

**Section A8**  
**Miscellaneous**

## Nonmetall...

at Michigan State University, East Lansing, Mich.

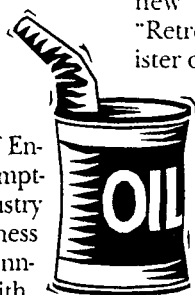
Bioplastics made of cornstarch polyester blends are already being commercialized. Narayan believes soy proteins offer functional and property enhancement that is even more beneficial than starch.

"Soy proteins are not as easy to work with," says Narayan. "If they are subjected to high temperatures, they break down and degrade. [But] we are modifying the soy protein so that instead of degrading, it will melt and flow."

## OIL

### ■ PENNSYLVANIA LOOKS TO BOOST OIL RECYCLING

Pennsylvania's Department of Environmental Protection is attempting to work with several industry associations to increase awareness of oil recycling methods. The Pennsylvania EPA plans to work with



ican Petroleum Industry, the National Oil Recyclers Association, the Steel Recycling Institute and several state organizations or national chapters to host workshops and produce brochures on used motor oil and oil filter recycling.

## RUBBER

### ■ ITRA ADDS BOUNCE TO ITS WEBSITE

The International Tire and Rubber Association (ITRA), Louisville, Ky., has upgraded its website ([www.itra.com](http://www.itra.com)) to offer more information and features. The new layout allows visitors to make "Retreaders Mart" transactions and register on-line for upcoming ITRA events.

In addition to the new registration capabilities, the site features articles from *The Tire Retreading/Repair Journal* and *Commercial Tire Service Update*; an industry events calendar; and access to the "Retreaders Mart," where casings and retread/repair equipment can

be bought and sold.

### ■ TIRE RECYCLER SETS UP SHOP IN BAY AREA

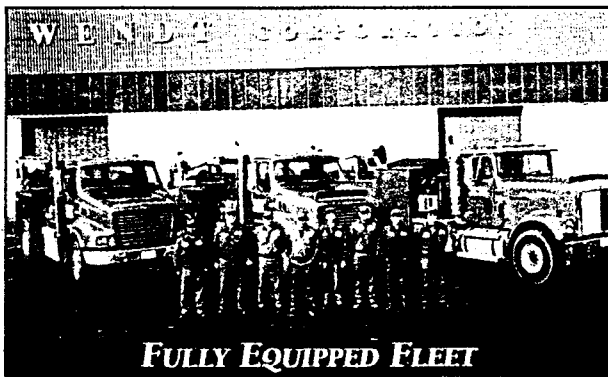
Bay Area Tire Recycling LLC will soon be operating at the site of the Davis Street Transfer Station in San Leandro, Calif. The transfer station is operated by a subsidiary of Waste Management Inc., Oak Brook, Ill.

The new tire recycling system can process up to 3,000 pounds of whole tires or tire chips per hour. The system can create pieces as small as 3/4" in size and separates out the steel contained within the tires in a single pass. A further step in the process can reduce the rubber to #40 mesh rubber powder. Bay Area Tire Recycling hopes to find markets for the recycled rubber as modified asphalt, playground safety surface material, and in running tracks and other sport playing surfaces.

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# Back Page

## ■ RECYCLING JARGON "HONORED"

Recycling and waste handling was the topic of a letter that has received a dubious honor as an example of unclear jargon. According to a Reuters item, the English Language Commission—a British organization that advocates the use of clear, understandable English—presented its Golden Rhubarb Trophy to the Edinburgh, Scotland City Council for a letter on waste handling.

Among the phrasing that led to the honor: "[Council is] fully committed to waste minimization and the recycling of waste and has . . . approved, in principle, a revised strategy encompassing the introduction of material recovery facilities post-refuse collection and pre-final disposal."

Martin Cutts of the English Language Commission says the writing "almost defies translation" and is, on the whole, "a fog of puzzling and pompous English."

## ■ SMILING FACES FITTED WITH GOLD BRACES

If you believe the time is right to buy gold because the price is down, the orthodontic industry can suggest an unorthodox storage place.

According to the Orthodontic Manufacturers Association, Milwaukee, gold-plated dental braces are increasing in popularity with patients at a 20 percent annual clip. For most patients, cost is not even a primary consideration, since the cost of materials makes up just 5 percent of the total cost of having braces made, custom-fitted and installed. According to an item in the *Wall Street Journal*, 15 percent of practicing orthodontists have installed gold braces and they see the switch to gold as a growing trend.

## ■ A RECYCLED FIELD TRIP IDEA

For teachers and students who've already been through the local art museum and fire station, two Connecticut solid waste organizations have a suggestion. The Southwest Connecticut Regional Recycling Operating Committee (SWEROC), Stratford, and the Connecticut Resources Recovery Authority (CRRA), Hartford, have opened the Children's Garbage Museum of Southwest Connecticut.

The museum, located in Stratford, includes 15 hands-on exhibits, an amphitheater presentation, and a glass-enclosed skywalk that extends over the tipping floor of the 40,000 square foot regional recycling plant. 90-minute field trip tours have been designed for children grades K through 8, according to museum director Valerie Knight-DiGangi.



## ■ DANGEROUS SCRAP PURSUIT

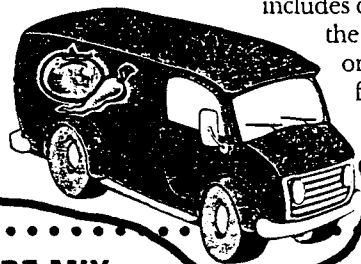
*Thieves with a scrap metal profit motive are making Chicago a dangerous place for pedestrians and motorists. According to a UPI report, a rash of manhole cover thefts took place in late 1997, with more than 60 of the iron discs disappearing from one neighborhood in just two weeks. City-wide, as many as 4,000 manhole covers are stolen in Chicago each year, according to the city's Streets and Sanitation Department.*

*While thieves probably make about \$2 per disc for the 150-pound sewer lids, it costs the city \$45 for each replacement manhole cover. The dangerous openings created must also be quickly barricaded by Sewer Department personnel. Scrap processors who knowingly purchase stolen manhole covers face fines and the loss of operating permits.*

## ■ VEGGIE VAN IS WELL-OILED MACHINE

New heights in material re-use innovation may have been reached with the "Veggie Van," which completed a 10,000-mile trip across the U.S. in 1997. The engine of the van was customized to operate on a biodiesel fuel made from used restaurant cooking oil.

Joshua and Kaia Tickell, directors of the Institute for Renewable Energy, Covington, La., journeyed in the Veggie Van and have prepared a summary of their trip that includes details of how the van operates on its restaurant fryer waste-derived fuel.



## ■ ORCHIDS SPROUT FROM TIRE MIX

Two Colorado companies have come up with a technological twist on the rustic used tire-as-flower planter motif. Fantasy Orchids, Louisville, Colo., and JaiTire Industries, Denver, have announced the development of a potting medium for orchids derived from recycled tire chips.

Epi-Grow consists of recycled tires and uses the properties of rubber to create a superior medium for young orchids, according to Stan Gordon of Fantasy Orchids and Cornelia Snyder of JaiTire. "I saw an increasing need for a new potting medium and when I heard of JaiTire's work with crumb rubber as a top dressing, we started to work with recycled tire chips," says Fantasy Orchid's Gordon. "We tried several different chip sizes, many of which proved unworkable, but after a year and a half [we] have a product which we are proud to offer to the serious orchid grower."

Orchids grow naturally on trees, cliffs or virtually any surface while extracting much of their sustenance from the air instead of from the soil. Commercial and hobby growers have traditionally used bark, coconut husks or other natural products as potting mediums.

**No. 22**

**Yolo County Controlled Landfill**

**Demonstration Project**



## LANDFILL OPERATIONS

# Yolo County Controlled Landfill Demonstration Project

*To avoid long-term difficulties with the "entombing" of membrane-covered waste, it is desirable to accelerate waste decomposition. Ideally, decomposition should be completed within five to 10 years. That is the objective of the Yolo project.*

By: Don Augenstein, P.E., Institute for Environmental Management, and Ramin Yazdani, P.E., Rick Moore, P.E., and Karina Dahl, Yolo County Department of Public Works



olo County Department of Public Works is demonstrating a new, unconventional landfill management strategy known as "controlled" or "enhanced" landfilling to manage solid waste at its Central Landfill outside of Davis, CA. The overall objective is to manage landfilled solid waste for rapid completion of total gas generation and maximum gas capture.

Landfill decomposition, or methane generation, is accelerated by improving conditions for biological processes. This is accomplished through carefully controlled additions of both water and leachate. Test cells are covered with gas-impermeable membranes to contain landfill gas and prevent its emission to the atmosphere. Permeable layers of shredded tires cover the waste in both cells to serve as a conduit for gas to reach various collection points. The cells are monitored to determine performance. Gas generation, waste volume reduction, and a range of other parameters will be monitored for the next several years, until the methane generation phase is near completion.

This "controlled" landfilling technology is expected to offer an important advance in landfill operations, enabling low-cost mitigation of methane emissions, maximization of beneficial energy capture, an ultimate landfill volume reduction, and a long-term reduction in waste management costs.

Methane fermentation, or bacterial generation of  $\text{CH}_4$ ,  $\text{CO}_2$ , and other trace gases, occurs in almost all landfills con-



*In this aerial view, the enhanced cell is on the left and the control cell is on the right.*

taining municipal wastes. Decomposition to gas is normally slow, taking decades, and inefficient under the dry conditions of conventional landfills. Slow and incomplete generation, inefficient recovery, and long-term low-rate gas generation are some of the reasons that conventional landfill gas recovery rates and yields are less than their potential.

Surface gas-impermeable membranes are a part of the solution to the inefficient gas recovery problem. These membranes are coming into wide use and may be a post-closure requirement for many landfills in the future. Synthetic membranes, in contrast to conventional clay caps, have negligible gas permeabilities. Membranes over gas-conducting layers should capture 95% or more of landfill gas generated. However, such membranes as the sole means to maximizing gas recovery, have serious disadvantages. Surface membranes will maintain waste

at initial low moisture levels of about 20 to 25%. This will, by itself, simply extend the time for decomposition, possibly up to a century or even more. Field results show a substantial slowing of decomposition beneath impermeable membranes. However, decomposition only slows; it never stops entirely.

Often termed "dry tomb," the dry containment approaches present a number of problems including economic viability and waste containment integrity when viewed over a longer period of time. To avoid long-term difficulties with the "entombing" of membrane-covered waste, it is desirable to accelerate waste decomposition. Ideally, decomposition should be completed within five to 10 years rather than the several decades experienced with conventional landfilling. Such an objective appears attainable and is the principal objective of the Yolo County project.



## LANDFILL OPERATIONS

### Controlled Landfilling

Waste decomposition and gas generation can be promoted by moisture, temperature, pH management, and nutrients. While many factors can be important, moisture is paramount; elevated moisture (by conventional landfill standards) appears essential for accelerating biological activity and methane generation. Temperature is also important, even though it receives little attention as a variable. Studies suggest approximate rate doubling for each 10°C increase, holding over a temperature span of about 10 to 50°C or more. Other factors are also important, however manipulation of some parameters in a landfill may be less critical than others, while some may be easier from a regulatory standpoint. Moisture is highly effective in augmenting and accelerating methane generation, working most favorably with membrane coverage. The presumption that landfill manipulations can reduce decomposition times to 10 years or less is supported by laboratory trials and is consistent with field results.

With elevated moisture, waste is expected to be less permeable to gas. This can impede gas extraction by vacuum and conventional vertical wells. Other effects may occur with wet waste, such as the reduction of the high horizontal/vertical permeability ratio that ordinarily facilitates conventional well extraction. However, even with wet waste, gas will ultimately pass through the path with least resistance and exit the waste. If side and bottom containment are secure, gas will permeate through to the landfill surface. With wet waste enhancement, wells are not only less functional, but may be unnecessary as well. One good gas recovery alternative can be a permeable extraction layer beneath the surface membrane.

Thus, combining surface membrane containment with landfill moisture and temperature management can speed-up and maximize gas capture, as well as drastically reduce fugitive methane and VOC emissions. However, to be useful, any process must also be economically compatible with current landfill practice and regulations. With this in mind, the only enhancement technique purposely applied by design in the Yolo County Project has been addition of water and recirculation of leachate.

### Expected Benefits

A number of energy, environmental, and landfill operational benefits are expected from enhanced landfilling. Methane energy recovery can be accelerated and yields should be maximized. Better economies of scale for energy use can be achieved with increased quantities of captured gas. Completing decomposition in a shorter time frame reduces long-term risks to the environment and reduces long-term gas and other management costs. In addition, with methane generation more predictable, landfill gas-fueled energy equipment may be sized to make maximum use of the generated gas. Other benefits include reductions in methane and VOC emissions, off-site disposal and landfill leachate treatment costs, and post-closure landfill care and gas system operations and maintenance costs, as well as landfill life extensions and leachate quality improvements (and correspondingly

parameters are also monitored. Gas-tight waste containment allows precise measurement of methane generation via accurate positive displacement meters in conjunction with gas analyses.

General performance objectives include:

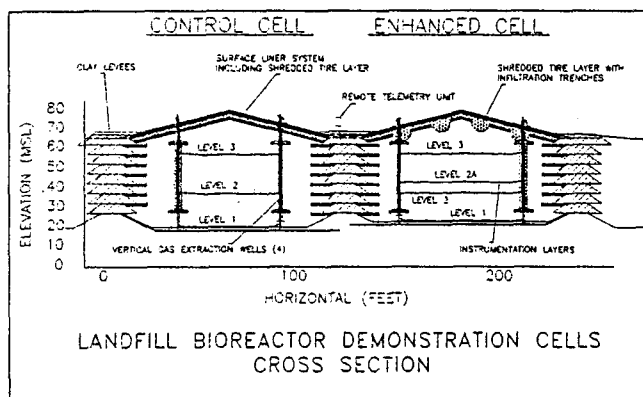
- Methane generation completion and biological stabilization of waste within 10 years or less. This would be evidenced by cessation of flow, which is expected when cumulated gas recovery reaches about 3.5 ft<sup>3</sup> of landfill gas per dry pound of waste.
- Demonstration of maximum fractional recovery (95% or more) of the methane generated.

### Liquid Recirculation System

Because of low moisture in "typical" landfill waste, and its lack of moisture infiltration through impermeable cover, leachate will be limited, and in some cases not generated at all. For example, the Sanitation Districts of Los Angeles County report that, generally, no leachate is generated in their landfills which have well-maintained clay covers. Thus, in general, leachate recycle cannot be effective as the sole means of moisture addition for enhancement. Supplemental liquid additions will normally be required.

The basic enhancement strategy has been to bring waste up to field capacity by controlled additions of water and leachate, and then recirculate resulting leachate to maintain some moisture movement in the waste. Some channeling or bypassing could occur, and the approach has been to continue circulation until achieving acceptably high sensor moisture readings throughout the waste. Initially water has been added to the enhanced cell from a groundwater extraction system. As leachate has become available from the enhanced cell, it has been recirculated via a pump capable of pumping between 11 and 12 gpm to the enhanced cell. Although the time to bring the enhanced cell to field saturation was initially expected to be about six months, flow and permeability proved sufficient for liquid to be added in three months.

Leachate and groundwater flows in and out of the cells are monitored with commercially available flowmeters. To add liquid to the enhanced cell, groundwater (i.e., reservoir) generated from an extraction system is pumped into an enhanced cell manhole. Leachate is draining into this manhole as well. The mixture of ground-



groundwater impact reductions).

The Yolo County project operates two test cells, each containing about 9,000 tons of waste. The cells are large enough to duplicate both the compaction and heat transfer of large-scale landfilling at normal waste depth. Cells are completely surrounded by landfilled waste in the larger landfill modules. Techniques to accelerate decomposition and enhance methane are applied to one cell (the "enhanced cell"), with the other serving as the control (the "control cell"). The enhanced cell has means for carefully managed liquid addition to permeate the waste and bring the cell to field capacity. Supplemental well water has been used to raise the waste moisture content to field capacity. To aid distribution and contacting, leachate is recycled as it is generated.

Both cells are monitored for waste moisture and temperature at multiple points. Volume reduction, leachate flow and composition, static head on the base liner, containment integrity, and other



## LANDFILL OPERATIONS

water and leachate is then pumped to the infiltration trenches in the enhanced cell. The groundwater flow can be shut off, allowing for the recirculation of undiluted leachate. Liquid can also be drained from the enhanced cell into the landfill liquid waste disposal system. The groundwater added to the enhanced cell manhole is metered, as is the liquid pumped to the enhanced cell for infiltration while any liquid drained from the manhole enters into the leachate disposal system. The volume in the manhole is relatively small and can be considered as constant in the mass balance. Liquid flows from the control cell can be easily monitored as the only inflow to the control cell manhole is leachate and the only outflow is drainage into the landfill liquid waste disposal system.

The cells are extensively instrumented and monitored. Both temperature and moisture sensors were placed within the waste during placement. Both gypsum block and PVC sensors are used for data collection. The data is collected continuously using a data logger.

### Refuse Temperature

Both cells experienced elevated temperatures upon filling, suggesting significant aerobic composting occurring for a limited time after waste placement. Both cells display the same basic pattern. A maximum temperature was achieved after waste placement followed by a slow decrease to a relatively stable temperature. Both cells were constructed with conventional composite liners. The liner systems are overlain with a geonet drainage layer

and a geotextile. To protect the liner systems, the geotextiles are covered with a 1-ft operations layer of gravel to facilitate drainage. In both cells, Level 1 is the gravel operations layer. The observation that temperatures in Level 1 for both cells are much lower than the other layers is attributed to heat losses to the cooler, underlying soil. Also, both cells are covered with a layer of shredded tires to facilitate gas recovery. The shredded tire layers also act as insulators. Temperature drops, roughly 7°C measured across the shredded tire layers, suggest it is an effective insulation. Table 1 summarizes the most notable changes in temperature in the enhanced cell, and Table 2 summarizes the temperature behavior of the control cell.

### Moisture Sensor Readings

There are two types of moisture sensors: gypsum blocks and PVC sensors. Gypsum block moisture sensors are typical of those used in soil moisture monitoring in agricultural applications. The PVC sensors are simply 2-in. PVC pipes filled with gravel with electrodes attached to measure current flow through the gravel. Typically, the reading from a gypsum block is correlated to the moisture content of a given type of soil through laboratory testing. The gypsum block establishes an equilibrium moisture content with the media (typically soil) in which it has been placed.

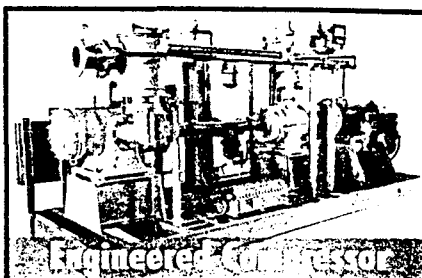
However, laboratory correlations between gypsum block readings and solid waste moisture contents are qualitative. The gypsum blocks give readings that allow changes in moisture conditions to

**Table 1. Enhanced Cell Refuse Temperature**

Level	Initial Temp. (°C)	Change from Initial Temp. (°C/day)	Max. Temp. (°C)	Steady State Temp. (°C) (Date)	Change after Addition Liquid (°C/day)	Min. Temp. (°C) (Date)	Temp. on 2/1/97 (°C)
3	43	0.05	49	49 (2/2/96)	-0.22	34 (12/25/96)	35 (increasing)
2	48	0.14	55	45 (5/14/96)	-0.11	41 (12/11/96)	42 (increasing)
1	14	0.06	27	27 (11/3/95)	0.03	27 (11/27/96)	29 (increasing)

**Table 2. Control Cell Refuse Temperature**

Level	Initial Temp. (°C)	Change from Initial Temp. (°C/day)	Max. Temp. (°C)	Change after Max. Temp. (°C/day) (Date)	Temp. on 2/1/97 (°C)
3	46	0.04	51	-0.03 (2/2/96)	43 (decreasing)
2	43	0.25	56	-0.03 (8/19/95)	39 (decreasing)
1	15	0.03	26	0 (3/30/96)	26 (constant)



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be observed. The minimum moisture content of a gypsum block would be that associated with immersion in saturated landfill gas that can be assumed to be present throughout the waste mass. At moisture contents above field capacity, the gypsum blocks would attain a maximum moisture content and do not represent changes in moisture content as accurately than at moisture contents below field capacity. The gypsum blocks are most reliable at tracking arrival of moisture at given points in the waste and increases in moisture content when waste is below field capacity.

### PVC Moisture Sensor

Laboratory tests were done with the PVC sensors to determine the relationship between the multimeter readings and the presence of free liquid in the PVC sensor. It was determined that a meter reading of less than 40 corresponded to an absence of free liquid. A reading between 40 and 80 corresponds to the presence of free liquid in the PVC pipe but less than saturated conditions. Readings of greater than 80 are indicative of saturated conditions; i.e., the PVC sensor is full of liquid. Tables 3, 4, and 5 present summaries of the moisture readings in the cells.

### Liquid Addition and Leachate Generated

A pressure transducer is placed in the lowest point of the leachate collection trench in the enhanced cell manhole. Additionally, a U-trap was placed at the outlet of the leachate collection pipe to prevent the entry of air or the escape of landfill gas. The transducer was intended to monitor leachate buildup in the trench to demonstrate that conventional leachate collection systems could prevent leachate head from developing when liquid is added to the landfill. It was initially expected that leachate recirculation would occur continuously. However, some anomalous and unexpected behavior was seen for a time. Rather than a continuous flow of leachate draining from the enhanced cell, leachate built up in the cell until reaching a depth of about 20 in., then all stored leachate drained rapidly from the cell. Thus, for a time, leachate recirculated in periodic pulses corresponding to breakthrough of leachate from the cell. A small scale model was constructed in an attempt to understand this occurrence and to develop a solution. It is theorized that this behavior was due to gas lock in the

**Table 3. Gypsum Block Moisture Sensors for the Enhanced Cell**

Level	# of Gypsum Block Sensors	Initial Reading	Change per Day from Initial Reading	Steady State Reading (Date of reading)	% of Gypsum Blocks with Max. Reading Since Liquid Addition
3	9	13	0.27	62 (3/30/96)	100%
2A	4	0	0.06	43 (7/28/96)	75%
2	9	88	-0.42	58 (3/30/96)	44%
1	3	0	0.11	81 (4/4/96)	67%

**Table 4. Gypsum Block Moisture Sensors for the Control Cell**

Level	Number of Gypsum Block Sensors	Initial Reading	Change per Day from Initial Reading	Steady State Reading (Date of reading)
3	6	5	0.12	29 (3/30/96)
2	6	92	-0.56	34 (3/30/96)
1	3	15	0.34	93 (3/30/96)

**Table 5. PVC Moisture Sensors for the Enhanced Cell**

Level	# of PVC Sensors	Steady State Reading (Date of reading)	Reading After Liquid Addition	% of PVC Sensors Reached Max. Reading Since Liquid Addition	# of Days to Reach Max. Reading Since Liquid Addition
3	4	7 (11/22/96)	99	100%	70
2A	4	2 (11/30/96)	49	75%	76
2	4	2	2	0%	N/A

outflow pipe. However, this pulsed outflow has stopped and drainage is continuous. It is considered that such pulsed outflow is avoidable by straightforward design change.

In early 1997, the supplemental liquid was shut off; only leachate continued to be recirculated to the enhanced cell. The supplemental liquid has remained off since with a one-day exception when freezing temperatures prompted the start-up of the supplemental flow. Following the shut down of the supplemental liquid, the flow of generated leachate diminished until about 3,200 gpd which is now continuously recirculated. It is believed that this behavior has reflected some channeling of the liquid upon first addition. Absorption of the channeled liquid occurred after its subsequent reintroduction into the waste. There is sufficient moisture holding capacity of the waste to limit leachate generation once moisture addition stops.

The amount of liquid that has been absorbed by the waste is the cumulative volume of supplemental liquid added, minus the volume of leachate that remains in recirculation, unabsorbed by the waste. Therefore, the amount of liquid that has been absorbed by the approximately 9,000 tons of waste in the enhanced cell is the cumulative volume of supplemental liquid added (336,640 gallons) minus the leachate remaining in recirculation (3,200 gallons), or about 333,000 gallons. The

supplemental liquid flow was started again in February 1997.

### Cumulative Gas Production

Landfill gas volumes for each cell are measured separately by temperature compensated, positive displacement rotary gas meters. Landfill gas production rates were calculated from the volumetric measurements. Cell filling took place between April and October 1995, and the synthetic surface liner was placed in November 1995. Between the time of placement and the beginning of the metering of the gas flow, landfill gas was generated but was not metered. From June to September 1996, after gas flow measurement began, the average gas flow rate for each cell was the same at 2.2 scfm. To estimate this unmeasured flow, the gas production for each cell prior to flow measurement is assumed to be no greater than the flow rates measured from June through September and to have begun in November 1995. This date corresponds to the time when falling temperatures indicate the aerobic phase of decomposition ended. An estimate of the volume of landfill gas generated prior to installation of the gas metering system is about 570,240 standard ft<sup>3</sup> of landfill gas per cell. The volume of this "lost" gas generated prior to metering can be presented as a fraction of total landfill gas potential. It has been calculated that each cell has the potential to generate about 50 million ft<sup>3</sup> of landfill





## LANDFILL OPERATIONS

gas. Therefore, the estimated volume of landfill gas that was not measured is about 1.2 % of the total landfill gas potential.

Beginning October 16, 1996, a vacuum was applied to both cells. Seven days later, liquid addition to the enhanced cell began. Ideally, applied vacuum would extract gas from the cells at exactly the same rate at which it was generated. Too much vacuum will pull air into the cells through whatever leaks might be present. Too little vacuum results in a pressure buildup in the cells, billowing of the surface liner, and the loss of gas through any existing leaks. The vacuum has been manually adjusted daily with an in-line valve so that the vacuum remains between 0- and 1 ft. of water. It has generally been possible to keep the vacuum between these limits. From October to December 1996, the gas flow rates averaged 9.2 scfm for the control cell and 8.6 scfm for the enhanced cell. This is about a four-fold increase in gas flow from the 2.2 scfm prior to application of the vacuum. This increase occurred immediately after application of the vacuum and was attrib-

uted to leaks in the pipeline of the gas collection system. Leaks were located and repaired. Immediately after application of the vacuum, nitrogen concentrations of about 10% were measured in both cells; following repair of the pipeline leaks, nitrogen concentrations dropped to 1.5% in the enhanced cell and 1.6% in the control cell. These concentrations are close to background levels.

The same leaks that allowed air intrusion after application of the vacuum would also have allowed landfill gas to escape prior to application of the vacuum, suggesting "lost" gas was somewhat underestimated. However, in spite of these uncertainties, the actual volume of "lost" gas is not more than a few percent of the total methane potential of the waste.

At the end of December 1996, the gas production in each cell started to increase. Total gas recovery rate from the enhanced cell increased about four-fold to 31.6 scfm, as averaged over all of calendar 1997. The control cell gas recovery also increased to reach a flow of 15.2 scfm over calendar 1997. The normalized productivity of gas on total waste (as-filled, wet) for the enhanced cell was 0.97

ft<sup>3</sup>/lb/year. The methane productivity of the enhanced cell over calendar 1997, normalized on dry waste, was 0.52 ft<sup>3</sup>/lb of dry waste per year, and from the control, 0.25 ft<sup>3</sup>/lb/year. It must be emphasized that the normalized methane recovery rate from the enhanced cell is the greatest documented from such a large mass of waste anywhere, approaching 10 times that normally expected from conventional landfills. On the basis of the encouraging results so far, it appears that the objective of completing decomposition to maximum methane yield in under 10 years should be met.

### Gas Composition Analysis

Gas measurements were taken from the ports on the extraction wells and along the extraction pipeline. Both cells were at 42% methane on July 2, 1996. The methane concentrations then increased to 52% in the enhanced cell and 51% in the control cell. Following the vacuum application, the methane concentration transiently dropped to a low of 41% in the enhanced cell and 39% in the control cell on October 31, 1996. Both cells recovered their methane concentration by February

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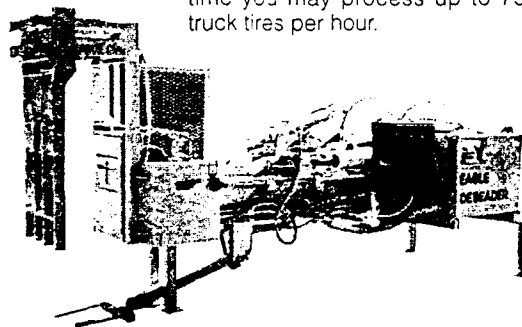
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## LANDFILL OPERATIONS

7, 1996, following the repair of gas pipeline leaks.

Leachate samples are taken periodically from the enhanced cell manhole, however, volumes of leachate available that are sufficient for sampling and analysis have been very rare from the control cell. Leachate draining from the enhanced cell mixes with the supplemental water in the enhanced manhole. Because of the low leachate flows from the control cell, samples are taken from a bucket suspended below the leachate collection pipe outlet to accumulate a sufficient volume of leachate for sampling. Thus, control cell leachate samples have been taken long after the liquid has been in equilibrium with the atmosphere.

The decomposition of solid waste in landfills can be characterized as proceeding through five phases: I) aerobic phase, II) transition phase, III) acid phase, IV) methane fermentation phase, and V) the maturation phase. The objective of this project has been to reach the methane fermentation phase as quickly as possible and to accelerate the methane fermentation phase as soon as possible. A drop in pH,

the solubilization of metals, and a dramatic increase in chemical oxygen demand (COD), are among the primary indicators of the acid phase. During the methane fermentation phase, pH values return to neutral, and the metals concentrations and COD drop. The maturation phase is characterized by the cessation of gas production and a low strength leachate.

Based on the results of leachate analyses, field measured pH, and observations of leachate characteristics, it is inferred that the acid phase had started in the enhanced cell by November 11, 1996, about one month following the start-up of liquid addition. It also appears that the enhanced cell is entering the methane fermentation phase. This is based on changes in leachate characteristics as well as landfill gas production and methane concentration from the enhanced cell. It should be noted that the management of liquid additions, particularly the discontinuation of the supplemental water addition on January 1, 1997 and subsequent recirculation of generated leachate, may have also played a role in the changing leachate characteristics.

Results of leachate analyses, field measured pH, and observations of leachate characteristics suggest that the acid phase

had started in the enhanced about one month following the start-up of liquid addition. It also appears that the enhanced cell rapidly entered the methane fermentation phase. This is based on changes in leachate characteristics as well as landfill gas production and methane concentration from the enhanced cell. It should also be mentioned that the management of liquid additions, particularly the discontinuation of the supplemental water and subsequent recirculation of generated leachate, may have played a role in the changing leachate characteristics.

For a list of reference, contact the Editor at (440) 248-1125.

For more information about this subject, contact the authors, Ramin Yazdani, Karina Dahl, and Rick Moore at County of Yolo Department of Public Works and Transportation, 600 A Street, Room 158, Davis, CA 95616; (916) 757-5577; Don Augenstein, Institute for Environmental Management, 4277 Pomona Ave., Palo Alto, CA 95306; (650) 856-2850. ◀▶

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## Wood Waste Shredders

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... were typically less than 10 percent. Even comparing results in one study area where recycling was high, but before automated co-collection, we had 85 percent trash and 15 percent recyclables. Recently, residents in the same area placed 53 percent on the trash side of the container and 20 percent on the recyclable side. The balance, 27 percent,

was being placed in green waste containers. As long as commingled recyclables are diverted at 15 to 20 percent ratio, the program expects to divert an additional 7,000 tons per year.

By the time automated co-collection is implemented city wide, route collection should be responsible for better than 40 percent diversion—well on its way to reaching the coveted 50 percent diversion mark. The recycling rate gets an addition-

## Visalia's Progress

What's progress been like in Visalia, where the split container has been in action since 1992? According to Tom Baffa, solid waste services manager for Visalia, the city finished converting to once-weekly co-collection for 26,000 households in April 1996. In its first full year of city-wide residential operation ending in April 1997, the program posted a total waste diversion rate of 58 percent. About 1/3 of the tonnage diverted was from the recyclables side of the split container; the other 2/3 comes from a separate yard waste collection program.

Visalia has also begun testing split containers on some commercial routes. Because of the significantly different waste stream, Visalia is considering using the container to collect wet and dry streams, or some other combination, instead of the typical garbage and recyclables.

... boost from recovery at a new transfer station/MRF that opened late last year.

Another payback is cutting losses of recyclables. The closed split containers are less susceptible to wind and scavengers. The coastal community "gets more than its share of days with high winds," says Dudley Perkins, Oxnard's supervisor of residential collection. "We'd always lose a small share of material on those days."

Scavenging was worse than wind for losing recyclables, according to Jay Duncan, the city's recycling specialist, especially when market values for some recyclables soared. "The scavengers were getting pretty organized. Some had taped over the license plates and logos on the sides of vans and went down the streets stealing full bins," Duncan says.

Perkins adds that implementing the co-collection system provided a chance to renew recycling education, thus tending to increase diversion. But, the biggest reason for increased diversion was that the new cart created more room—40 additional gallons—for recyclables over the old bins. In the past, residents just didn't have the room they needed, and some of the material inevitably made it into the trash instead of being held for the next pick up day.

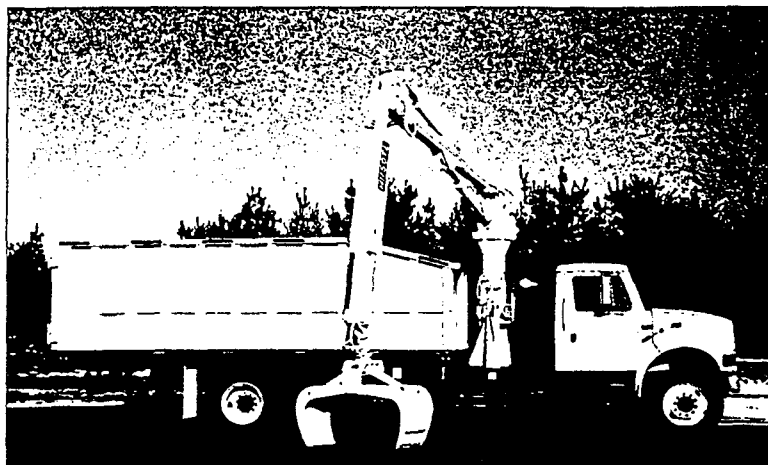
For more information, contact Ruben Mesa in Oxnard, (805) 385-8060, or Tom Baffa in Visalia, (209) 738-3569. ◀▶

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## AMERICAN HAWK BULK WASTE CRANES



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estimates to be used for designing a regional materials recovery facility:

- Estimation of waste composition and quantities for a new commercial development (as required for a new land-use permit); and
- Projection of changes in wastestream composition and quantities given a significant change in the commercial/industrial make-up of an area."

"Our state database contains all the components," claims Tseng as he displays disposal, diversion, and generation totals for San Diego's commercial, industrial, and residential sectors

on his laptop computer. "For every ty, ness, the system will display the overall composition of the garbage and show the percent of each type of waste generated by each company in that category.

### Source Reduction

Source reduction is the preferred waste management option and is at the top of the integrated waste management hierarchy. The use of electronic data interchange and double-sided copying are leading methods of source-reducing office paper, and replacement of one-time

counterparts is being as as a cost-effective business practice. Although the extent of source reduction is difficult to quantify, Tseng reports, "Recent reviews of waste prevention audits performed at businesses in various jurisdictions indicate that...a surprising amount of source reduction is taking place."

There appear to be few public programs providing incentives for source reduction, however. Tseng explains this by pointing out that administrators "need to know how much diversion will likely result from a given level of investment. If, as is generally the case today, there is no way to equate waste diversion with dollars spent, it is difficult for them to justify continued funding."

Home composting programs are proliferating and appear to be popular and effective. According to a study sponsored by the Composting Council and conducted by Applied Compost Consulting, more than one million people now compost at home in just the 43 communities that provided data for the study. Clearly the potential for successful programs is enormous. While only a tiny fraction of residents in a city like Los Angeles backyard-compost, the study team found that smaller communities across the country reached a backyard composting rate of 50% or more from single-family residences.

One such community is Olympia, the capital of Washington. Through the combination of home composting and grasscycling, 60% of Olympia's residents in single-family homes participated; each of these 6,000 participants diverted an estimated 500 lb. of yardwaste from the wastestream that year. The city has promoted this successful program at a cost of just 31 cents per resident. Key to its success has been an effective public communications program and the distribution of composting bins. Residents who attend free composting workshops are able to conveniently purchase one of six different bins, which the city sells at its wholesale cost.

### Reuse

Reuse takes many forms, including tire recapping, battery reclamation, and stainless-steel flatware in commercial food service. Moreover, the impetus for reuse programs today seems to be increasingly coming from the original manufacturers.

For example, Evergreen Glass Inc., headquartered in Stockton, CA, is beginning operation of a high-volume, state-of-the-art facility to recycle wine bottles by washing them and making them reusable. This is expected to provide fresh, new, revenue-enhancing alternatives to the refuse-removal industry. Evergreen plans to process 9 million cork-finish bottles in its first year and more than 40 million bottles by its fifth year.

Coming Inc.'s Telecommunications Products Division, located both in Wilmington, NC and Coming, NY, has embarked on an ambitious campaign, improving product quality while reduc-

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NEWS

## TOP OF THE HEAP

ered for recycling/composting. By 1993, 8.4 million tons were recovered.

□ In 1980, the average American discarded 175 pounds of grocery packaging. In 1993, the average was 132 pounds.

The report details a noted increase in recycling efforts within the industry.

## Everybody's Talkin' Trash

Interesting spokespersons are showing up across the nation . . . Tacoma, WA is "talkin' trash" with their new ad campaign aimed at convincing the city's 51,000 garbage customers to choose new garbage and recycling cans, put their garbage out on new days, and use different recycling methods. The campaign, featured on radio and promotional pieces, feature The Collectors, five singing garbagemen . . . Environmentally conscious celebrities from television, movies, sports, and the music industry are teaming up to promote recycling and other environmental issues through ECO-Quiz, a daily radio show to be aired on nearly 2,000 radio stations across the nation. The quiz will question listeners' knowledge of the environment. Participants will include Kathleen Turner, Kenny G, and Dick Vitale.

## Briefly...

MASS Corp. and Capital Environmental Resources will pilot a weighing in-motion on-board scale system that is accurate to  $\pm 10$  lbs. The MASSfel digital scale system will be tested in the commercial waste market. The pilot will take place over a 48-day period.

Leach Company and Leach Credit Corp. will work with Fleet Capital Services to aid municipal leasing of the company's waste collection and Vac/All units through Leach distributors. These leasing options will provide frequent replacement with new equipment, and a variety of payment options requiring no down payment.

Rusmar Inc. has signed an agreement to market the EcoCare product line throughout the U.S. Manufactured by Nature Plus, Inc. EcoCare is a fermentation based, odor neutralizing system that is ecologically safe.

OSHA's Voluntary Protection Program has awarded Montanay Energy Resources of Montgomery County Inc. its "STAR" rating. This rating is awarded in response to achieving injury and illness rates below the industry average and implementing health and safety programs that go beyond the minimum OSHA requirements. Annually, only 337 of 5.2 million industrial sites in the U.S. receive the award.



NEWS

## TECH UPDATE

## Secondary Uses for Cullet

According to the Glass Packaging Institute, there are several options or secondary uses for recycled glass, known as cullet. Secondary uses include a wide range of applications and markets. The following, to name a few, were taken directly from the Institute's web-site. 1. Abrasives: finely ground container and non-container glass may be used in sand-blasting. Abrasives have no silica, so they will not cause silicosis. 2. Aggregate Substitute: container and non-container glass may be used in concrete, road beds, pavement, and parking lots. They can be used as a drainage medium, as backfill, or for landscaping. 3. Bead Manufacturing: melt container and non-container

## A New Home ...

Solid Waste Technologies has moved from Atlanta, GA to Cleveland, OH. Our new mailing address is: Solid Waste Technologies, 29100 Aurora Rd., Ste. 200, Solon, OH 44139; (440) 248-1125; fax (440) 248-0187.

## A New Service ...

Solid Waste Technologies is now your online connection to the



solid waste industry. Our EnviroNet site offers news and events, industry links/online resources, trade show information, magazines/archives, special sections, educational materials, and much more. Come visit with us online at [www.environet.net](http://www.environet.net) today.

glass into rounded glass pellets or beads and use in reflective paint for highways, as well as in peening and cleaning metals. 4. Decorative Applications: cullet may be used in ceramic tiles, picture frames, costume jewelry, and some household items. 5. Fiberglass: recycled glass may be used in the manufacture of fiberglass. This industry is the second highest volume of post-consumer glass. 6. Frictionators: recycled glass may be used to make frictionators for lighting matches and firing ammunition. 7. Fluxes/Other Additives: glass powders may be used as lubricants, core additives and fluxes in metal foundry work and fabrication, as well as flux/finers in the ceramics industry. For more information, contact the Glass Packaging Institute at (202) 887-4850 or visit their web-site at [www.gpi.org](http://www.gpi.org).

## WWW.EPA.GOV Briefs

This technology update brief was pulled directly from the EPA's web-site. Headquarters Press Release section.

## New Report on Air Toxics from Power Plants

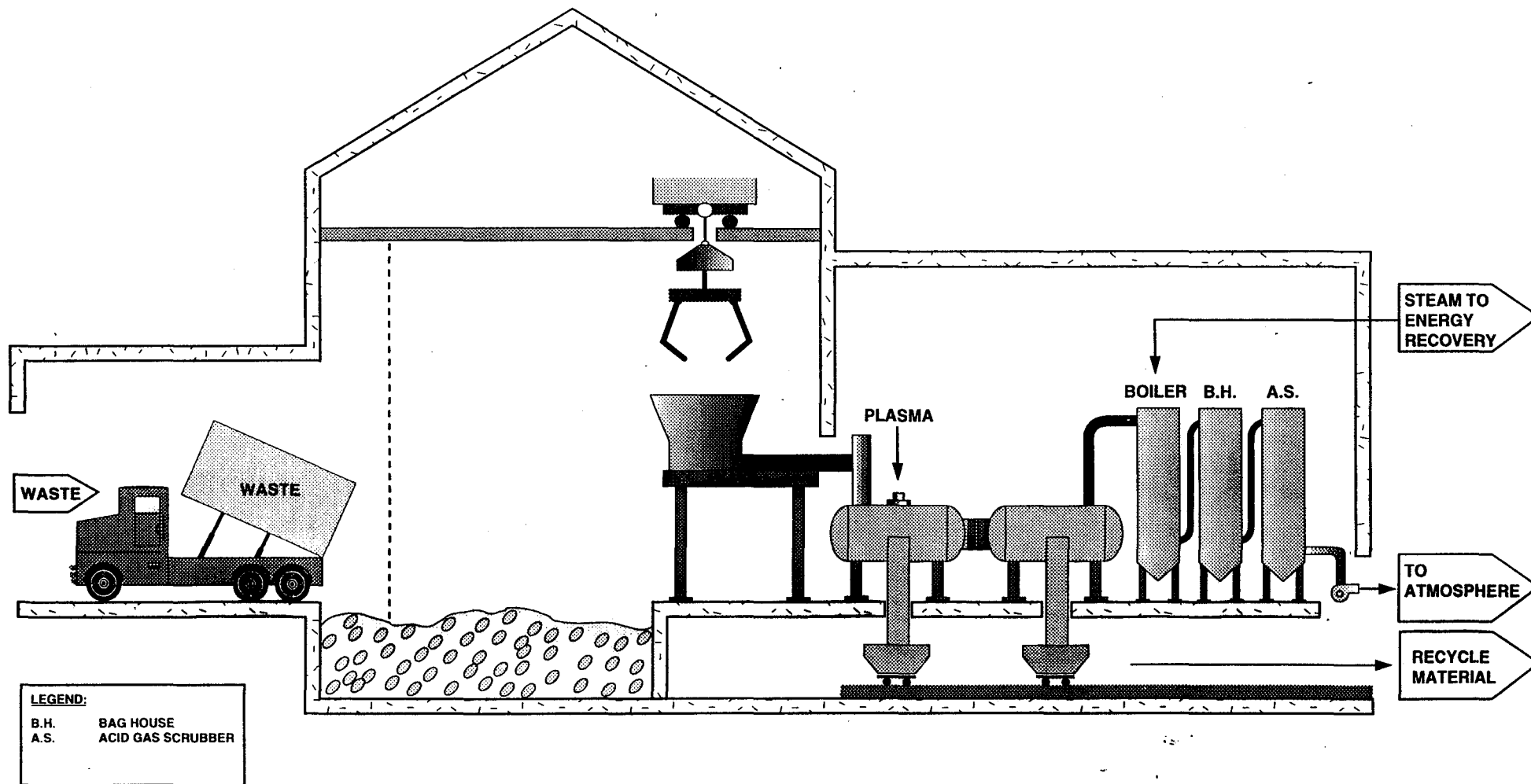
The EPA released a technical report evaluating toxic air emissions from electric power plants and detailing a series of steps it is taking to protect human health and the environment from these emissions. The report, titled "Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units: Final Report to Congress," concludes that mercury is the air toxic of greatest public health concern from utilities. One-third of all human-generated U.S. mercury emissions stemming from coal-fired plants. Non-conclusive evidence suggests there is a link between utility mercury emissions and the methylmercury occasionally found in soil, water, air, and fish living in contaminated waters.

According to EPA Administrator Carol Browner, "[a]ctions this Administration already has taken will reduce emissions of mercury by over 50 percent by 2006," and the EPA "... will continue to take cost-effective, common-sense actions to protect public health and the environment from these emissions." The report concludes there are no feasible technologies currently available to effectively reduce mercury emissions generated by coal-fired facilities. However, the EPA is taking steps that will likely further reduce mercury emissions, including: implementing new and more stringent air standards for smog and particulate matter; evaluating new and promising control technologies; and seeking better emissions information on individual power plants, and developing a right-to-know type proposal to enable more information to be made available to citizens regarding mercury emissions.

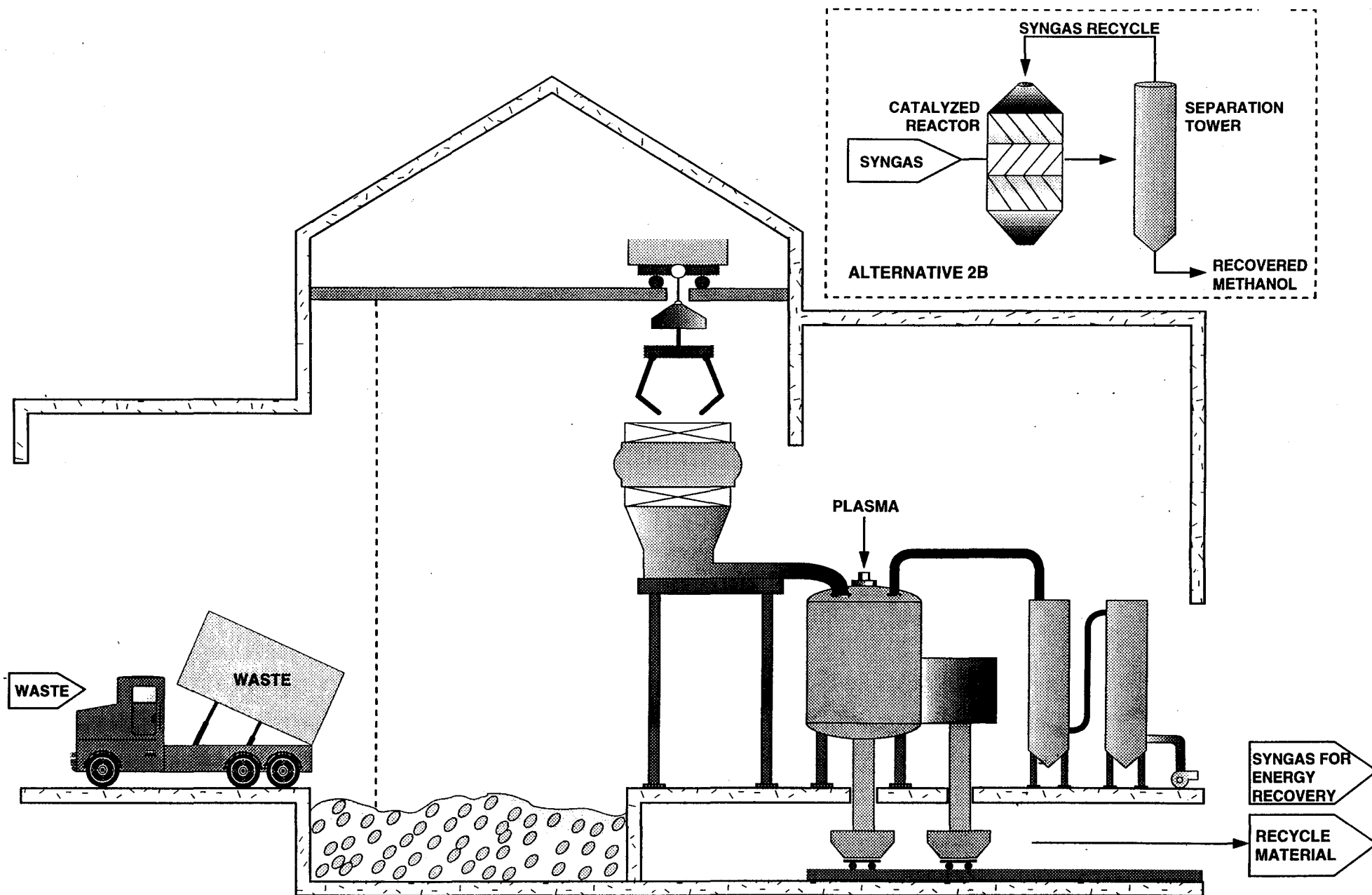
The EPA is also encouraging power plants to take steps to help reduce greenhouse gases and reduce mercury emissions. And finally, since 1995, the EPA has taken several steps to address other important sources of mercury emissions in its attempt to meet Browner's stated goal of reducing emissions by over 50% by 2006. These include issu-

**New Systems Research Task**  
**Vendor and Literature Technology Survey**  
**for the**  
**City & County of Honolulu**

**Exhibit C**  
**Selected Flow Sheets for New Technologies**

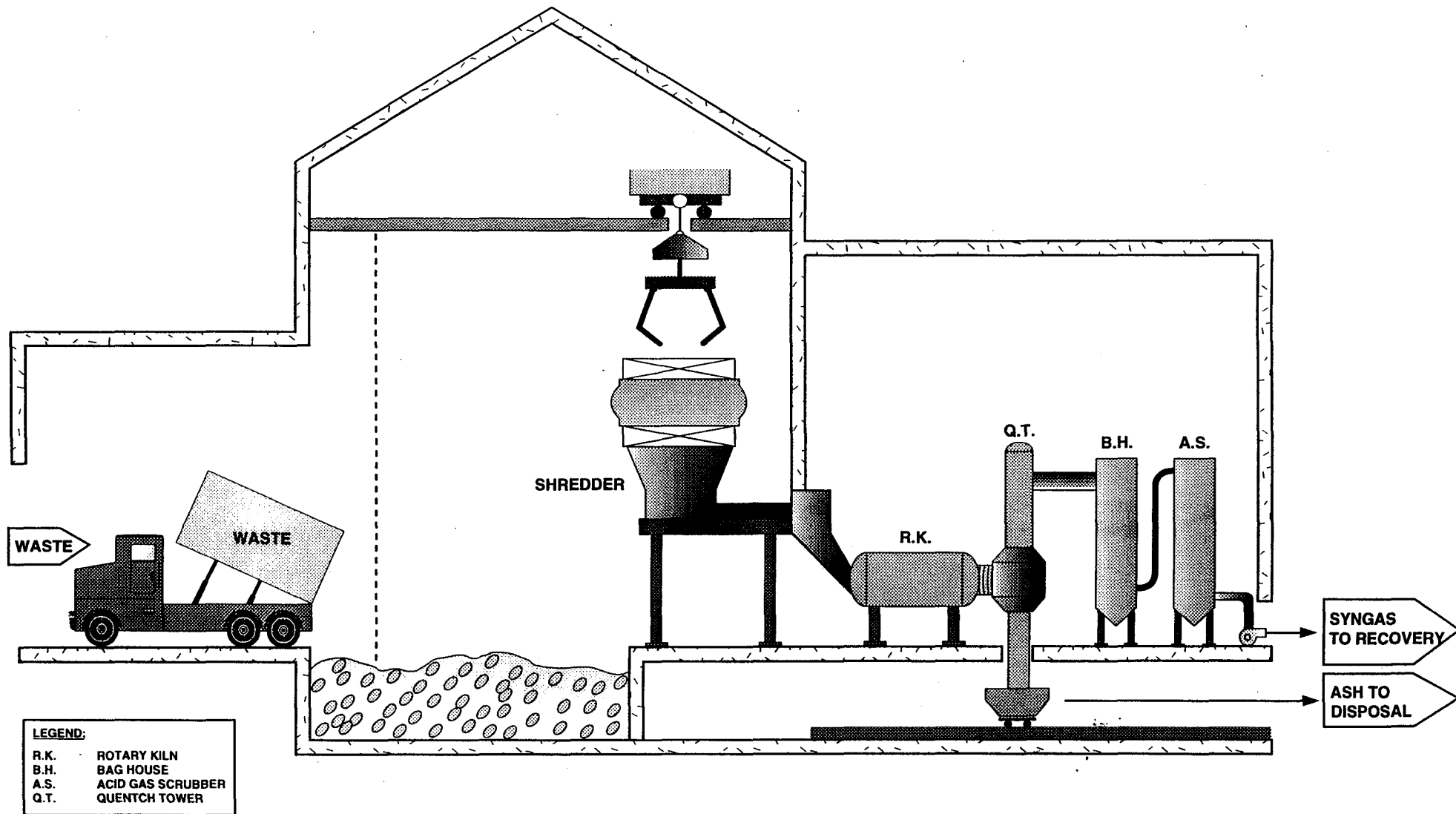


**ALT 1. PLASMA VITRIFICATION**

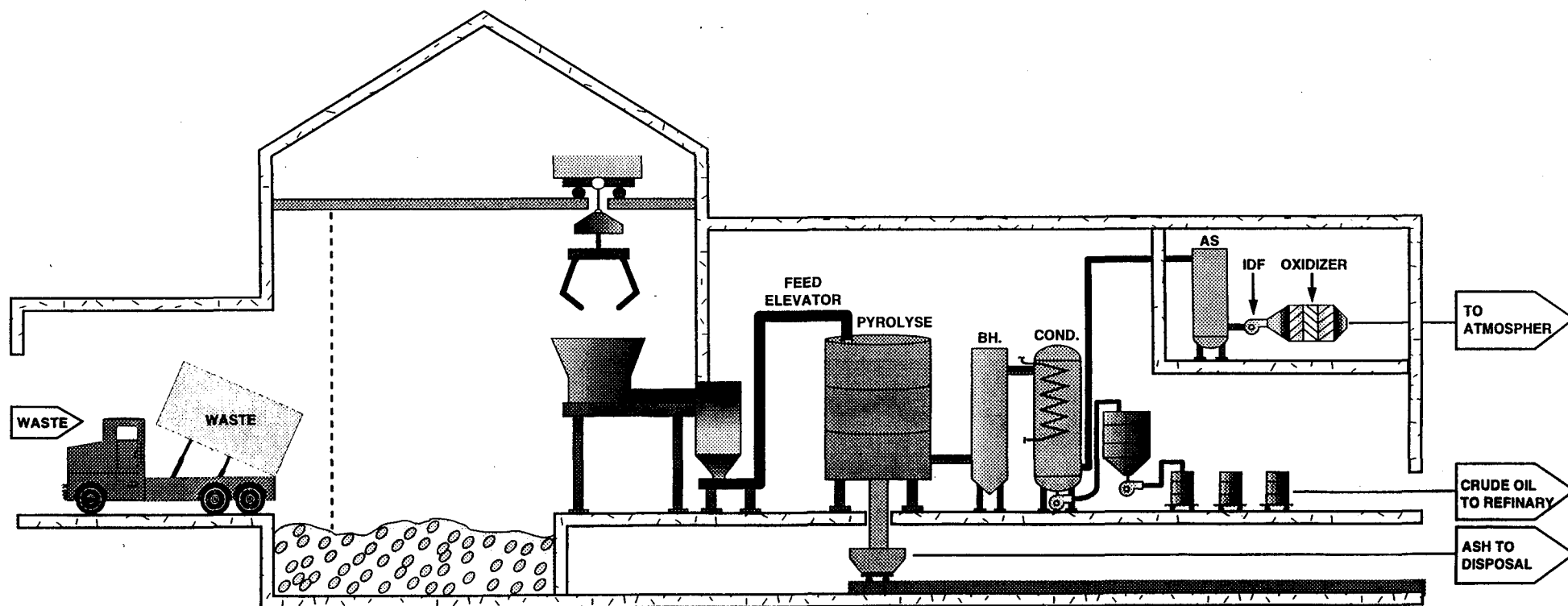


**ALT 2. PLASMA GASIFICATION/VITRIFICATION**

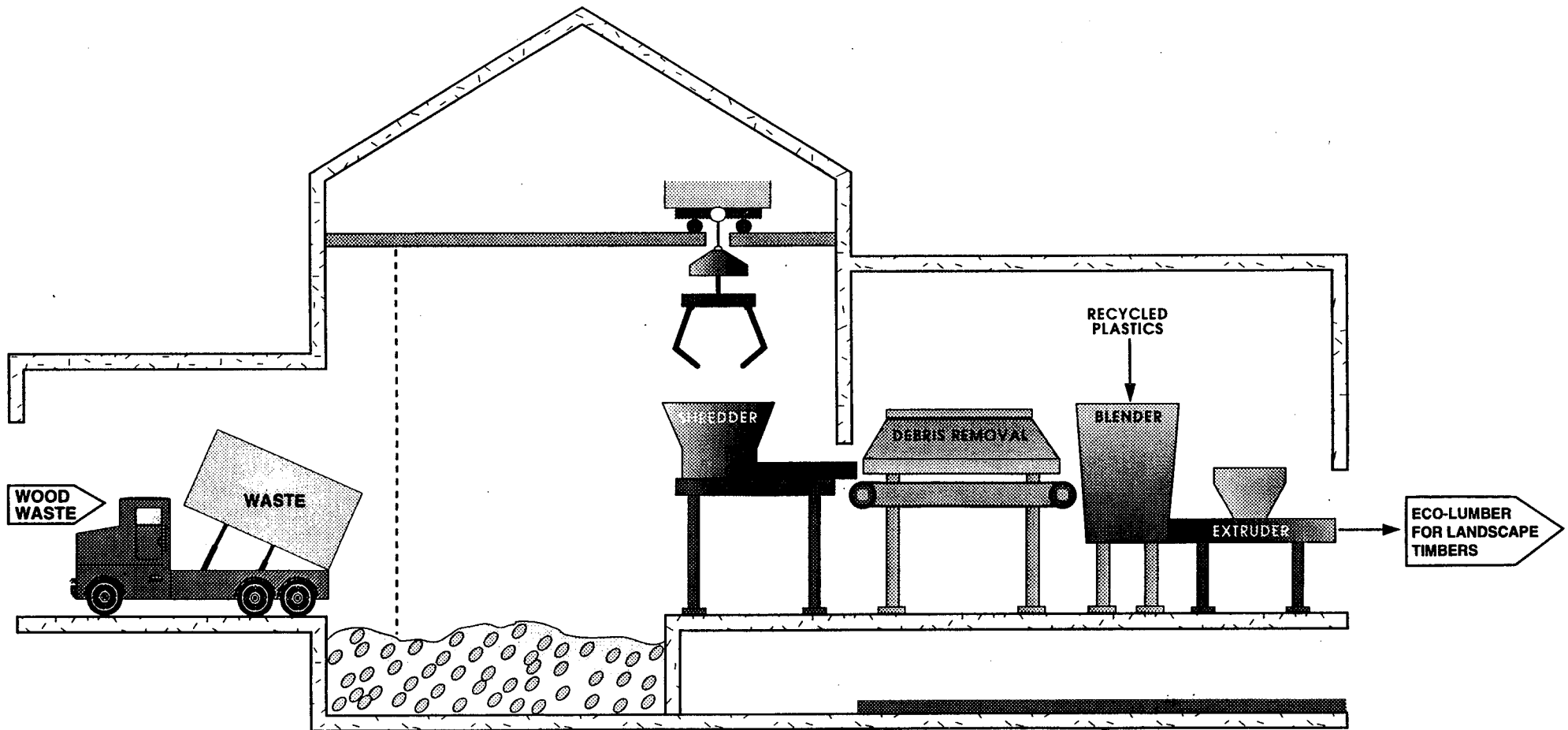




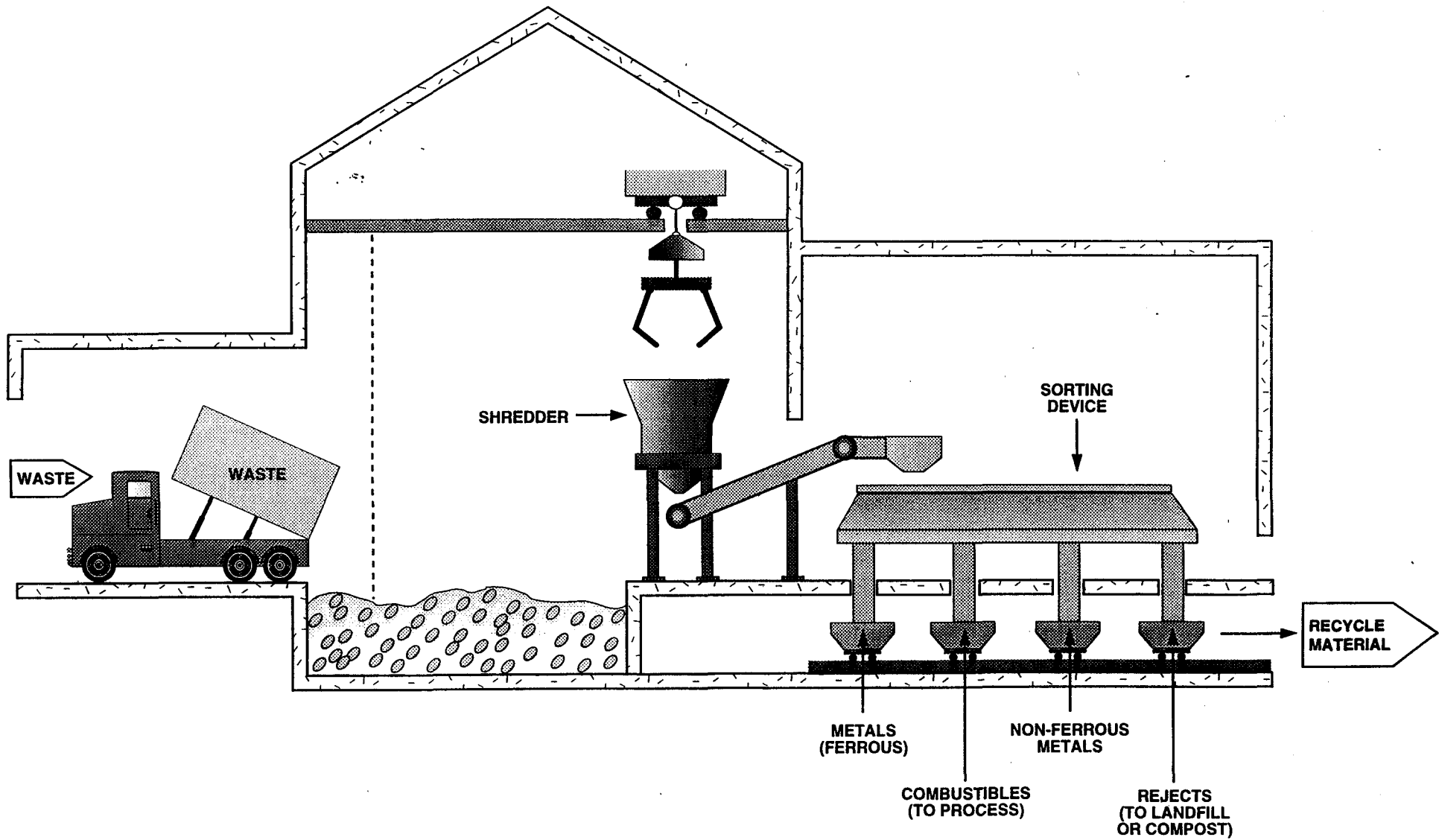
**ALT 3. ASHING GASIFICATION/METHANOL RECOVERY**



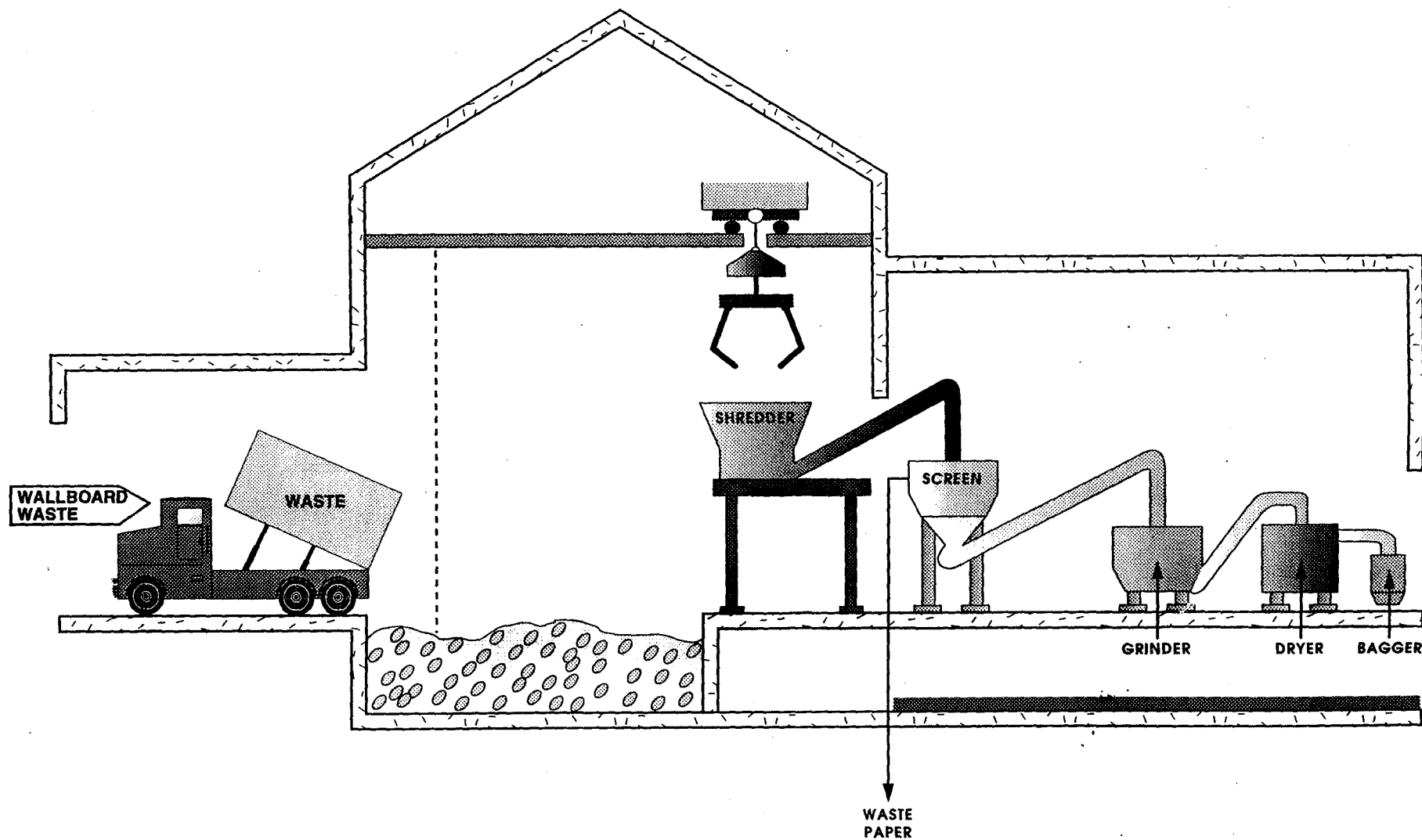
ALT 4. LOW-TEMP PYROLYSIS/OIL RECOVERY



**ALT 5. WOOD/PLASTIC WASTES TO ECO-TIMBERS**



**ALT 6. METALS RECOVERY**



**ALT 7. GYPSUM RECYCLE FROM WALLBOARD**