# Analysis of GHG emissions from Travis County Landfills from 2010 to 2030

A Report to the City of Austin Office of Sustainability

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The purpose of this report is to estimate the greenhouse gas (GHG) emissions for Travis County landfills given the existing zero-waste and recycling goals of Austin Resource Recovery of the City of Austin. The analysis of GHG emissions projections for Travis County waste/resources proceeds with 2 steps: Develop Baseline Waste Disposal Tonnage and then Calculate GHG Emissions for baseline and zero-waste scenarios.

## Step 1: Develop Baseline Waste Disposal Tonnage

Project baseline GHG emissions from landfills assuming 2010 patterns and programs for Austin Resource Recovery continue to 2030 along with baseline projections for Austin/Travis County.

The **baseline patterns** that are assumed to continue are:

1. **Population Projection**

   Waste generation models are partially a function of the Travis County and Austin populations. The population data and future projections are:

   Travis County population[1]:
   a. Population in 2000 = 812,280
   b. Population in 2010 = 1,024,266
   c. Population in 2020 = 1,273,260
   d. Population in 2030 = 1,508,642

   City of Austin population[2]:
   a. Population in 2000 = 656,562
   b. Population in 2010 = 790,390
   c. Population in 2020 = 951,562
   d. Population in 2030 = 1,104,326

[1] http://www.austinchamber.com/do-business/data-research/area-profile/population.php
[2] http://www.austintexas.gov/sites/default/files/files/Planning/Demographics/austin_forecast_2013_annual_pub.pdf

Applying linear interpolation gives the population projections shown in Figure 1.

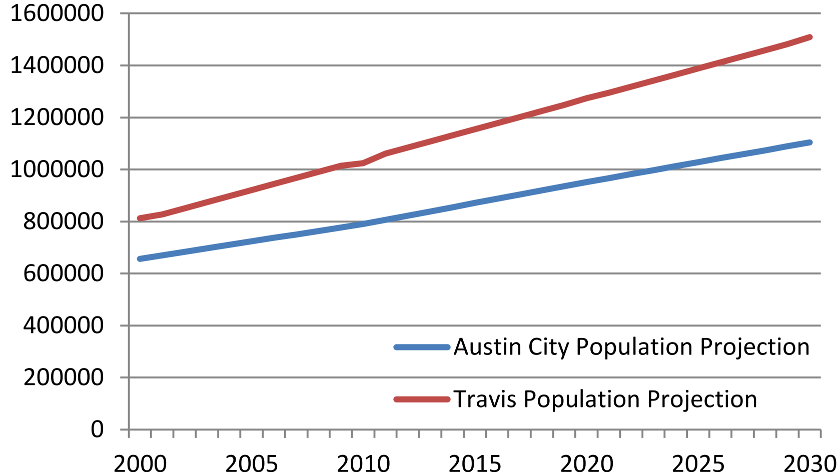


**Figure 1**. Population projection for Travis County (Red) and the City of Austin (Blue) from 2000-2030.

**2. Waste Generation and Deliveries to Landfill**

From TCEQ historical data (2003-2011), the amount of waste sent to Travis County landfills is as in [1].

**Table 1.** TCEQ historical data on the amount of waste sent to Travis County landfills from 2003-2011 [1].

| Year | Short tons of waste per year |
|---|---|
| 2003 | 2,069,262 |
| 2004 | 2,147,979 |
| 2005 | (TCEQ gave replica of 2006 report) |
| 2006 | 2,232,416 |
| 2007 | 2,405,619 |
| 2008 | 2,520,528 |
| 2009 | 2,420,120 |
| 2010 | 1,719,446 |
| 2011 | 1,545,914 |

We model total landfill waste deliveries as a function of construction activity and population. To estimate construction activity we use data for residential housing in construction for the southern United States [2] as a proxy for housing construction activity in Travis County. The equation used to estimate total landfill deliveries, in tons of material per year, is shown in Equation (1) where $T$ is tons/yr of landfill deliveries, $T_C$ are landfill deliveries from construction activity (waste), and $T_{NC}$ are landfill deliveries from non-construction activity (waste).

$$T = T_C + T_{NC} \quad (1)$$

$T_{NC}$ is modeled as an assumed constant per capita rate of waste generation, $\alpha$ (tons/person/yr), multiplied by Travis County population. See Equation 2 where $P$ is the population of Travis County.

$$T_{NC} = \alpha P \tag{2}$$

**Table 2. Assuming $\alpha$ = (365/2000)(lb/person/day) in "tons/person/yr" and population from Figure 1 in Equation 2, and using total Travis County landfill waste data, we calculate $T_C$ from Equation 1. Original data are in units of "lb/person/day" of waste generation estimated from a graph in the source.**

| Year | ***T***: **"Data"** Total Landfill waste in Travis Co. [tons/yr][a] (using Equation 1) | ***$T_{NC}$***: **"Modeled"** Non-Construction Landfill waste [tons/yr] (using Equation 2) | ***$T_C$***: **"Modeled"** Construction Landfill Waste [tons/yr] (using Equation 3) | **Capital area solid waste generation** (approx.) (lb/person/day)[b] | **Travis Co. Population** |
|---|---|---|---|---|---|
| 2003 | 2,069,262 | 1,292,054 | 806,240 | 8.1 | 874,043 |
| 2004 | 2,147,979 | 1,342,995 | 606,678 | 8.2 | 897,424 |
| 2006 | 2,232,416 | 1,516,363 | 818,937 | 8.8 | 944,186 |
| 2007 | 2,405,619 | 1,553,913 | 936,845 | 8.8 | 967,567 |
| 2008 | 2,520,528 | 1,482,954 | 1,052,189 | 8.2 | 990,948 |
| 2009 | 2,420,120 | 1,203,248 | 1,045,228 | 6.5 | 1,014,329 |
| 2010 | 1,719,446 | 1,121,571 | 725,192 | 6 | 1,024,266 |
| 2011 | 1,545,914 | 1,138,658 | 418,221 | -- | 1,061,092 |

**a**: TCEQ Annual Summary of Municipal Management in Texas, 2003-2011. See http://www.tceq.state.tx.us/permitting/waste_permits/waste_planning/wp_swasteplan.html.
**b**: CTSIP (2012) Central Texas Sustainability Indicators Project, 2012 Data Report (obtained from UT School of Architecture). Also see http://soa.utexas.edu/csd/research/sustainability-indicators.

Table 2 shows the estimate for both construction ($T_C$) and non-construction ($T_{NC}$) waste deliveries to landfills. In order to project landfill waste deliveries to the year 2030, we performed a multiple linear regression using the input data in Table 3. These data are the annual change in employment in the "Natural Resources, Construction" sector for the Austin-Round Rock area [2]. The regression model equation for $T_C$ is shown in Equation 3 ($r^2$ = 0.76, standard error = 144,000 tons/yr). The input factors for prediction include change in employment for the previous year ($Emp_{-1}$), or "lag-1 year data" as well as the same data lagged 2 years ($Emp_{-2}$). The lagged variables are included because there is higher (and positive) correlation of our model of construction waste as compared to 2-year and 1-year lagged "Natural Resources, Construction" employment data. However, we do not include employment data for the current year as an input factor because, for the data we are modeling, the coefficient for current year employment is negative, and there is a negative correlation between construction waste and current year change in employment "Natural Resources, Construction" employment. ***This negative correlation with current "Natural Resources, Construction" employment makes little intuitive sense***, and hence we neglect it from the model. It is also possible that there is indeed a lagged effect of both construction waste and waste generation from new home activities (furnishing, appliances, moving and discarding old items, etc.).

Given the small set of calibrating data from 2003 to 2011 (neglecting duplicate data for 2005), our estimate has a prediction standard error (sample standard deviation) of approximately 144,000 tons/yr for construction waste. Nonetheless, it captures the general trend of the rising then falling data trend for our estimate of construction waste.

$$T_C = \beta_{-1} Emp_{-1} + \beta_{-2} Emp_{-2} + \delta \quad (3)$$
$$T_C = 1.22 Emp_{-1} + 54.9 Emp_{-2} + 799{,}528$$

**Table 3. Annual change in employment in "Natural Resources, Construction" in the Austin-Round Rock area, including those same data lagged 1 year and 2 years. These data are used as a proxy for construction activity.**

| Year | "Natural Resources, Construction" change in employment, approx. (Austin-Round Rock MSA) | "Natural Resources, Construction" change in employment, approx. (Austin-Round Rock MSA), Lag 1-yr | "Natural Resources, Construction" change in employment, approx. (Austin-Round Rock MSA), Lag 2-yr |
|---|---|---|---|
| 2003 | -500 | -3500 | 200 |
| 2004 | 300 | -500 | -3500 |
| 2006 | 4500 | 2400 | 300 |
| 2007 | 4500 | 4500 | 2400 |
| 2008 | -1200 | 4500 | 4500 |
| 2009 | -6900 | -1200 | 4500 |
| 2010 | -1900 | -6900 | -1200 |
| 2011 | 400 | -1900 | -6900 |

Figure 2 shows the data (total tons of trash in Travis County landfills), modeled historical data (of 2003-2011 construction and non-construction waste into landfills), and projected future (2012 to 2030) construction, non-construction, and total landfill waste into Travis County landfills. The projections assume that (i) there is a +1%/yr annual rate of change in per capita non-construction waste generation and (ii) the assumed change in employment for the "Natural Resources, Construction" sector is +2% for 2012-2030 (that is to say the assumption is that construction increases over time). These assumptions can easily be changed to understand different waste projections.

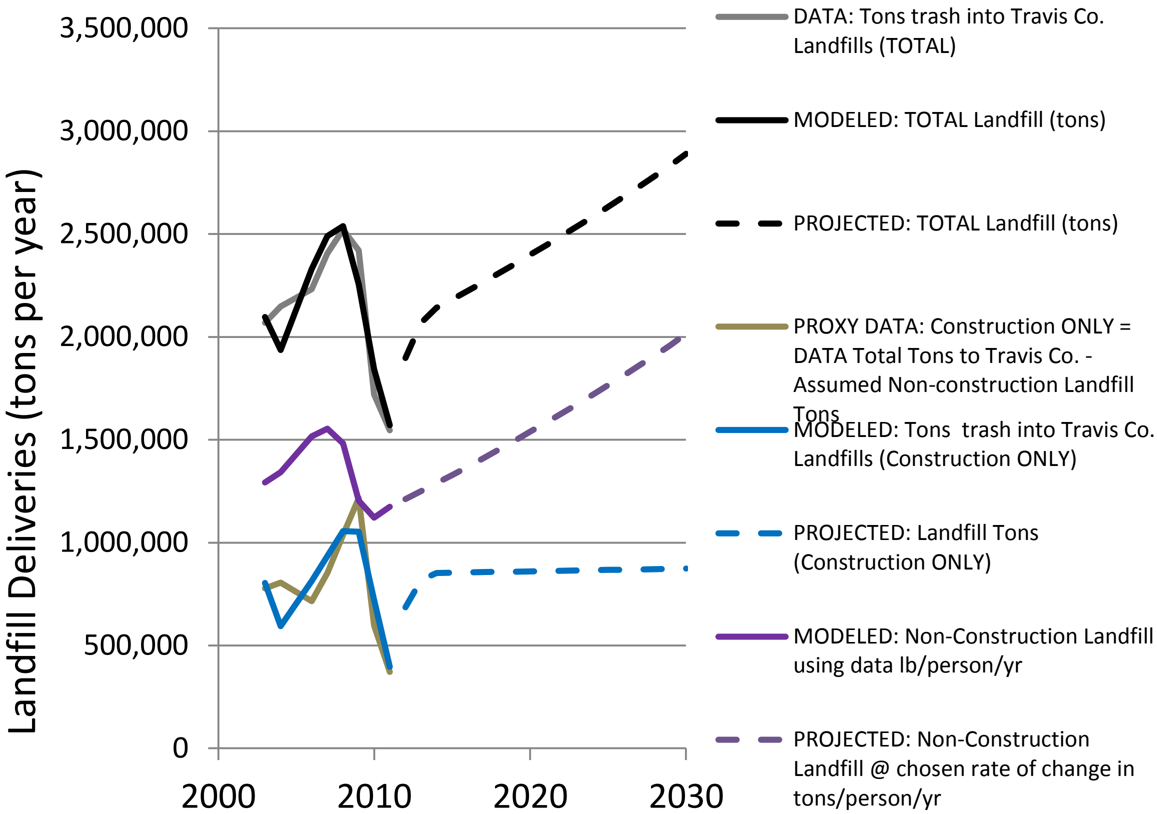


**Figure 2. Historical data and models are used to project future landfill waste from both construction and non-construction activities. The projections assume that (i) there is a +1%/yr annual rate of change in per capital non-construction waste generation and (ii) the assumed change in employment for the "Natural Resources, Construction" sector is +2% for 2012-2030 (that is to say the assumption is that construction increases over time).**

Using Figure 3 below (Table 28 from the Austin Resource Recovery Master Plan, 2011), we can assume a baseline waste diversion of 34% for the city of Austin as already occurring in 2010.

Table 28 - Citywide Controlled Totals

| | In Tons | | | | |
|---|---|---|---|---|---|
| Citywide Controlled Totals | FY 2010 (Est.) | FY 2015 | FY 2020 | FY 2025 | FY 2030 |
| Projected Diversion | 432,611 | 715,000 | 1,255,000 | 1,637,250 | 1,952,000 |
| Projected Disposal | 838,757 | 715,000 | 418,000 | 289,000 | 217,000 |
| Projected Total Waste Generation | 1,271,368 | 1,430,000 | 1,673,000 | 1,926,250 | 2,169,000 |
| Citywide Diversion Rate | 34% | 50% | 75% | 85% | 90% |

**Figure 3. Projected City wide waste generation, disposal, and diversion figures as a result of Austin Resource Recovery Programs [3].**

Since we want to obtain a business-as-usual (BAU) waste generation scenario for Austin, we assume that there are no new Austin Resource Recovery (ARR) programs implemented beyond 2010 and that 66% of waste generated each year goes to landfill. Using 'Total Waste Generation' numbers from Figure 3 at the specified years and interpolating in between, we can obtain the amount of waste to landfill from 2010-2030.

To obtain the amount of waste going to landfill after Austin Resource Recovery Programs have been implemented, we *make the assumption that these ARR programs will only affect waste generated in Austin itself and not the rest of Travis County*. For each program in the years 2010, 2015, 2020, 2025, and 2030, we obtain the waste diversion tonnage from ARR figures [3]. Then, interpolation is used to find the amount of waste diversion for interval years. The final figures for diversion are different from reported totals for several reasons:

1) Household Hazardous Waste is not taken into account, since they are processed by specialized facilities and do not go into general landfills.

2) Since several ARR programs are already in effect by 2010 and simply become more effective over time, they have been partially taken into the business-as-usual scenario. This means that the amounts of diversion by these programs in 2010 are subtracted from the diversion tonnages in subsequent years. This ensures that, for every year after 2010, a certain portion of the diversion tonnage is included in the 34% baseline diversion we have assumed for the city.

We obtain the following Table 4 of waste going to landfills (total tons) for Travis County and Austin.

**Table 4. Landfill trash (total tons), per year. Note that: 1)"After ARR (Travis)" and "After ARR (Austin)" have been reduced by the same amount, and 2) the "After ARR (Travis)" number for 2011 is lower than usual. This difference is due to the fact that values from 2010 and 2011 are actual reported TCEQ numbers, while values from 2012-2030 are projected values. "After ARR (Travis)" includes the "After ARR (Austin)" values, and that is why it has a decreasing trend.**

| Year | BAU Travis | BAU Austin | After ARR (Travis) | After ARR (Austin) |
|---|---|---|---|---|
| 2010 | 1,719,446 | 838,757 | 1,719,446 | 838,757 |
| 2011 | 1,545,914 | 859,766 | 1,523,227 | 837,079 |
| 2012 | 1,897,319 | 880,774 | 1,849,472 | 832,927 |
| 2013 | 2,068,313 | 901,783 | 1,995,306 | 828,776 |
| 2014 | 2,141,938 | 922,791 | 2,043,771 | 824,624 |
| 2015 | 2,182,898 | 943,800 | 1,900,727 | 661,629 |
| 2016 | 2,224,547 | 975,744 | 1,844,806 | 596,003 |
| 2017 | 2,266,897 | 1,007,688 | 1,789,086 | 529,877 |
| 2018 | 2,309,957 | 1,039,632 | 1,734,076 | 463,751 |
| 2019 | 2,353,737 | 1,071,576 | 1,679,786 | 397,625 |
| 2020 | 2,400,351 | 1,103,520 | 1,628,330 | 331,499 |
| 2021 | 2,443,499 | 1,137,136 | 1,600,178 | 293,815 |
| 2022 | 2,489,501 | 1,170,752 | 1,574,880 | 256,131 |
| 2023 | 2,536,266 | 1,204,368 | 1,550,345 | 218,447 |
| 2024 | 2,583,802 | 1,237,984 | 1,526,581 | 180,763 |
| 2025 | 2,632,123 | 1,271,600 | 1,503,602 | 143,079 |
| 2026 | 2,681,238 | 1,305,140 | 1,495,017 | 118,919 |
| 2027 | 2,731,159 | 1,337,260 | 1,487,238 | 93,339 |
| 2028 | 2,781,897 | 1,369,380 | 1,480,276 | 67,759 |
| 2029 | 2,833,463 | 1,401,500 | 1,474,142 | 42,179 |
| 2030 | 2,890,294 | 1,433,620 | 1,473,273 | 16,599 |

### 3. Characterization of Landfill Waste Content

Since the exact composition of Travis county waste is unknown, estimations must be made regarding both the existing composition of the landfills and how Austin Resource Recovery programs impact this composition.

From TCEQ data, it can be seen that total landfill waste is significantly higher than can be accounted for through *(population)×(per capita waste generation)*. Thus, we conclude that a large portion of the waste stream is comprised of construction waste. From the previous section, we establish construction waste to be approximately 40% of the total.

To account for how ARR programs impact the waste stream, we examined each program in terms of what type(s) of material(s) it impacts and the reported ARR values for total tons of waste the program diverts. If a program diverts multiple types of materials (e.g. paper and lumber), then the relative amount of each type of material is determined by applying the relative compositions found in Table 5. See **Appendix** for assumptions about what material(s) each program impact(s). Tables 6-1 to 6-4 indicate our assumption for the quantities of each type of waste material that are diverted by each ARR "zero waste" program. The items listed in each row of Tables 6 relate to the landfill GHG tool used for estimating GHG emissions from landfills.

**Table 5. Resource breakdown of Austin waste stream into 12 Market Categories by percentage in second column [4].**

**Resource Commodity Analysis Austin Texas**
(In order of value of materials discarded)

| Categories | % | Annual Tons | $/Ton[13] | Annual $ |
|---|---|---|---|---|
| Paper | 36 | 360,000 | 50 | 18,000,000 |
| Reusables | 2 | 20,000 | 550 | 11,000,000 |
| Textiles | 5 | 50,000 | 100 | 5,000,000 |
| Polymers | 8 | 80,000 | 50 | 4,000,000 |
| Metals | 5 | 50,000 | 40 | 2,000,000 |
| Plant Debris | 20 | 200,000 | 7 | 1,400,000 |
| Putrescibles[14] | 9 | 90,000 | 7 | 630,000 |
| Glass | 5 | 50,000 | 10 | 500,000 |
| Wood | 6 | 60,000 | 8 | 480,000 |
| Ceramics | 2 | 20,000 | 4 | 80,000 |
| Soils | 1 | 10,000 | 7 | 70,000 |
| Chemicals | 1 | 10,000 | 5 | 50,000 |
| **Total** | **100** | **1,000,000** | | **$ 43,210,000** |

**Table 6-1. Waste Avoidance.** The cumulative quantity (tons) of each type of organic material assumed to be diverted from 2010 to 2030.

| | Expanded Reuse Entrepreneur Opportunities | Waste Reduction Assistance Program (WRAP) | Waste Pairing (By-product Synergies) |
|---|---|---|---|
| Newspaper | 23,074 | 0 | 90,957 |
| Office Paper | 23,074 | 100,000 | 90,957 |
| Corrugated Boxes | 23,074 | 100,000 | 90,957 |
| Coated Paper | 23,074 | 0 | 90,957 |
| Food | 0 | 0 | 0 |
| Grass | 0 | 0 | 0 |
| Leaves | 0 | 0 | 0 |
| Branches | 0 | 0 | 0 |
| Lumber | 15,384 | 0 | 60,640 |
| Textiles | 12,820 | 0 | 50,532 |
| Diapers | 0 | 0 | 0 |
| Construction/Demolition | 0 | 0 | 0 |
| Medical Waste | 0 | 0 | 0 |
| Sludge/Manure | 0 | 0 | 0 |
| TOTAL (tons) | 120,500 | 200,000 | 475,000 |

**Table 6-2. Recycling.** The cumulative quantity (tons) of each type of organic material assumed to be diverted from 2010 to 2030.

| | Single Stream Recycling (Residential) | Commercial and Multifamily Recycling (plus URO impacts) | Expanded Multifamily Drop-Off Recycling Services | Clean Austin-Expanded Bulk Collection and Recycling |
|---|---|---|---|---|
| Newspaper | 405,620 | 0 | 0 | 0 |
| Office Paper | 405,620 | 4,683,334 | 580,000 | 0 |
| Corrugated Boxes | 405,620 | 4,683,333 | 580,000 | 0 |
| Coated Paper | 405,620 | 4,683,333 | 580,000 | 0 |
| Food | 0 | 0 | 0 | 0 |
| Grass | 0 | 0 | 0 | 0 |
| Leaves | 0 | 0 | 0 | 0 |
| Branches | 0 | 0 | 0 | 0 |
| Lumber | 0 | 0 | 0 | 65,779 |
| Textiles | 0 | 0 | 0 | 54,815 |
| Diapers | 0 | 0 | 0 | 0 |
| Construction/Demolition | 0 | 0 | 0 | 0 |
| Medical Waste | 0 | 0 | 0 | 0 |
| Sludge/Manure | 0 | 0 | 0 | 0 |
| TOTAL (tons) | 1,622,479 | 14,050,000 | 1,740,000 | 120,594 |

**Table 6-3. Other recycling and Construction and Demolition.** The cumulative quantity (tons) of each type of organic material assumed to be diverted from 2010 to 2030.

| | Public Area Recycling Containers | Glass Collection Pilots for Multifamily and Commercial Sites | C&D Debris Ordinance- Development, Implementation, Enforcement | Event Recycling Ordinance |
|---|---|---|---|---|
| Newspaper | 9,400 | 0 | 0 | 2,550 |
| Office Paper | 9,400 | 0 | 0 | 2,550 |
| Corrugated Boxes | 9,400 | 0 | 0 | 2,550 |
| Coated Paper | 9,400 | 0 | 0 | 2,550 |
| Food | 0 | 0 | 0 | 2,550 |
| Grass | 0 | 0 | 0 | 0 |
| Leaves | 0 | 0 | 0 | 0 |
| Branches | 0 | 0 | 0 | 0 |
| Lumber | 0 | 0 | 0 | 0 |
| Textiles | 0 | 0 | 0 | 0 |
| Diapers | 0 | 0 | 0 | 0 |
| Construction/Demolition | 0 | 0 | 1,940,000 | 0 |
| Medical Waste | 0 | 0 | 0 | 0 |
| Sludge/Manure | 0 | 0 | 0 | 0 |
| TOTAL (tons) | 28,200 | 0 | 1,940,000 | 12,750 |

**Table 6-4. Composting and Organics.** The cumulative quantity (tons) of each type of organic material assumed to be diverted from 2010 to 2030.

| | Compost Incentive Program | Residential Organics Collection | Storm-Ready Austin | Commercial and Multifamily Organics |
|---|---|---|---|---|
| Newspaper | 0 | 0 | 0 | 0 |
| Office Paper | 0 | 0 | 0 | 0 |
| Corrugated Boxes | 0 | 0 | 0 | 0 |
| Coated Paper | 0 | 0 | 0 | 0 |
| Food | 40,000 | 342,630 | 0 | 2,000,000 |
| Grass | 0 | 253,800 | 0 | 0 |
| Leaves | 0 | 253,800 | 74,000 | 0 |
| Branches | 0 | 253,800 | 74,000 | 0 |
| Lumber | 0 | 0 | 0 | 0 |
| Textiles | 0 | 0 | 0 | 0 |
| Diapers | 0 | 0 | 0 | 0 |
| Construction/Demolition | 0 | 0 | 0 | 0 |
| Medical Waste | 0 | 0 | 0 | 0 |
| Sludge/Manure | 0 | 0 | 0 | 0 |
| TOTAL (tons) | 40,000 | 1,104,030 | 148,000 | 2,000,000 |

From the above Tables 6-1 to 6-4, we can see that certain types of materials such as organics and paper are dealt with in larger quantities than average. Combined with the fact that construction waste fills up much of the waste stream and that some types of waste (such as glass) are not accounted for by the material categories listed above, some ARR programs may divert more material of a certain type than actually exists. We do not know this for sure, however, since we do not know either the real waste composition or the composition of diverted waste streams for each ARR program.

The fact that certain programs may divert more of a certain type of material than actually exists does complicate our final waste composition assumptions. We know that, as programs go into effect, the total tonnage of waste to landfill will decrease and the composition will change. ***For our GHG estimates, however***, ***we make the simple assumption that composition stays constant from 2010-2030***. Although this results in some inaccuracies, the error is reduced by two factors: 1) ARR affects only Austin, and therefore the rest of Travis county follows a constant material composition, and 2) existing waste in landfills follow the initial composition assumption.

**Table 7. In the first column, tons of waste to landfill is broken down by the standard composition assumed for waste in 2010 (see Table 8). In the second column, waste is broken down based on what the ARR programs deal with (see Tables 6-1 to 6-4 where we assume certain type of waste are associated with an ARR program). Column three is the difference of the two; if the number is negative, more waste may be diverted than there exists. Note that C&D waste plays a large role in skewing the overall figures. The total tons to landfill (16,599) is lower than the reported ARR value in Figure 3 because of Household Hazardous waste and unaccounted materials such as glass.**

| | Tons of waste to landfill in 2030 (using 2010 "BAU" trash composition) | ARR plans to divert resources in 2030* | Calculated 2030 waste to landfill after ARR Programs |
|---|---|---|---|
| Newspaper | 77,415 | 31,883 | 45,533 |
| Office Paper | 77,415 | 354,225 | -276,840 |
| Corrugated Boxes | 77,415 | 354,225 | -276,840 |
| Coated Paper | 77,415 | 348,587 | -271,172 |
| Food | 77,415 | 141,702 | -64,287 |
| Grass | 57,345 | 15,587 | 41,758 |
| Leaves | 57,345 | 19,838 | 37,507 |
| Branches | 57,345 | 19,838 | 37,507 |
| Lumber | 51,610 | 8,502 | 43,108 |
| Textiles | 43,009 | 7,085 | 35,923 |
| Diapers | 7,168 | 0 | 7,168 |
| Construction/Demolition | 573,448 | 116,196 | 457,252 |
| Medical Waste | 8,602 | 0 | 8,602 |
| Sludge/Manure | 8,602 | 0 | 8,602 |
| TOTAL (tons) | 1,433,620 | 1,417,021 | 16,599 |

* The relationship of ARR Zero Waste plans to type of material (e.g. newspaper) is an interpretation of the authors of this report.

For GHG emissions calculations, we did not document a change in waste composition as a result of ARR programs. Although inaccurate, this method avoids the "negative waste" situation that arises in the table above.

### 4. Characterization of Landfill Waste Content that anaerobically degrades

The ANDOC% (Anaerobically Degradable Organic Carbon percentage) is the type of content of recovered resources that is degradable (e.g. the percent of collected trash that is organic in content). Assuming approximately 40% of tons to landfill is construction waste and then assigning waste percentages from Table 5 to the other categories, Table 8 shows the landfill-specific waste characterization is used to project GHG emissions from Travis County landfills. Our estimate is that 6.72% of waste into landfills will degrade into methane and $CO_2$.

**Table 8.** The percentage of ANDOC assumed for Travis County waste stream sent to landfills (Landfill Specific Waste Characterization based on Resource Commodity Analysis for Austin and construction waste percentage calculated in Part 2). The table is taken from the "California Air Resources Board's Implementation of IPCC's Mathematically Exact First-Order Decay Model" under the "Landfill Specific ANDOC values" tab [5].

**Landfill Specific Value Calculator**
**for the Percent of Anaerobically Degradable Carbon (ANDOC%)**

Landfill specific Waste Characterization Data

| Waste Type | WIPFRAC | TDOC | DANF | %ANDOC |
|---|---|---|---|---|
| Newspaper | 5.40% | 47.09% | 15.05% | 0.38% |
| Office Paper | 5.40% | 38.54% | 87.03% | 1.81% |
| Corrugated Boxes | 5.40% | 44.84% | 44.25% | 1.07% |
| Coated Paper | 5.40% | 33.03% | 24.31% | 0.43% |
| Food | 5.40% | 14.83% | 86.52% | 0.69% |
| Grass | 4.00% | 13.30% | 47.36% | 0.25% |
| Leaves | 4.00% | 29.13% | 7.30% | 0.09% |
| Branches | 4.00% | 44.24% | 23.14% | 0.41% |
| Lumber | 3.60% | 43.00% | 23.26% | 0.36% |
| Textiles | 3.00% | 24.00% | 50.00% | 0.36% |
| Diapers | 0.05% | 24.00% | 50.00% | 0.01% |
| Construction/Demolition | 40.00% | 4.00% | 50.00% | 0.80% |
| Medical Waste | 0.60% | 15.00% | 50.00% | 0.05% |
| Sludge/Manure | 0.60% | 5.00% | 50.00% | 0.02% |
| **MSW Total** | 86.85% | | | **6.72%** |

**1)** Enter your landfill specific waste characterization data (WIPFRAC).
**2)** Copy the result of the calculation (MSW total) and overwrite the default %ANDOC value for the particular year on the ***Landfill Model Inputs*** page.
**Note:** Only the data for the Fraction of the Waste in Place (WIPFRAC) should be altered. If you wish to modify the TDOC or DANF values, please contact ARB staff.

The waste composition in Table 8 is assumed to be the waste composition for Austin and Travis County in 2010 before new ARR programs are implemented. Since we are neglecting the changes in composition as a result of ARR, 6.72% ANDOC is used for GHG emissions calculations in all years.

Figure 4 plots our assumed landfill disposal and diversion quantities for Travis County (excluding Austin) and the city of Austin.

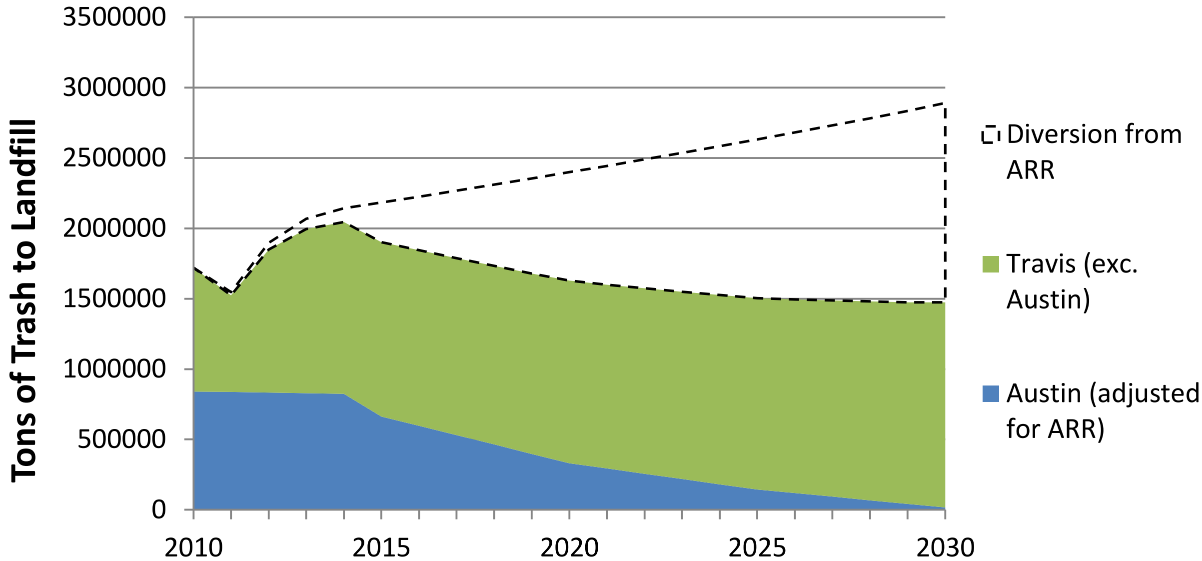


**Figure 4.** Projected disposal values adjusted from the Austin Resource Recovery Master Plan for Travis County (Programs in Place). Given the assumptions in this report, ARR programs divert nearly 100% of Austin's waste going into landfills. The ARR Master Plan projects ~200,000 tons to landfills in 2030, with household hazardous waste (100,000 tons in 2030) and glass making up over 50% of the discrepancy in this figure and the ARR Master Plan.

## Step 2: Calculating GHG Emissions

For calculations of GHG emissions for Austin and Travis, the "California Air Resources Board's Implementation of IPCC's Mathematically Exact First-Order Decay Model" tool is used [5]. The tool uses a "k Value" to account for rainfall levels, and for Central TX we have assumed a value of k= 0.038 (20-40 inches of rain/year). We input BAU disposal tonnage and the 6.72% ANDOC value, and assume no methane flaring.

Figure 5 shows baseline emissions (separately for $CH_4$ and $CO_2$) from Travis county landfills assuming:

1. our waste generation projections to 2030,
2. there is no landfill gas flaring,
3. there are no waste diversion programs (e.g. no ARR programs), and
4. no more waste generation after 2030 (the plot of GHG emissions continues after 2030 based on waste generation through 2030).

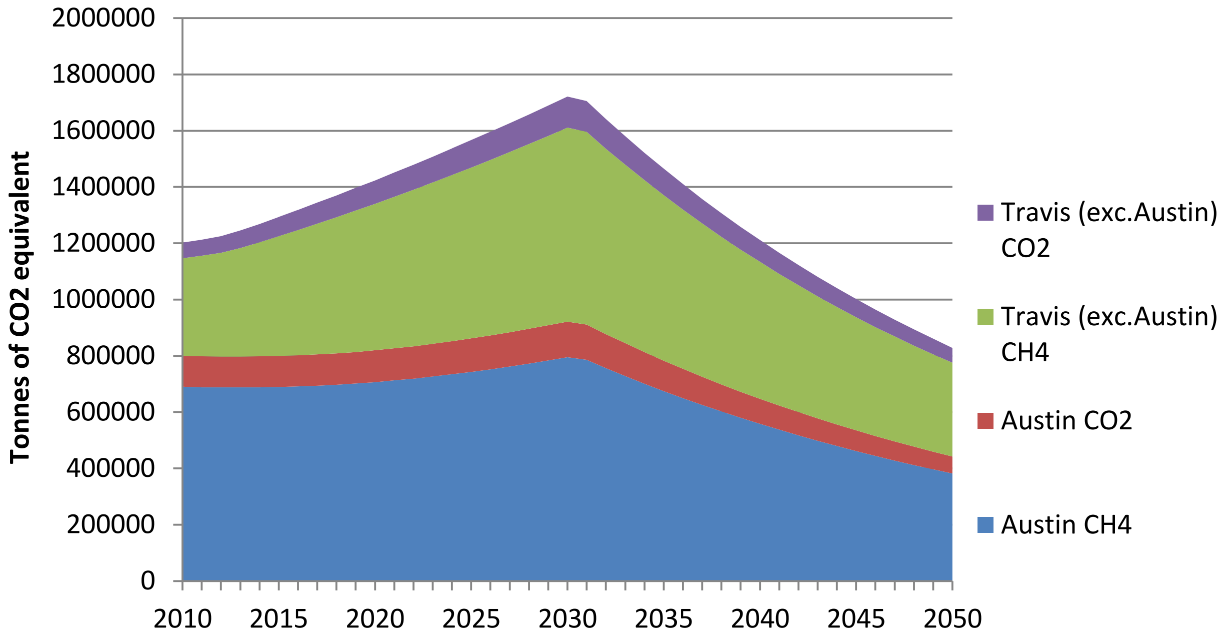


**Figure 5.** Projected GHG emission scenario for BAU waste disposal in Travis and Austin, ***with no flaring of landfill gas.*** Given the scope of this report, this figure represents emissions from waste deposited into landfills through 2030, but not waste deposited after 2030.

## Reductions of GHG emissions due to landfill gas flaring

Using Figure 5 above, we then attempt to characterize the effects of flaring on emissions. Since we are aggregating all the waste as though they are going into a single landfill, the exact amount of flaring must be approximated. ***The California IPCC tool assumes that the landfill captures 75% of all methane emitted and we keep this assumption***. From TCEQ's 2011 report, about half of the landfills in Travis collect/flare GHG.

**Table 9.** Landfills in Travis with CH4 flaring. From "Municipal Solid Waste in Texas: A Year in Review, TCEQ, 2011".

| | Waste | State of Landfill gas collection | | | |
|---|---|---|---|---|---|
| Type | | LGC? | Collect/Vent | Collect/Flare | Collect/Generate |
| 1 | AUSTIN COMMUNITY LANDFILL | Y | | | Y |
| | CITY OF AUSTIN LANDFILL | Y | | Y | |
| 1 | BFI SUNSET FARMS LANDFILL | | | | |
| 4 | IESI TRAVIS COUNTY C&D LANDFILL | N | | | |
| 1 | TEXAS DISPOSAL SYSTEMS LANDFILL | Y | | Y | |

The EPA Landfill and Energy project report for Texas in 2012 can be found at the following link: http://www.epa.gov/lmop/projects-candidates/index.html.

From the EPA data available, we see that the Austin Community landfill reduced emissions by 270,000 tonnes $CO_2$e/year, while the Sunset Farms landfill reduced emissions by 127,000 tonnes $CO_2$e /year. Taking into account the existence of undocumented diversions, we arrive at a conservative estimate of 400,000 tonnes/year of $CO_2$ equivalent reductions in 2012 for Travis County landfills.

We then adjusted the percentage of total cumulative landfill volume (or mass) that has ***landfill gas flaring*** until the GHG emissions for 2012 roughly match up with these reported reductions in GHG emissions due to flaring. We arrive at lower and upper bound estimates for landfill gas flaring in Travis County: lower bound = 40% of cumulative landfill mass has gas flaring in 2012 (see Figure 6), upper bound = 100% of cumulative landfill mass has gas flaring in 2012 (see Figure 7).

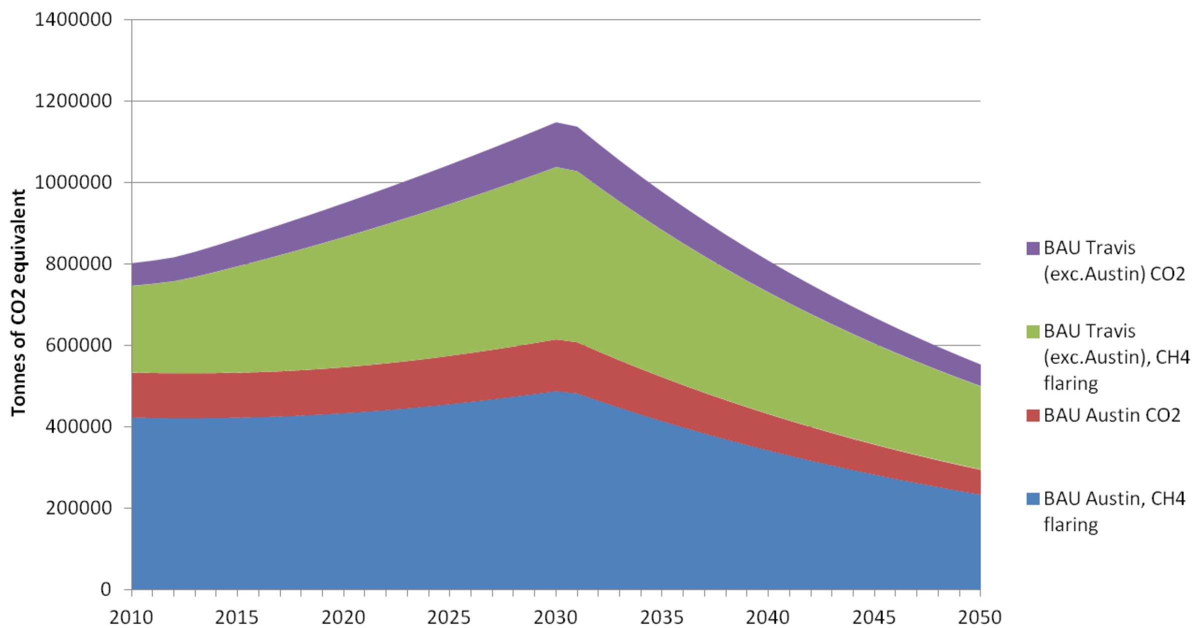


**Figure 6.** Projected GHG emission scenario for BAU waste disposal in Travis and Austin ***with flaring of landfill gas. The amount of cumulative landfill volume that has landfill gas flaring is assumed to be 40%.*** Given the scope of this report, this figure represents emissions from waste deposited into landfills through 2030, but not waste deposited after 2030.

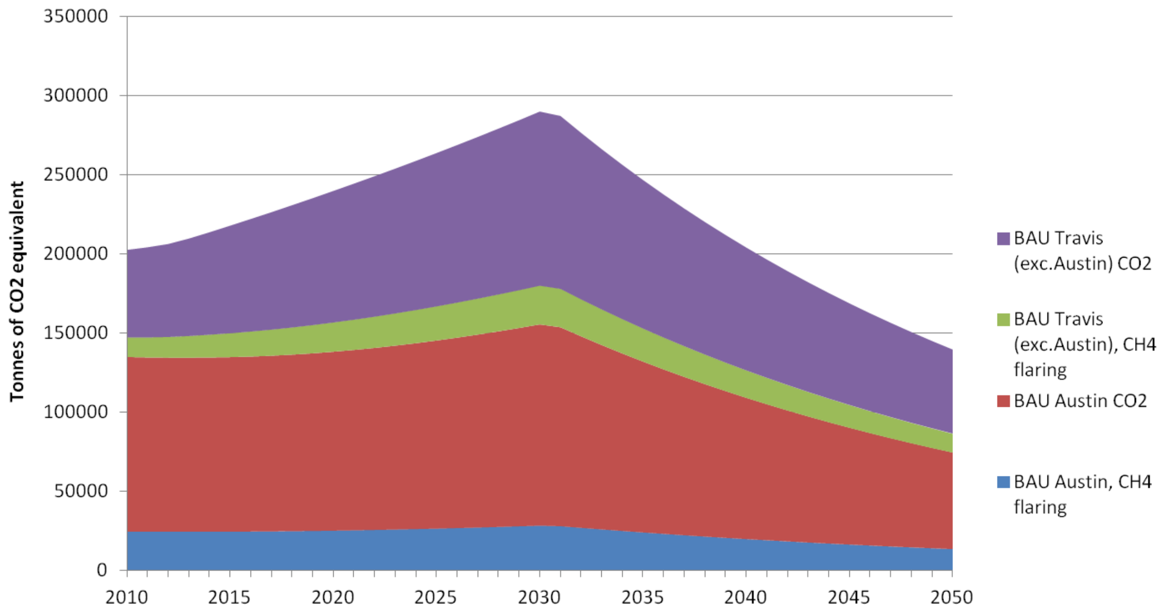


**Figure 7.** Projected GHG emission scenario for BAU waste disposal in Travis and Austin ***with flaring of landfill gas. The amount of cumulative landfill volume that has landfill gas flaring is assumed to be 100%.*** Given the scope of this report, this figure represents emissions from waste deposited into landfills through 2030, but not waste deposited after 2030.

## Reductions of GHG emissions due to ARR Master Plan programs

We then estimate emissions while taking into account ARR program impacts on the waste stream sent to landfills. To do this, we first inputted adjusted waste tonnage (see Table 4) into the emissions tool, and then adjusted the GHG output using the same assumptions for flaring (40% lower bound, 100% upper bound on landfill tonnage with flaring) that we took for the BAU figures.

Figure 8 shows the same information as in Figure 6 (that 40% of landfill mass has its landfill gas flared), but total GHG emissions are reduced by the amount attributed to ARR programs. Figure 9 shows the same information as in Figure 7 (that 100% of landfill mass has its landfill gas flared), but total GHG emissions are reduced by the amount attributed to ARR programs. Figure 8 shows an upper bound on GHG emissions while Figure 9 shows a lower bound. The “emissions avoided” are those avoided due to ARR waste diversion programs. One can see that landfill gas flaring has much higher impact on emissions than diverting waste from the landfills.

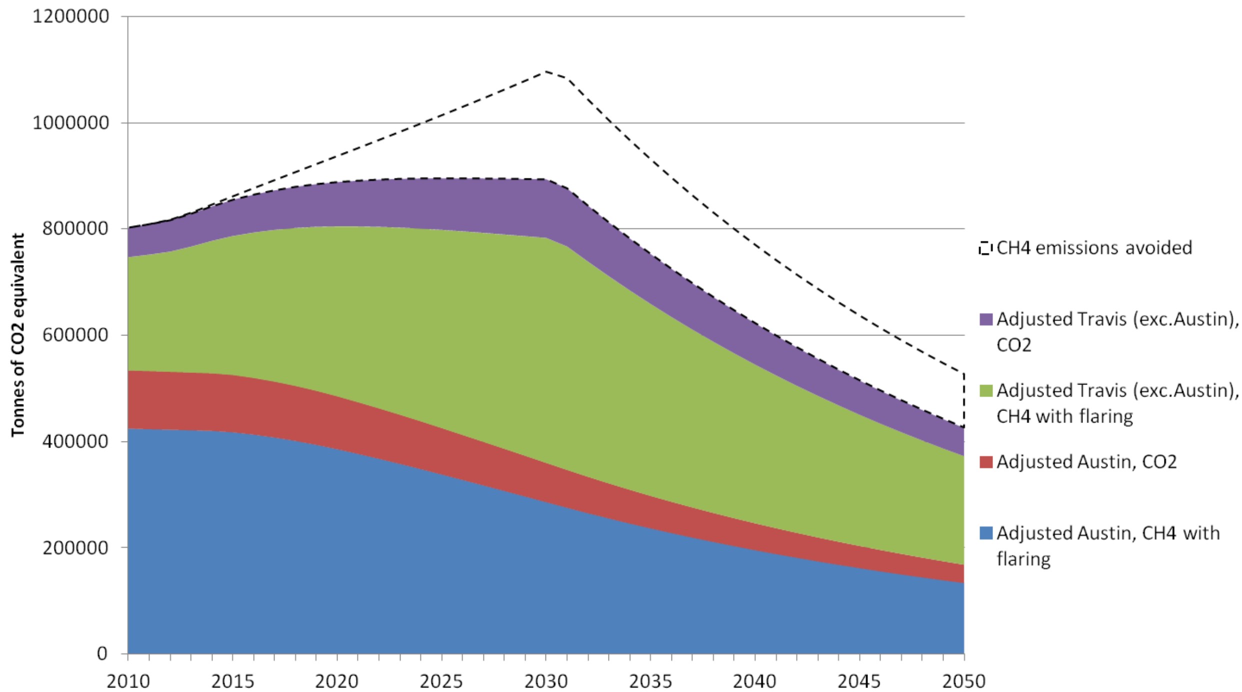


**Figure 8.** Projected GHG emission scenario for ARR-adjusted waste disposal in Travis and Austin ***with flaring of landfill gas. The amount of landfill volume that has CH4 flaring is assumed to be 40%.*** Given the scope of this report, this figure represents emissions from waste deposited into landfills through 2030, but not waste deposited after 2030.

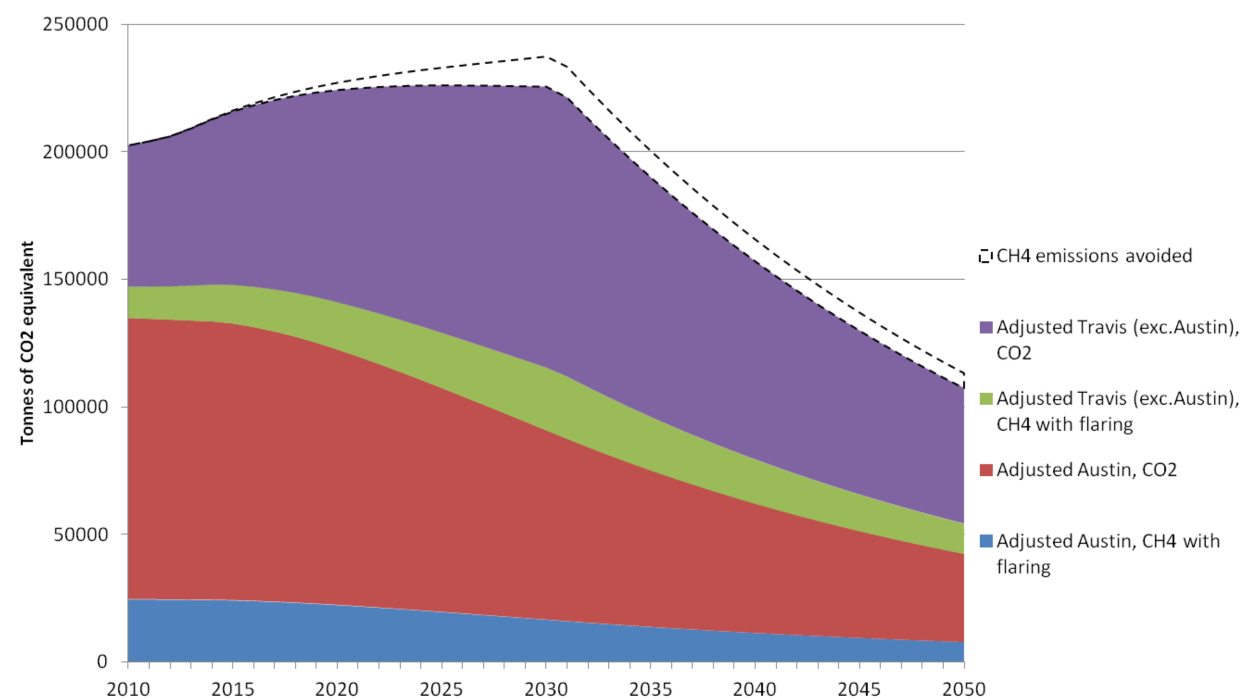


**Figure 9.** Projected GHG emission scenario for ARR-adjusted waste disposal in Travis and Austin ***with flaring of landfill gas. The amount of landfill volume that has CH4 flaring is assumed to be 100%.***

## GHG emissions materials diverted from landfills by ARR Master Plan programs

Due to a lack of data on Waste-in-Place tonnage for Travis county landfills and an inadequate understanding of waste stream composition, we have not yet calculated GHG emissions from any materials diverted by ARR programs. That is to say, there are some GHG emissions form materials that did not go to landfills, but ended up in other locations (e.g. composting bins within the city).

## Conclusions

For 2010, the combined tonnes of CH4 and CO2 emissions (in CO2e) we calculated using the "California Air Resources Board's Implementation of IPCC's Mathematically Exact First-Order Decay Model" tool (Table 10) differs significantly from total emissions reported in the Community Inventory (Table 11). This difference (1.2 million versus 1.7 million tonnes of $CO_2$e) may be explained by inherent differences within each tool's calculation methods, or from inaccurate original waste tonnage inputs due to a lack of knowledge about historical landfill data predating 2003. As such, both calculation uncertainties and a lack of accurate reporting may contribute to inaccuracies in the GHG emission figures.

In terms of flaring estimates, errors may also arise from inaccurate reporting in the 2012 Texas EPA Landfill and Energy project report (http://www.epa.gov/lmop/projects-candidates/index.html), which do not include emission diversion figures for some Travis landfills because they are not available. Compounded with existing calculation and reporting uncertainties, the GHG emissions results reported in Section 2 should only be taken as rough models showing the general trend and magnitude of emissions for Austin and Travis County.

Table 10 shows the GHG impacts of the Austin Resource Recovery programs for diverting waste from landfills mostly depends on whether or not landfill gases are flared (or used for electricity generation). Methane emissions in 2030 could range from 50,000 to 910,000 tonnes $CO_2$e depending upon how much of the landfill is under active gas collection and flaring. **These GHG emissions from methane could be reduced by approximately 22% in each case by the ARR waste diversion programs** (not yet accounting for GHG emissions from the diverted waste streams that are in locations other than the landfill).

**Table 10.** Summary of landfill waste GHG emissions calculation for 2010 and 2030, for all **Travis County including Austin**.

| | Year | 2010 | 2030 |
|---|---|---|---|
| | Tons of Waste to Landfill (BAU) | 1,719,446 | 2,890,294 |
| | Tons of Waste to Landfill (ARR Adjusted) | 1,719,446 | 1,473,273 |
| **BAU (no flaring)** | Tonnes $CO_2$e of GHG emissions ***from*** $CH_4$ (BAU, no flaring) | 1,040,000 | 1,480,000 |
| | Tonnes of $CO_2$ emissions (BAU, no flaring) | 170,000 | 240,000 |
| **LOW estimate of landfill gas flaring** | Tonnes of $CO_2$e of $CH_4$ ***only*** emissions (BAU, flaring on 40% of landfill volume) | 640,000 | 910,000 |
| | Tonnes of $CO_2$e of $CH_4$ ***only*** emissions (with ARR programs & flaring on 40% of waste volume) | 640,000 | 710,000 |
| **HIGH estimate of landfill gas flaring** | Tonnes of $CO_2$e of $CH_4$ ***only*** (BAU, flaring on 100% of landfill volume) | 37,000 | 53,000 |
| | Tonnes of $CO_2$e of $CH_4$ ***only*** emissions (with ARR programs & flaring on 100% of waste volume) | 37,000 | 41,000 |

**Table 11.** Community Inventory 2010, "Waste" tab, Summary of Landfills.

**Summary of Landfills**

**Travis County Landfills**

| Location | TCEQ Permit Number | Landfill Type | $CO_2$ Tonnes | $CH_4$ Tonnes | $CO_2$-eq Tonnes |
|---|---|---|---|---|---|
| AUSTIN COMMUNITY LANDFILL | 249 | 1 | 50,820 | 18,525 | 439,839 |
| CITY OF AUSTIN LANDFILL | 360 | 4 | 26,989 | 9,834 | 233,500 |
| BFI SUNSET FARMS LANDFILL | 1447 | 1 | 59,020 | 21,510 | 510,730 |
| IESI TRAVIS COUNTY C&D LANDFILL | 1841 | 4 | 56,928 | 9,091 | 247,839 |
| TEXAS DISPOSAL SYSTEMS LANDFILL | 2123 | 1 | 32,420 | 11,820 | 280,640 |

**Total Emissions ($CO_2$-eq Tonnes)** **1,712,549**

Landfill contacts w ere found on either tier 2 reports or information w as gathered from TCEQ
Data Contact John Edw ards (TCEQ - know permit # before you call) - 239-5863
Individual MSW Landfill Facility Data (source: TCEQ's 2002 - 2006 Municipal Solid Waste Data Summary and Analysis)
Texas Disposal System: Wade Wheatley (w w heatley@texasdisposal.com) office: 421-1306, cell: 296-3584)
Data not provided (told to contact Daw n Dollins w ith TCEQ 239-6713).
Waste Management: Tim Champagne (tchampag@w m.com, 512-731-9768)

## Future Work

If we desire more accurate predictions of GHG emissions, may consist of gathering the following:

- A more detailed history of waste into landfills since their inception
- A more detailed breakdown of waste types and the percentage of ANDOC waste in landfills
- A more detailed landfill gas capture tonnage figure and capture starting year
- A better understanding of how each Austin Resource Recovery initiative actually affects different waste types

Additionally, we are not currently modeling any landfill waste inputs after 2030 or GHG emissions from waste diverted due to ARR programs. A more accurate report may examine these figures in greater detail.

## References

[1] TCEQ municipal solid waste reports from 2003-2011: http://www.tceq.texas.gov/permitting/waste_permits/waste_planning/wp_swasteplan.html

[2] CTSIP (2012) Central Texas Sustainability Indicators Project, 2012 Data Report (obtained from UT School of Architecture). Also see http://soa.utexas.edu/csd/research/sustainability-indicators.

[3] Austin Resource Recovery Master Plan, 2011, p.247: http://austintexas.gov/sites/default/files/files/Trash_and_Recycling/MasterPlan_Final_12.30.pdf

[4] Zero Waste Strategic Plan, 2008, p.6: http://austintexas.gov/sites/default/files/files/Trash_and_Recycling/Zero_Waste_Plan_-_full_version_-_Council_Adopted_w-resolution.pdf

[5] California Air Resources Board's Implementation of IPCC's Mathematically Exact First-Order Decay Model. See http://www.arb.ca.gov/cc/landfills/landfills.htm and http://www.arb.ca.gov/cc/protocols/localgov/pubs/landfill_emissions_tool_v1_3_2011-11-14.xls.

# Appendix

**Table A1, Waste Avoidance. Total waste diversion tonnage (found in the Austin Resource Recovery Master Plan) for a program is divided among materials labeled "Y".**

| Type of material | Expanded Reuse Entrepreneur Opportunities | Waste Reduction Assistance program (WRAP) | Waste Pairing (By-product synergies) |
|---|---|---|---|
| Newspaper | Y | | Y |
| Office Paper | Y | Y | Y |
| Corrugated Boxes | Y | Y | Y |
| Coated Paper | Y | | Y |
| Food | | | |
| Grass | | | |
| Leaves | | | |
| Branches | | | |
| Lumber | Y | | Y |
| Textiles | Y | | Y |
| Diapers | | | |
| Construction/Demolition | | | |
| Medical Waste | | | |
| Sludge/Manure | | | |

**Table A2, Recycling. Total waste diversion tonnage (found in the Austin Resource Recovery Master Plan) for a program is divided among materials labeled "Y".**

| Type of material | Single Stream Recycling (Residential) | Commercial and Multifamily Recycling (plus URO impacts) | Expanded Multifamily Drop-Off Recycling Services | Clean Austin-Expanded Bulk Collection and Recycling |
|---|---|---|---|---|
| Newspaper | Y | | | |
| Office Paper | Y | Y | Y | |
| Corrugated Boxes | Y | Y | Y | |
| Coated Paper | Y | Y | Y | |
| Food | | | | |
| Grass | | | | |
| Leaves | | | | |
| Branches | | | | |
| Lumber | | | | Y |
| Textiles | | | | Y |
| Diapers | | | | |
| Construction/Demolition | | | | |
| Medical Waste | | | | |
| Sludge/Manure | | | | |

**Table A2, Recycling (continued)**

| Type of material | Public Area Recycling Containers | Glass Collection Pilots for Multifamily and Commercial Sites | C&D Debris Ordinance | Event Recycling Ordinance |
|---|---|---|---|---|
| Newspaper | Y | | | Y |
| Office Paper | Y | | | Y |
| Corrugated Boxes | Y | | | Y |
| Coated Paper | Y | | | Y |
| Food | | | | Y |
| Grass | | | | |
| Leaves | | | | |
| Branches | | | | |
| Lumber | | | | |
| Textiles | | | | |
| Diapers | | | | |
| Construction/Demolition | | | Y | |
| Medical Waste | | | | |
| Sludge/Manure | | | | |

**Table A3, Composting and Organics. Total waste diversion tonnage (found in the Austin Resource Recovery Master Plan) for a program is divided among materials labeled "Y".**

| Type of material | Compost Incentive Program | Residential Organics Collection | Storm-Ready Austin | Commercial and Multifamily Organics |
|---|---|---|---|---|
| Newspaper | | | | |
| Office Paper | | | | |
| Corrugated Boxes | | | | |
| Coated Paper | | | | |
| Food | Y | Y | | Y |
| Grass | | Y | | |
| Leaves | | Y | Y | |
| Branches | | Y | Y | |
| Lumber | | | | |
| Textiles | | | | |
| Diapers | | | | |
| Construction/Demolition | | | | |
| Medical Waste | | | | |
| Sludge/Manure | | | | |