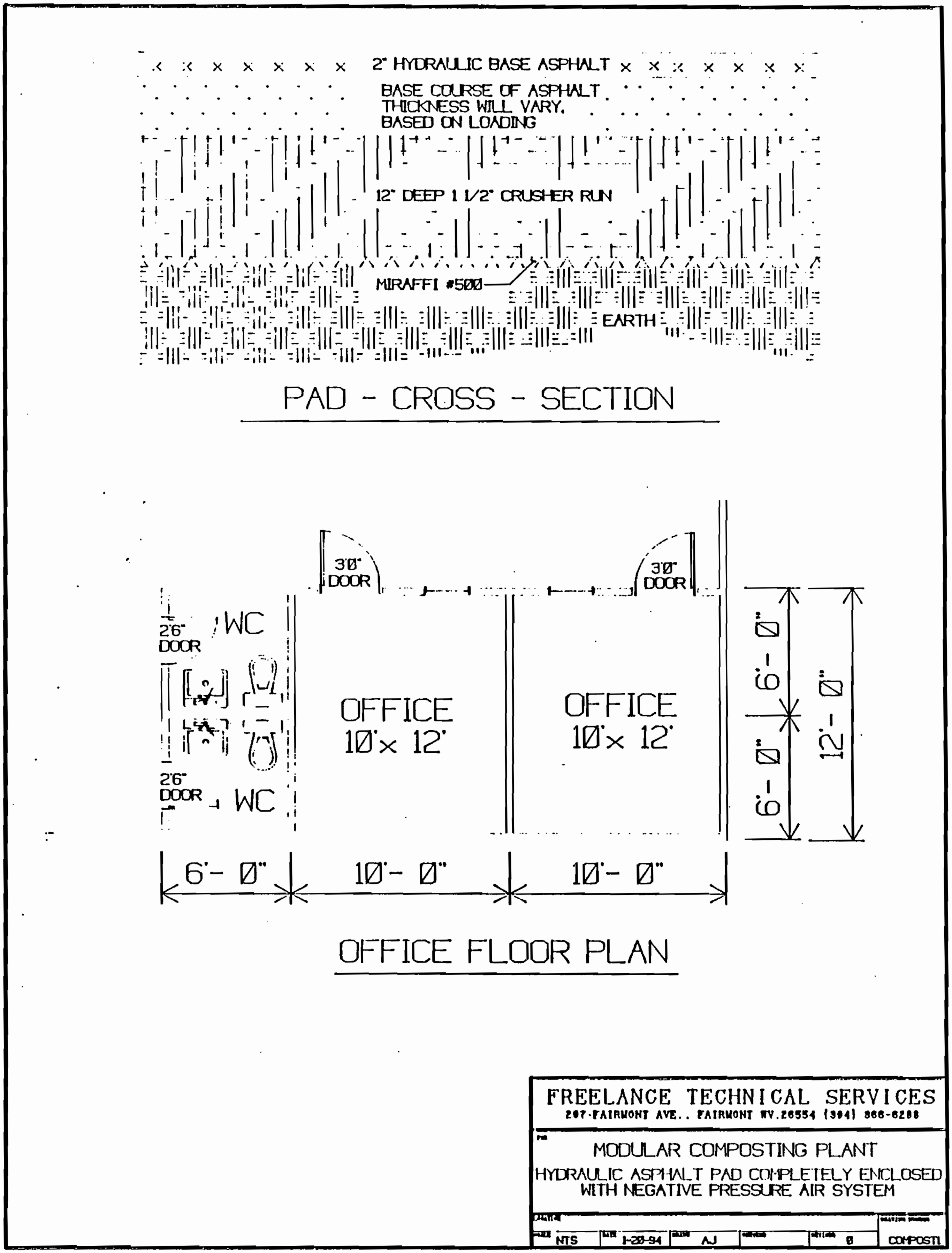
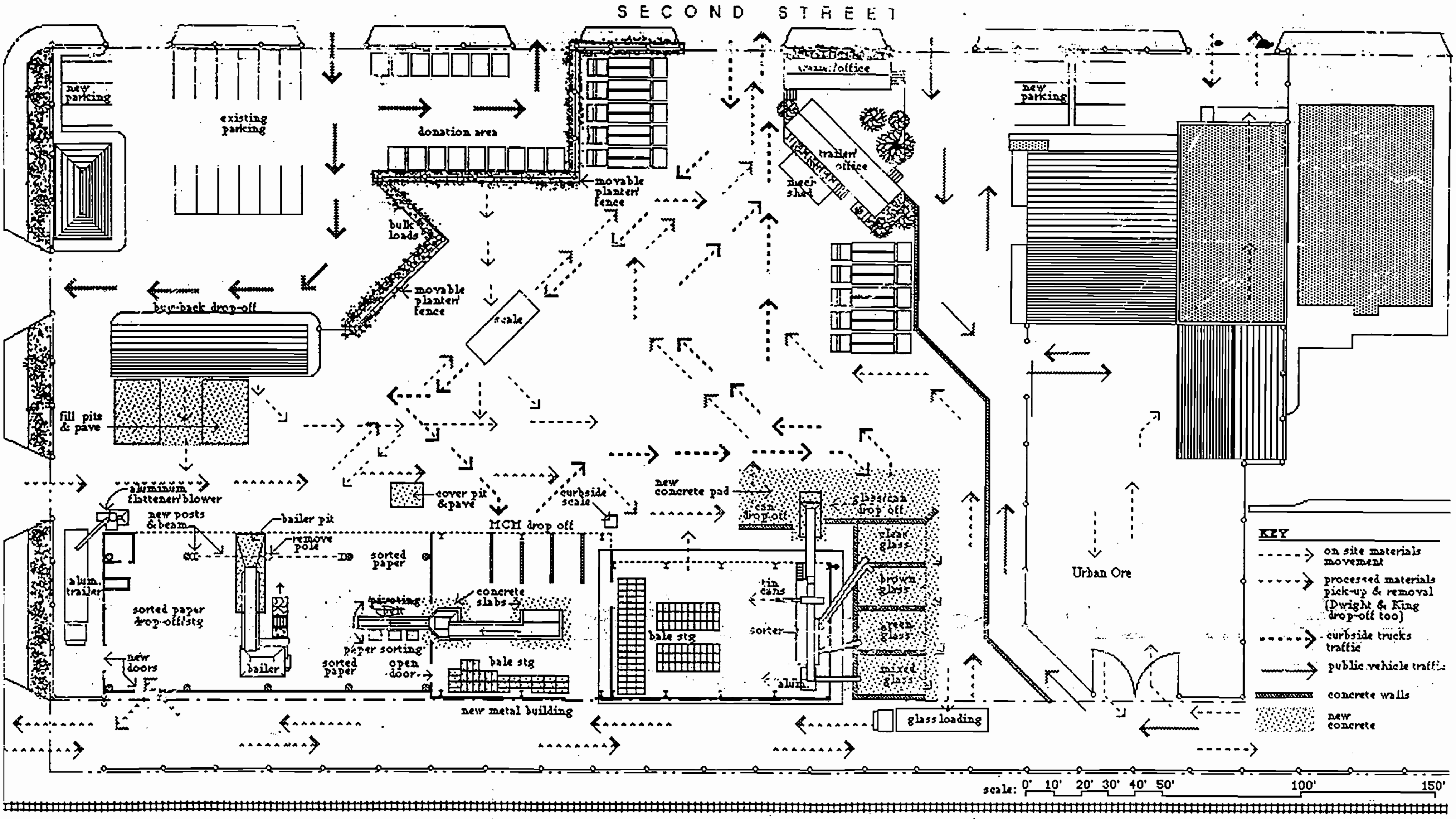


Figure 7. Hydraulic Asphalt Pad

IRRF PRICE SHEET SUMMARY

	0 - 100,000 (same as landfill)
Siting	
Building	
Recycling building/Reusable exchange	$6,000 - 200,000
Compost building	0 - 800,000
Reusable Exchange Approx. 14 bags	100,000
Equipment	
Slow Grinder	5,000 - 100,000
Baler	8,000 - 120,000
Chopper Hay Baler	4,000 - 30,000
Sweat Furnace	3,000 - 20,000
Conveyor belts/Sorting	1,000 - 15,000
Forklift	2,000 - 70,000
Skid Loader	5,000 - 30,000
Trailers (tandem axle dump) at sattelite IRRFs	4,000
Roll Offs (10-20)	20,000 - 100,000
Front End Loader	5,000 - 150,000
Scales	3,000 - 25,000
Reusable Lumber	
Metal Detector	1,000
Chop Saw	1,000
Planner	1,000
Splitter	1,500
Tub Grinder	20,000
Tire Shredder	150,000
Rock Crusher	100,000
Screen	20,000 - 100,000
Compost Facility	
Siting	0 - 100,00
Preparation	200 - 10,000
Storage	5 - 15,000
Bagging plant	10 - 30,000
Equiment	
Tractor	25,000
Turner	10,000 - 50,000
Screen	10,000 - 50,000

Appendix E



BERKELEY RECYCLING CENTER
1231 SECOND STREET • BERKELEY • CALIFORNIA

Mark Gorrell, Architect • 850 Mendocino Avenue • Berkeley • California 94707 • (510) 528-1208

SHOWING NEW CONCRETE AREAS
N
SITE PLAN