Analysis of Portland Metropolitan
Solid Waste Trends

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Final Report
February 1992

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Introduction

Between 1984 and 1990 the volume of solid waste delivered to processing and disposal facilities in the tri-county Portland metropolitan region increased at a 7.6 percent annual rate. This rapid growth was a consequence of a robust and prolonged recovery from the early 1980s recession, strong population growth in the latter half of the decade, and a corresponding construction boom. Current estimates of solid waste volume for 1991, however, are 6.9 percent below the 1990 level and 8.5 percent below what had been projected for the year. The main objective of this report is to evaluate possible causes of these “shortfalls,” amounting to 75 and 105 thousand tons, respectively.

The 1991 waste volume reduction comes in a year when the metropolitan population growth rate actually exceeds the rate assumed in the Metropolitan Service District’s (Metro) solid waste projections, but two other important economic forces also need to be considered. First, construction activity, whether measured by employment or building permit data, slowed down from very active 1990 levels. The construction sector generates a significant amount of waste and, consequently, a reduction in building would translate into a reduction in solid waste generation. Second, rates charged at solid waste disposal facilities (tip fees) have increased sharply in recent years. For example, the tip fee at the Clackamas Transfer & Recycling Center (“Metro South”) increased from $16/ton in December 1983 to nearly $67/ton in April 1991, with the largest gains occurring in the past three years. In contrast with most metropolitan areas, Portland area waste generators (households, businesses, etc.) are charged directly by haulers according to volume. Increases in tip fees are at least in part passed on to waste generators through higher hauling fees, which provides a strong incentive to reduce waste volumes, recycle and engage in illegal dumping. Also, to the extent that tip fees in the metropolitan area rise sufficiently above those elsewhere, there is an incentive to transport solid waste out of the area.
The imposition of solid waste pricing creates incentives for both undesirable and desirable behavior by waste generators. Historically, pricing has been seen as an incentive for illegal disposal. However, as generators are required to face the full cost of disposal, they have an incentive to participate in waste reduction and recycling. Skumatz and Breckinridge present empirical evidence that increased prices makes the time and money investment in recycling more feasible (Skumatz 1990). Wiseman (1991) concludes that, with respect to waste producers, true pricing has two positive effects. First, waste disposal prices provide an incentive to consider costs when using materials that will require subsequent disposal. Second, pricing increases incentives for voluntary recycling, thereby reducing the demand for solid waste disposal. In general, pricing that reflects the true social cost of waste disposal enables households and businesses to make intelligent decisions regarding the purchase of disposable materials. Results from an experiment conducted in Seattle presents evidence that weight-based pricing increases incentives for additional waste reduction and recycling (Skumatz 1991). These findings indicate the importance of rate design. Richardson and Havlicek have made two studies of the generation rates and composition of household solid waste (Richardson 1974, 1975). They conclude that in the absence of a price signal increasing incomes produce increasing amounts of solid waste. One of the aims of this study is to determine the effects of pricing on demand for waste disposal. Previous studies have reported price elasticities of -0.14 and -0.10 (Skumatz 1990).

The price elasticities reported above are short-term price effects that indicate immediate behavioral responses. Over the longer term, the change in behavior may be more pronounced. For example, in a study of the demand for gasoline, Dahl (1982) reports that short and long term price elasticities elasticities differ considerably (-0.2 in the short run versus -0.98 in the long run). As in the case of gasoline demand, long-term structural responses such as capital investment in waste reduction and source reduction may be significant factors in the generators’ response to pricing of waste disposal. Postrel and
To assess the effects of various economic factors on solid waste trends in the metropolitan area, a time series analysis of direct haul monthly tonnage volumes between 1984 and 1990 is performed. The intent of this analysis is to provide insight on the contribution of such factors as construction activity, income and tip fees to changes in solid waste volumes.

It should be emphasized that while the time series analysis may indicate why solid waste volumes change, it cannot provide an explanation of how they change. To meet the latter objective information is needed on the following topics: a) changes in the volume of waste disposed at facilities outside the tri-county region; b) changes in waste generation, recycling and source reduction behavior. This information is recovered from a survey of local solid waste generators, and landfills within a 50 mile radius of the Portland metropolitan area.

The remainder of this report is organized as follows. The next section reviews the economics literature on solid waste generation and disposal. The time series analysis of economic effects on solid waste volumes is then presented. A discussion of the survey findings follows. The report concludes with an assessment of Metro’s solid waste forecasting methodology.

**Literature Review**

Until recently, few communities have charged for solid waste disposal services in the way that Metro does. In general, the cost of waste disposal has been imposed at a flat rate or through general taxes. Page (1977) concludes that under these circumstances the cost of increased disposal to the individual is effectively zero. Nevertheless, the cost that the community faces, the social marginal cost, has risen dramatically in recent years. In order to control the increase in demand for disposal services, the social marginal cost must be borne by the waste generator.
Scarlett suggest that only a combination of pricing policy and investment in source reduction can produce an effective solution to the problems of municipal solid waste (Postrel 1991).

Time Series Analysis

The purpose of the time series analysis is twofold. First, we assess the extent to which economic factors were statistically related to standardized waste tonnages during the 1984 to 1990 period, when the trend was generally moving upward. With the statistical results obtain for this period, we then estimate the extent to which the 1991 reduction in solid waste tonnage can be attributed to changing economic conditions, specifically the decline in construction activity and increase in tip fees.

The time series model of direct haul solid waste tonnage is specified as follows:

\[
\ln \text{Tons/000 pop}_t = f(\ln \text{Constr.Empl}_t, \ln \text{Income}_t, \ln \text{Tip Fee}_t), \text{ where}
\]
\[
\ln \text{Tons/000 pop}_t = \log \text{ of direct haul tons per 1000 population in month } t;
\]
\[
\ln \text{Constr.Empl}_t = \log \text{ of Portland MSA construction employment in month } t;
\]
\[
\ln \text{Income}_t = \log \text{ of average weekly earnings of Portland MSA manufacturing workers in month } t, \text{ in constant 1982 dollars};
\]
\[
\ln \text{Tip Fee}_t = \log \text{ of the volume-weighted average tip fee of the CTRC and St. John's facilities in month } t, \text{ in constant 1982 dollars};
\]

The left hand variable in the equation above standardizes solid waste tonnage by population. Employment in the construction sector provides a contemporaneous indicator of construction activity and related waste generation in that sector. Average weekly income of manufacturing employees provides a proxy for disposable income. Given that manufacturing accounts for about 20 percent of metropolitan employment, a more
encompassing measure of income would have been preferred. However, more broadly defined income statistics are available at the annual level only and are released with an approximate two year lag. The tip fees were calculated as the volume weighted average of the St. John’s and Metro South facilities. Income and tip fee data were converted to constant 1982 dollar values using the monthly CPI series for all urban consumers.

The time series regression results covering the period from January 1984 through December 1990 are presented in Table 1. Two regressions were estimated: 1) for wastes delivered to all facilities in the metropolitan area, and 2) wastes delivered to Metro facilities only. Ordinary least squares estimates were subject to serially correlated errors, which necessitated application of the Cochrane-Orcutt technique. With the variables in log form, regression coefficients are directly interpretable as elasticities.

In both regressions the construction employment and tip fee elasticities are statistically significant. Focusing on the “All Facilities” elasticities, for example, the estimates indicate that a 10 percent reduction in construction employment would result in an 8 percent reduction of solid waste volumes. We should note that this relationship reflects both seasonal and annual trend relations between construction activity and solid waste generation. Regarding seasonality, the construction cycle corresponds closely with the seasonal pattern for yard debris generation, which could have a confounding effect on the estimated elasticity. If so, this would have an upward biasing effect on the construction elasticity. Such confounding should not apply to the annual trend effect of construction activity on solid waste volumes unless annual yard debris trends were highly correlated with annual construction trends, which is unlikely.

The tip fee elasticity indicates that a 10 percent increase in disposal charges would result in about a 1.5 percent decline in the volume of solid waste delivered to all facilities. The tip fee elasticity is greater (but not significantly so) in the Metro facility equation, suggesting that Metro acts as a price leader among regional disposal facilities and that this
may lead to a marginal amount of shifting of waste flows from Metro to non-Metro facilities.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Facilities</th>
<th>Metro Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>-3.66</td>
<td>-1.67</td>
</tr>
<tr>
<td></td>
<td>(-1.01)</td>
<td>(-.53)</td>
</tr>
<tr>
<td>ln Constr. Empl.</td>
<td>.80</td>
<td>.70</td>
</tr>
<tr>
<td></td>
<td>(5.12)</td>
<td>(5.65)</td>
</tr>
<tr>
<td>ln Income</td>
<td>.08</td>
<td>-.13</td>
</tr>
<tr>
<td></td>
<td>(.18)</td>
<td>(.33)</td>
</tr>
<tr>
<td>ln Tip Fee</td>
<td>-.155</td>
<td>-.195</td>
</tr>
<tr>
<td></td>
<td>(-2.16)</td>
<td>(-3.41)</td>
</tr>
</tbody>
</table>

adj. R²          | .71            | .66              |
SEE              | .079           | .070             |
DW               | 2.24           | 2.18             |
DV Mean          | 4.31           | 3.95             |
\n
n               | 84             | 84               |

* t values in parentheses.

The income elasticity estimates in both regressions are not statistically significant. Clearly, changes in income over time lead to changes in consumption and waste generation, but the real income trend during the 1984-90 period was relatively flat to slightly downward and thus did not exhibit sufficient variation to affect waste volumes.
Overall, the statistical fit of the regressions is quite good considering that the dependent variable was specified in standardized form. The standard error of estimate for the All Facilities and Metro Facilities equations were about 1.5 and 2.0 percent of the mean values of the dependent variable. The standard errors also served as a benchmark for evaluating alternative specifications of the models. These alternatives included introducing variable length lags of construction employment and tip fees. Another alternative involved the substitution of building permit data (with varying lags) for construction employment. The standard errors of estimate increased significantly in all of the alternatives relative to the errors associated with the results presented in Table 1.

Given the time series elasticities estimated from the 1984-90 data, we can now assess the extent to which 1991 changes in construction employment, tip fees and population have contributed to changes in solid waste tonnage. To demonstrate these effects we apply the tip fee and construction elasticities from the All Facilities equation to the observed changes (listed in Table 2).

**Table 2**


<table>
<thead>
<tr>
<th></th>
<th>Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>+3.3</td>
</tr>
<tr>
<td>Construction Employment</td>
<td>-1.9</td>
</tr>
<tr>
<td>Tip Fees</td>
<td>+22.7</td>
</tr>
</tbody>
</table>

Preliminary estimates of July 1, 1991 population have been made by Portland State University's Center for Population Research and Census. July through December population growth was projected by extending the average monthly percentage increase derived from the July 1990 to July 1991 period. The resulting Portland MSA population gain for 1991 was estimated to total 39,364 persons, a 3.3 percent increase over 1990.
The monthly construction employment series reported by the Oregon Employment Division runs through October 1991, and employment for the remaining two months was estimated to be equal to the corresponding 1990 level multiplied by the mean 1990-91 percentage change observed from January through October of the respective years. Average monthly construction employment in 1991 was estimated to be 28,810, down 1.9 percent from the 29,370 monthly average of 1990. The 22.7 percent real tip fee increase in 1991 resulted in part from a rate increase which occurred in April and in part from the closure of the St. Johns facility, which had been charging a lower disposal rate than the Metro South and recently-opened Central facilities.

Figure 1 presents the estimated changes in solid waste tonnage attributed to the varying causes. The observed decline in direct haul tonnage in 1991 totals about 75,400. The 1991 deficit grows to about 110,000 tons when the estimated increase in population is factored in. The increase in real tip fees this year is estimated to have produced a 42,000 ton reduction, and the construction decline is estimated to have produced another 18,000 ton reduction. This leaves a 50,000 ton reduction associated with causes which are unexplained by the 1984-90 time series model elasticities applied to 1991 data.

Among the factors to be considered in interpreting the 1991 reduction in solid waste tonnage due to “other causes” is the closure of the St. Johns landfill, the opening of the Metro Central Transfer Station and associated rule changes for the types of wastes which can be accepted. Thus part of the reduction is the result of the recently-instituted prohibition from accepting liquid solid wastes. There may also have been a temporary reduction associated with the switch to a new facility.
Part of the 1991 solid waste deficit due to other causes may also be attributable to imprecise estimates of recent changes in population and construction. For example, one of the reasons the Portland metropolitan area population grew rapidly in the late 1980s was that its unemployment rate was consistently below the national average, which served to attract new residents from other regions. But this gap shrank noticeably in 1991. Thus the estimate of 1991 waste generation associated with population growth may be too high if immigration to the region has slowed down in recent months. Second, solid waste generation from construction activity may have fallen off more in 1991 than construction employment data indicate, due to difficulties of sampling and estimation of employment in this sector. There is considerable entry of new establishments on the up side of a construction cycle and closure of firms on the down side. Estimates of employment have a tendency to be low when construction is expanding because the sampling frame does not include recent
entrants. Conversely, employment estimates tend to run high in a downturn because the sampling frame contains a number of establishments which are no longer operating. Building permit data for the metropolitan area suggest that construction activity may have fallen considerably more than the recorded two percent drop in construction employment. For example, through October 1991 the cumulative monthly value of permits issued in the Portland SMSA was running below 1990 levels as follows: residential, -29.6%; non-residential, -4.5%; total, -21.9%. While these reductions are much greater than the decline in employment, it is also important to remember that permits represent an intent to build at some time in the future rather than actual execution of construction activity in a given time period. With credit becoming more restrictive, the 1991 permit figures may reflect changes in both timing and intent aside from actual levels of construction. Thus there are reasons to believe that construction activity in 1991 fell off more than the recorded employment decline but less than the change in building permits would indicate. Where in the 20 percentage point gap between these two indicators the reality resides, however, is unclear.

The estimated decline in solid waste volumes resulting from tip fee increases may be understated if recent increases have raised the costs of disposal above a threshold which would trigger discrete changes in waste generating, recycling and disposal behavior. There are opportunity costs in the form of time and other resources required to reduce wastes generated, with time probably being a relatively more important consideration for households and capital probably more important for commercial and industrial generators. Disposal costs may be reaching levels where it now makes implicit economic sense for a comparatively large segment of the waste generating population to change their basic behavior. Finally, the tip fee increases, if not matched elsewhere, also raise the incentive to mitigate higher disposal costs by hauling wastes outside the region, or avoid the costs altogether by dumping illegally.
Survey Findings

Disposal Site Survey

In the first of several surveys to identify how wastes were being reduced or diverted from the Metro waste stream, we contacted firms and government agencies with state approved disposal sites in Oregon and Washington. In this survey, we looked primarily at disposal sites in the counties within in a 50-mile radius of the Portland metropolitan area. The hypothesis behind this survey was that with rapidly increasing tipping fees being charged in Portland, waste generators and haulers would consider sites outside the Metro boundary if the fees were significantly less.

To begin the study, we used lists provided by the Oregon Department of Environmental Quality and the Washington State Department of Ecology of permitted disposal sites. We narrowed the scope of the survey to Clark, Cowlitz, Klickitat and Pacific counties in Washington and to Columbia, Clatsop, Tillamook, Yamhill, Polk, Linn, and Hood River Counties in Oregon. We assumed that disposal sites in Multnomah, Clackamas, and Washington counties were covered by the SWIS report.

We quickly discovered that landfills were being closed throughout the two states and that tipping fees were rising rapidly. All the municipal landfills in Columbia, Clatsop, Tillamook, Clark, and Pacific counties are now closed. The remaining landfill sites in these counties are either timber company log yards or industrial sites that are dedicated to one company.

We also discovered that municipalities are increasingly sending their solid wastes to a few regional landfills that have met the new environmental guidelines and that counties are sending their waste enormous distances. All solid waste in Tillamook County and part of Marion County’s waste now go to the Coffin Butte Landfill in Benton County. Solid waste in Pacific and Clark Counties now goes to the Finley Buttes Landfill in Morrow County in Eastern Oregon. All solid waste in Clatsop and Columbia Counties now goes to
the Riverbend Landfill in Yamhill County. Hood River County now sends its waste to the Northern Wasco County Landfill.

In all, there are four waste disposal sites operating along the Columbia River east of the Cascades: Northern Wasco County, Finley Buttes, the Columbia Ridge Landfill used by Metro and Seattle, and the Rabanco Landfill in Goldendale, Washington, used by Spokane, King and Snohomish Counties in Washington. Three of these sites opened in the last two years and are planned for rapid expansion. West of the Cascades are four older solid waste disposal sites and one incinerator: the Cowlitz Landfill used solely by Cowlitz County, the Hillsboro Landfill used solely by Metro-area customers, the Riverbend Landfill, the Coffin Buttes landfill, and the Woodburn Energy Recovery Facility, used solely by Marion County and Metro.

**Summary of Destination of Solid Waste and Tipping Fees**

<table>
<thead>
<tr>
<th>County</th>
<th>Major In-County Disposal Sites</th>
<th>Out-of County Disposal Sites</th>
<th>Per-Ton Tipping Fees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multnomah</td>
<td></td>
<td>Metro</td>
<td>$67</td>
</tr>
<tr>
<td>Clackamas</td>
<td></td>
<td>Metro</td>
<td>67</td>
</tr>
<tr>
<td>Washington</td>
<td>Hillsboro</td>
<td>Metro</td>
<td>67</td>
</tr>
<tr>
<td>Columbia</td>
<td></td>
<td>Riverbend</td>
<td>60</td>
</tr>
<tr>
<td>Clatsop</td>
<td></td>
<td>Riverbend</td>
<td></td>
</tr>
<tr>
<td>Tillamook</td>
<td></td>
<td>Coffin Buttes</td>
<td>60</td>
</tr>
<tr>
<td>Yamhill</td>
<td>Riverbend</td>
<td>Coffin Buttes</td>
<td>28 ($23 in-county)</td>
</tr>
<tr>
<td>Marion</td>
<td>Woodburn</td>
<td>Coffin Buttes</td>
<td>67</td>
</tr>
<tr>
<td>Polk</td>
<td>Coffin Buttes</td>
<td>Northern Wasco</td>
<td>35 (cu. yd. equiv.)</td>
</tr>
<tr>
<td>Hood River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific</td>
<td></td>
<td>Finley Buttes</td>
<td>83</td>
</tr>
<tr>
<td>Cowlitz</td>
<td></td>
<td>Finley Buttes</td>
<td>35</td>
</tr>
<tr>
<td>Clark</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Klickitat</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In terms of prices, all of the counties and disposal sites have raised their tipping fees rapidly, reflecting the rising cost of regulation for maintaining a waste site, the cost of transporting waste larger distances, the cost of recycling operations, and the cost of maintaining transfer stations. There is substantial variation in tipping fees between the
different jurisdictions, although regulation appears to prevent waste generators from exploiting this differential. Clark County, for example, does not accept out-of-county waste at their facility and has relatively small volumes. Hood River is a small population county with no reported out-of-county waste diversion, and Yamhill County only accepts out-of-county waste from Metro itself.

**Summary of Solid Waste Volumes and Tipping Fees**

<table>
<thead>
<tr>
<th>County</th>
<th>1989-91 Tipping Fees</th>
<th>1989-91 Tonnages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multnomah</td>
<td>rose to $67/ton</td>
<td>fell in 1991 for first time</td>
</tr>
<tr>
<td>Clackamas</td>
<td>“</td>
<td>“</td>
</tr>
<tr>
<td>Washington</td>
<td>“</td>
<td>“</td>
</tr>
<tr>
<td>Tillamook</td>
<td>rose $40 to $50 to $60</td>
<td>declining 2-3% per year, at 10k</td>
</tr>
<tr>
<td>Marion</td>
<td>rose $26 to $35 to $67</td>
<td>fell 1/2 % in FY90</td>
</tr>
<tr>
<td>Hood River</td>
<td></td>
<td>Volumes fell, data poor</td>
</tr>
<tr>
<td>Pacific</td>
<td>rose $31 to $83 in 8/91</td>
<td>Volumes steady at 11k</td>
</tr>
<tr>
<td>Cowlitz</td>
<td>rose $16 to $35 in 2/90</td>
<td>Fell 85k to 84k to 83k</td>
</tr>
</tbody>
</table>

The survey indicates that throughout the region, tipping fees are increasing well above the rate of inflation, much in line with Metro’ fees. Moreover, all of the counties have experienced declines in solid waste volumes, despite rising populations. Therefore, Metro’s experience of declining solid waste is not unique, and it appears unlikely that the “lost tonnages” of Metro-area waste are being diverted into the municipal waste streams of neighboring towns and counties. Either the tipping fee differential is insignificant to encourage exporting or the lower-cost county is sufficiently small as to monitor and prevent imports.

The survey did uncover evidence of diversions that were not expected. First, the Rabanco facility has accepted contaminated soils from various sources in the Portland area, amounting to 10-15,000 tons in the last six months. Although price and customer data were not available, this appears to be petroleum-contaminated soil surrounding excavated gas station tanks. In other parts of the surveys, we discovered that some firms are burning
the petroleum contamination to avoid the cost of landfilling this waste. This 10-15,000 tons diverted does not appear to be accounted for in Metro statistics. One problem in detecting these sorts of diversions is that unlike municipal collection, generator-to-private landfill transactions are proprietary information. The Rabaaco manager expects these deliveries to rise in future years. He reports being contacted by Portland-area auto salvager and Metro itself about receiving wastes.

Second, we investigated the scope of operations at the North Plains Landfill, an unlicensed disposal facility in northern Washington County currently under observation by the Oregon DEQ and the Washington County Department of Health. North Plains is located on the site of the Sunset Lumber Mill which closed several years ago. The owner claims to be operating a wood waste recycling and composting facility that requires no state permit. DEQ and the Health Department officials believe that the North Plains facility may be an illegal operation, accepting land clearing debris (tree trunks and branches). A recent inspection, for example, found piles of asphalt and metal, suggesting that the landfill accepts construction and demolition waste. The material is collected in a four-story tall pile, roughly an acre in size ("not quite a football field").

Determining the annual amount of waste received at the North Plains site is more difficult. In October, 1991, a Health Department official observed 5 dump trucks delivering material over a 45 minute period. Given a conservative estimate of 1 ton per truck, 10 45-minute periods per day, and 200 working days in a year, this site could be receiving 10,000 tons per year. A worker at the site claimed that they charge $2 per cubic yard for receiving waste material and charge $2 per cubic yard for selling composted material. Neither the DEQ nor the Health Department has observed any sales of composted material and suspect that none occur. By any measure, the delivery prices are well below Metro tipping fees. Since this estimate is based on a single observation, the annual tonnage is speculative and we cannot assess if the volumes are an increase or decrease from
previous years. The owner claims that the pile is an accumulation of material from 40 years of operating the lumber mill.

Finally, the disposal site survey presents a picture of how metropolitan Portland’s solid waste generation industry compares in size to waste generation in the timber industry and how rising disposal prices are affecting behavior in this industry. Most lumber mills, paper mills, and logging companies own disposal sites to handle their wood wastes and only use them internally. However for companies without a permitted disposal site, the Mount Solo Landfil in Cowlitz County is a private facility for wood waste and charges customers $15 per cubic yard (roughly $30 per ton). Their disposal rates have risen from $2-3 per cubic yard in 1989. As with solid waste, their volume of waste has fallen almost in half, from 600,000 tons to 300,000 tons in the last few years. The site manager at Mt. Solo reports that its customers are investing heavily in separating wood waste from rocks and debris and grinding it up for “hogged fuel” for paper mills. A manager at a Clatskanie log yard gave us an idea of the economics of producing this fuel, based on now outdated prices. For $7-8 per ton, they can separate and produce the hogged mill chips, and for $10 per ton, they can ship them to a paper mill. Although worth only $10 a ton as fuel for paper mills, the loss from making and selling hogged mill fuel is nevertheless only a third of the (then) $20 per ton disposal costs (now $30-70). This cost differential suggests that any industry that produces significant amounts of wood waste (chips, sawdust, pallets), even with impurities, may consider recycling and energy recovery at high tipping fees.

It is also noteworthy that Mt. Solo’s 300,000 tons compares with the Cowlitz County solid waste figure of 83,000 tons. This suggests that any previous diversions of wood waste into the Metro solid waste flow stream would confound any comparison of volumes over time. From other parts of the survey, we have noticed firms with wood waste and soil waste adopting alternative disposal methods.
Liquid Waste Generators

In this survey, we attempted to determine the effects of Metro's ban on accepting liquid wastes and increases in disposal costs. Our hypothesis was that these changes would result in a reduction in the amount of waste generated. From a list of holders of special waste permits provided by Metro, we selected a cross-section of establishments expected to be generating liquid wastes. The generators included in this survey were manufacturers, services of various kinds, and public agencies. Although the generators surveyed do not constitute a scientific sample, we believe the information they provided are illustrative of the more general population.

We discovered that all of those surveyed had been affected by the ban on liquid waste disposal and by the cost increases. Although responses varied depending on type of business and waste generated, it is clear that the changes instituted by Metro have had an impact on generators of liquid wastes. Responses to higher prices and restrictions on liquid waste included changes in industrial processes and recycling.

Among manufacturers, there were examples of significant cost and effort expended to reduce the volumes of liquid wastes. For example, a chemical producer, which had generated over 500,000 gallons/year of slurry containing 5% solid material, has installed a filter press and water treatment facility that reduces the slurry to 95% solids. This process permits disposal of the remaining liquid in the sewer and constitutes a 90% reduction in waste disposal. In addition, through implementation of a raw materials recovery system, this company expects to reach a zero waste disposal goal within two years.

These changes in industrial processes to eliminate wastes have become quite common. Another manufacturer which has produced 1000 tons/year of slurry waste, now uses a chemical process to precipitate the solids which are filtered out. The waste liquid is then treated and disposed as industrial sewage. This process results in a 50% reduction in disposed weight. An ink manufacturer has introduced a waste water treatment system that removes suspended solids from the waste stream and the treated liquid is sent to the sewer.
A producer of chemicals for the plywood industry has reduced its disposal of liquid waste by 30% through internal recycling (a reduction of approximately 3 tons/month).

Among service industries, we find similar efforts to reduce liquid waste volumes. A publishing company has reduced disposed wastes by 30,000 pounds/year through treatment of its liquid waste stream and recycling (90% reduction). A dealer in asphalt and related products, through a combination of recycling, elimination of leaks and spills, and protection of equipment from rainfall has reduced their waste disposal from 100 55-gallon drums/year to 10 55-gallon drums/year (90% reduction). And by implementing a program of recycling asphalt by-products, they expect to eliminate solid waste generation within two years. A large public agency is making extensive use of drying and bio-remediation to reduce the amount of liquid waste it generates. An extreme case is that of a hauler of industrial and commercial waste which has ceased to transport liquid waste because it no longer has access to Metro facilities. Clearly, the change in liquid waste policies by Metro has stimulated widespread changes in industrial and commercial practices.

**Solid Waste Generators**

In this survey, we also selected a group of solid waste generators from a list of Metro customers whose waste tonnages had dropped considerably after January, 1991. Since this date coincided with the closure of St.John's Landfill, we hypothesized that this may have caused a diversion of solid wastes away from Metro facilities. If so, we wanted to determine the amount and destination of the diverted waste. The generators selected included construction companies, environmental service companies, food wholesalers, transportation service companies, and public agencies.

Many of the generators simply diverted their wastes to other non-Metro facilities following the closure of St. John’s. The greatest number were the construction companies who without exception simply shifted their wastes to other facilities that were accounted for by Metro: Hillsboro Landfill and Metro Transfer Stations. As another example,
Hillsboro High School District began using Forest Grove Transfer Station—also included in the Metro figures. For these generators, the closure of St. John’s was merely an inconvenience that caused them to look elsewhere.

For other generators, the closure at St. John’s and the concurrent rise in tipping fees led them to consider recycling and waste elimination strategies. For example, a beverage distributor which had previously disposed of 10 tons/month at Metro facilities has reduced that amount by 80% through commercial recycling. A transportation company has reduced their waste disposal from 7,000 pounds/month to 1,000 pounds/month by recycling wooden pallets and shipping crates to a "hogging mill" of the type mentioned earlier in this report. An environmental services company that specializes in the disposal of petroleum contaminated soils operates a mobile treatment facility that can handle excavations in excess of 200 cubic yards (approximately 100 tons) and has reduced their demand for landfill disposal by 90%. These large waste reductions may well continue in the future even without any additional increase in Metro’s tipping fees, as our previous discussion of long-term elasticities indicated. We spoke with a manager of a foundry that presently disposes of 1,000 tons/year of solid waste. In the near future, they expect to receive permission to recycle foundry sand in roadbeds and asphalt thereby eliminating 90% of their solid waste.

While this survey information is not derived from statistically valid samples, some tentative general conclusions can still be drawn. We have shown that waste generators are responding to regulatory and price changes and that the magnitude of these responses is very large. The generators surveys also shed light on the behavioral changes that were either explained or unexplained in the time series analysis. Although it is difficult to separate the impacts of price increases and other regulatory changes on any individual generator’s behavior, much of the reduction in liquid waste disposal is clearly due to the change in regulation and should be considered as an example of waste reductions unexplained by the variables in the time series analysis. In the case of solid waste disposal,
the increased activity involving recycling of wood waste and disposal of petroleum contaminated soils are examples of waste reduction that are explained by the time series analysis.

**Summary of Waste Generator Survey**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number Surveyed</th>
<th>Response</th>
<th>Average Reduction (% weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturers</td>
<td>7</td>
<td>Elimination &amp; Recycling</td>
<td>40%</td>
</tr>
<tr>
<td>Services</td>
<td>9</td>
<td>Elimination &amp; Recycling</td>
<td>50%</td>
</tr>
<tr>
<td>Light Construction</td>
<td>6</td>
<td>Diversion to Another Facility</td>
<td>0%</td>
</tr>
<tr>
<td>Public Agencies</td>
<td>3</td>
<td>Elimination, Recycling &amp; Diversion</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Assessment of Forecasting Methodology**

It should be understood that the time series analysis presented in this report is the result of a short-term modeling effort using very limited resources. While we believe the parameter estimates and structure of the time series model improve on the existing forecasting process, there are a variety of issues which ought to be considered in relation to constructing a solid waste forecasting model and developing a forecasting process.

There are two basic issues to address in developing a forecast. The first is the type of statistical model which is best suited to the task. It is important to balance forecast reliability against cost and difficulty of use. It is also important to avoid the appearance of greater precision than is in fact available. The second major issue is how to respond to changes in parameters or other issues which are not captured in the statistical model. One
example might be changes in regulations regarding what wastes can be accepted at a facility.

**Modeling**

A model of the amount of solid waste generated is an important starting point for a forecast. It helps insure consistency in the parameters reviewed and automatically highlights changes in key variables. The model however must be reasonable for the amount of data available and the parameters which are estimated. For example, there is some evidence that measures of construction activity other than employment might provide a better measure of the activities which generate solid waste, but data limitations may prevent that refinement from being made. For the data available, construction employment may be the best proxy for construction activity. These relationships should be explored more systematically than could be done for the current study.

The estimated price elasticity of demand for the current model assumes that the quantity response is directly related to the contemporaneous price. When price is changing slowly, this assumption may be very reasonable; however, when there are large changes in price, the full quantity response may take considerable time to occur. It will take time for firms and individuals to change the methods of waste generation and processing. For example, firms may respond to higher prices by drying liquid waste, but it may take time to purchase and install the drying equipment. Some firms may only consider such steps after observing other firms using the new process. Given the relatively large increases in the recent past, this is likely to be an important issue in refining the forecast.

The amount of solid waste generated will be responsive to a large number of parameters. The key to accurate forecasting is to determine the parameters which are most important in determining variations in the amount of waste generated in the Portland area. Some of these parameters will be related to local characteristics but some will be determined at the state or national level. In addition, there are likely to be regulatory changes which
may cause sudden changes in waste generation or disposal. The forecasting process should start with a statistical analysis of the changes in the major parameters and the effect of these changes on solid waste volumes. However, it should also include a process to identify the changes in other characteristics, such as the regulatory environment, which are likely to impact on waste generation and disposal activity.

**Advisory Panel**

Most forecasting models used either at the national or state level, rely on a forecast from a model as the starting point. This forecast is then modified after discussion relating to the reasonableness of some of the key estimates. The forecast is then modified to take account of certain inconsistencies and then re-run. The standard approach to such issues is to appoint a forecast advisory panel which reviews the key elements of the forecast and provides input regarding plausibility of key parameters as well as information on items outside of the variables considered in the statistical study. This panel would typically consist of people knowledgeable about key areas which affect the forecast. For example, it probably should include someone in the construction industry to advise about industry practices and the anticipated level of activity. This method has proven to be superior to either straight model forecasts or straight expert-opinion forecasts.

Examples of the types of anomalies which might arise at the national level would be a forecast of automobile production which industry experts consider unrealistic or a forecast of employment growth and output growth which implied unrealistic rates of productivity improvement. Regarding solid waste, changes in regulatory activity may be the most difficult items to treat systematically. However, it is important not to neglect this source of variability, since it may lead to sudden changes in volume. For most forecasts, the process is likely to be simple and straightforward, but specifying the process in advance creates an opportunity to identify changes likely to impact on the forecasts before they create problems.
Refining The Forecast Model

The identification of key variables should start with the statistical results identified in this report. In particular, the price-quantity relationship should be addressed simultaneously, and the impact of construction activity should be modeled carefully. Some of the national trends in waste generation might also be of importance in forecasting. While these factors may not make much of an impact from year to year, the cumulative effect could be quite large, and incorporating them into the forecast could improve reliability.

The forecast should also look at alternatives within the region but outside of the metropolitan area to determine if there are changes occurring in availability or price of waste disposal which would affect the amount generated within the Metro region. This may require some extension of the work done in this study to determine how the reduction in generated wastes was accomplished. It may be necessary to model the activity and capacity of other landfills as part of the Metro forecasting process.

To generate a forecast from the statistical model, it is necessary to have forecasts of some key variables which drive the model. The overall level of economic activity will be important, and population growth is likely to have an impact as well. Most of the items which are of relevance can probably be taken from the Oregon Economic Forecast, which is generated quarterly. This forecast usually summarizes key national forecast variables as well. It is the judgment of the authors of this study that a relatively simple process would best serve Metro’s needs. A simple forecasting model based on the tipping fee, construction activity and proxies of the overall level of economic activity in the region would provide a reasonable forecast most of the time.

The solid waste system is sufficiently complex that the effort to model it would appear to be prudent simply to identify other changes which may occur in the future. Further, it would be prudent to have a forecast review panel since this is typically a low cost way to control for changes in the parameters outside of the modeling process.
Conclusion

This report sought to explain the reduction in solid waste volumes experienced in the Metro region in the past year. In the time series analysis section, we provide an explanation of why the Metro area had a reduction by looking at the impact of prices, construction activity, and population growth. In the survey section, we provide an explanation of how waste generators are responding by interviewing the generators themselves and the disposal sites they send their wastes to.

The time series analysis explained variations in solid waste volumes by variations in the tipping fee, regional population growth, and employment in the construction industry. The model showed that the tipping fee had the expected negative effect on waste generation while the other two variables had positive relationships, with the estimated price elasticity well within the range of previous work in this area. Much of the overall decline in solid waste volumes in 1991 can be explained by the continued rise in tipping fees and by the decline in construction employment. Although this model can be improved upon, it can serve as a rough tool for estimating future levels of solid waste generated.

The survey data that we collected gives a more detailed picture of what activities firms are engaging in as a response to changing prices and regulation. Many landfills are no longer open, which by itself is forcing firms to consider new outlets for their wastes. Tipping fees throughout the region are uniformly high, even taking inflation into account, and for the counties where reasonable data was available, all were experiencing reductions in the amount of solid waste collected. We found that generators were responding to the higher prices by eliminating waste in their production processes, by recycling their by-products, by incinerating or minimizing waste, and in some cases by disposing of their wastes illegally. We know that firms are making long-term investments in waste reduction whose effects we will see in upcoming years. Finally, while our surveys were limited to
manufacturing and commercial businesses, we believe that the similar incentives are faced by households in their waste generation, although their waste is measured by volume and not weight and must be adjusted in large amounts to win cost savings.

We recommend that Metro adopt and refine a model for predicting future solid waste volumes and employ a forecasting review panel. We also recommend that Metro consider the impact of future regulatory changes on waste generation, whether promulgated by the federal EPA, by the state DEQ, by local government, or by Metro itself. Finally, we recommend that Metro sponsor an inter-agency task force to monitor illegal dumping. As a monopoly-supplier of solid waste disposal services, Metro must be careful that illegal competitors do not capture its business. Although the other agencies will be concerned with the condition of their landholdings or with public health, Metro must safeguard its revenue base.
References


