INTEGRATED MASTER PLAN

FOR

THE MAIN WASTEWATER TREATMENT PLANT

Task Name: R2 Summary and Coarse-level Projection
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Table of Contents

List of Figures

List of Tables

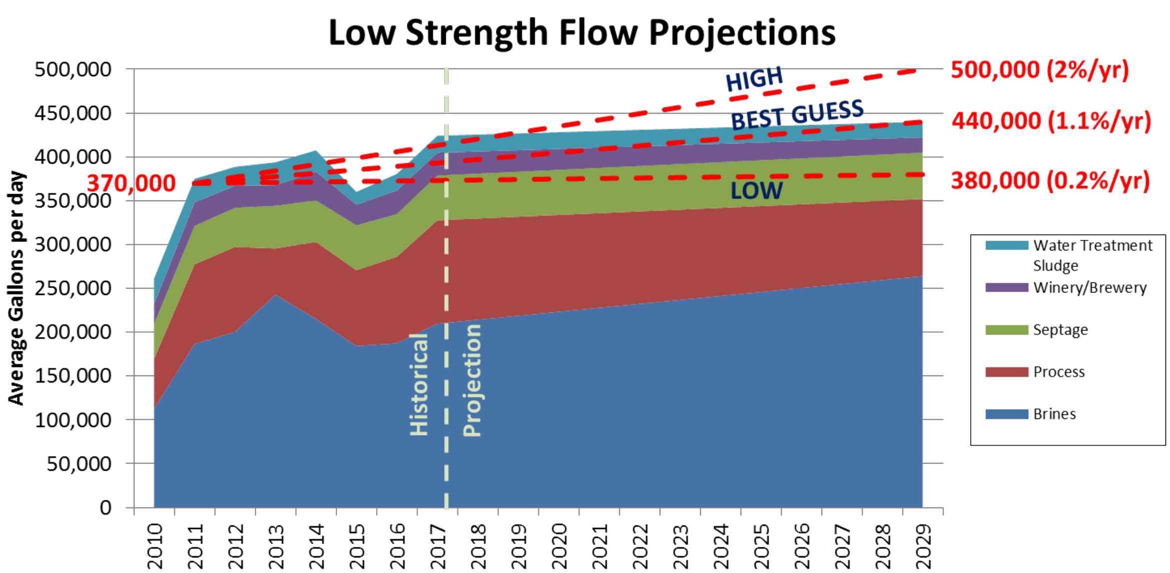
LIST OF ACRONYMS

AD	Anaerobic Digestion
COD	Chemical Oxygen Demand
CODf	Chemical Oxygen Demand (filtered)
CV-Salts	The Central Valley Salinity Coalition
EBMUD	East Bay Municipal Utility District
FOG	Fats, Oil, and Grease
GPD	Gallons per day
HSL	High Strength Liquids
MWWTP	EBMUD's Main Wastewater Treatment Plant
PGS	Power Generation Station
R2	Resource Recovery
RNG	Renewable Natural Gas
SCFM	Standard Cubic Feet per Minute
SLW	Solid/Liquid Waste
TDS	Total Dissolved Solids
TIN	Total Inorganic Nitrogen
TKN	Total Kjeldhal Nitrogen
TN	Total Nitrogen
TS	Total Solids
TSS	Total Suspended Solids
TWAS	Thickened Waste Activated Sludge
VS	Volatile Solids
WT	Wet Ton
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

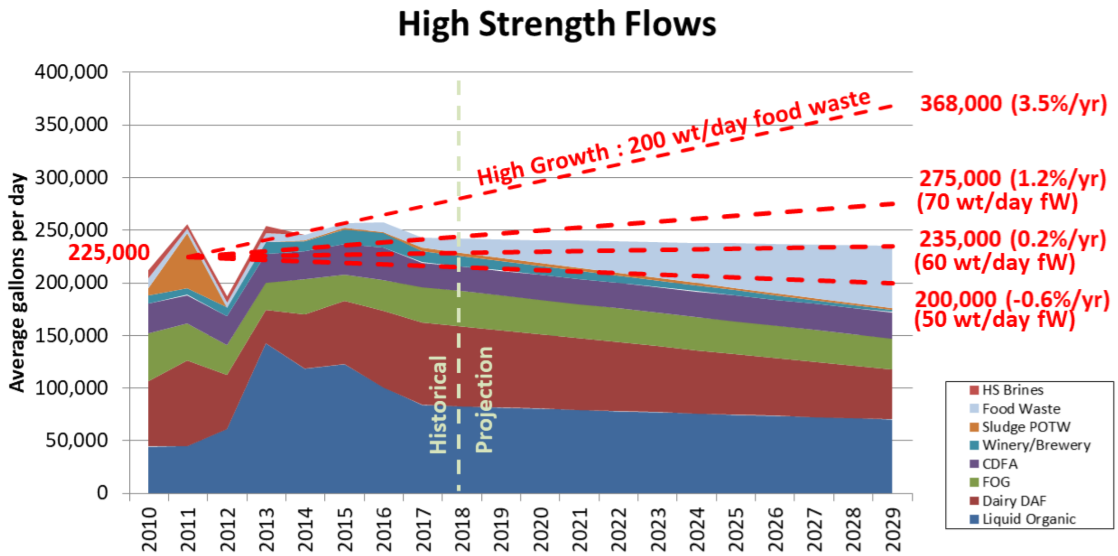
Since the R2 Program was implemented in 2002, the share of MWWTP power demand met by the onsite Power Generation Station (PGS) has increased from about 40 percent to over 130 percent with the excess power being sold to the Port of Oakland via the PG&E distribution system. The majority of this increase is due to greater digester gas production from wastes delivered directly to the digesters through the R2 Program. Over the years, the R2 program has grown significantly and is responsible for two thirds of total digester gas production. The program has reached a scale where the flows and loadings are no longer marginal and their impact is relevant to the master planning process.

Low Strength Wastes: Low strength wastes (COD < 20,000 mg/l) are sent to the head of the plant, at the influent lift station, and these flows have remained fairly steady since 2011 at around 350,000 gpd (<1 percent of plant influent flow). Over the next ten years low strength flows are expected to increase slightly, primarily with growth in brine deliveries, to around 440,000 gpd. This is based on the assumption that winery/brewery wastes and process water will continue the trend of being treated onsite or hauled locally while brine wastes will continue to present a challenge to the region and will continue to be sent to EBMUD.



High Strength Wastes: High strength wastes (COD > 20,000 mg/l) are sent to directly to the digesters, bypassing the primary and secondary treatment process. Overall flows have been steady since January 2013 at around 225,000 gpd, with possibly a slight downtrend in recent years. The high strength wastes are approximately 35 percent of the total volume fed to the digesters. Over the next ten years, high strength flows are expected to remain relatively constant, with possibly some slight growth as local food waste slowly replaces organics coming from farther away. The business as usual projection, which is most likely, is for flows to remain relatively constant. However, for the purpose of exploring the range of possible scenarios, more significant growth is also analyzed.

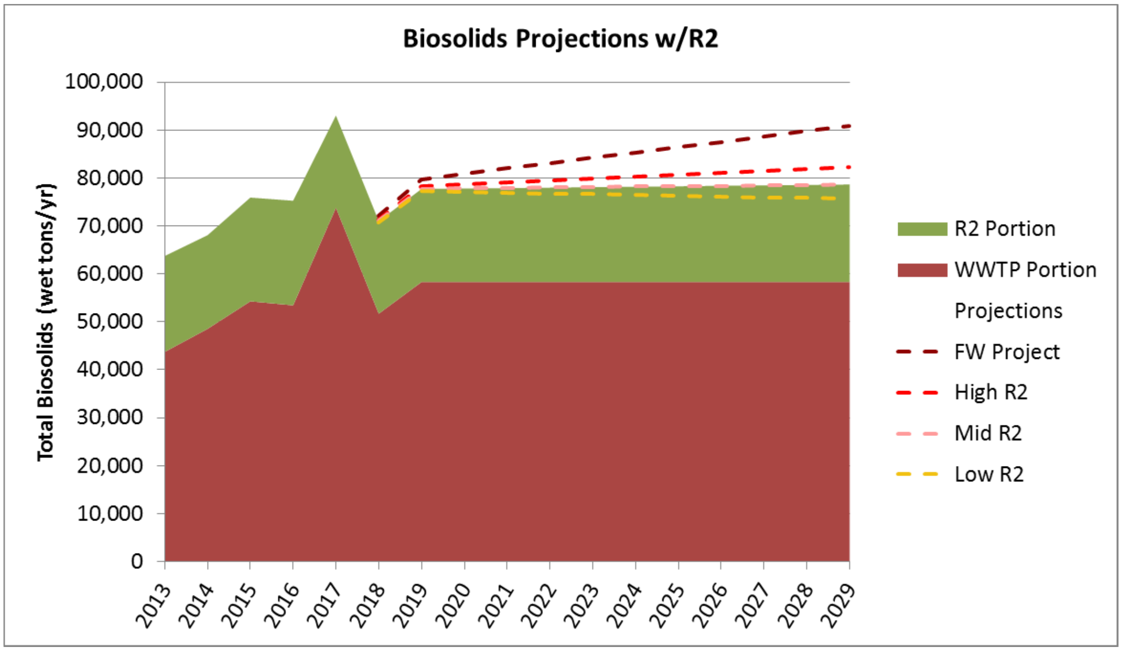
Under this scenario, a large scale project food waste project could grow the program significantly. The scale of such a project would likely be around 200 wt/day of food waste which would represent a significant increase in high strength flows and plant gas production.

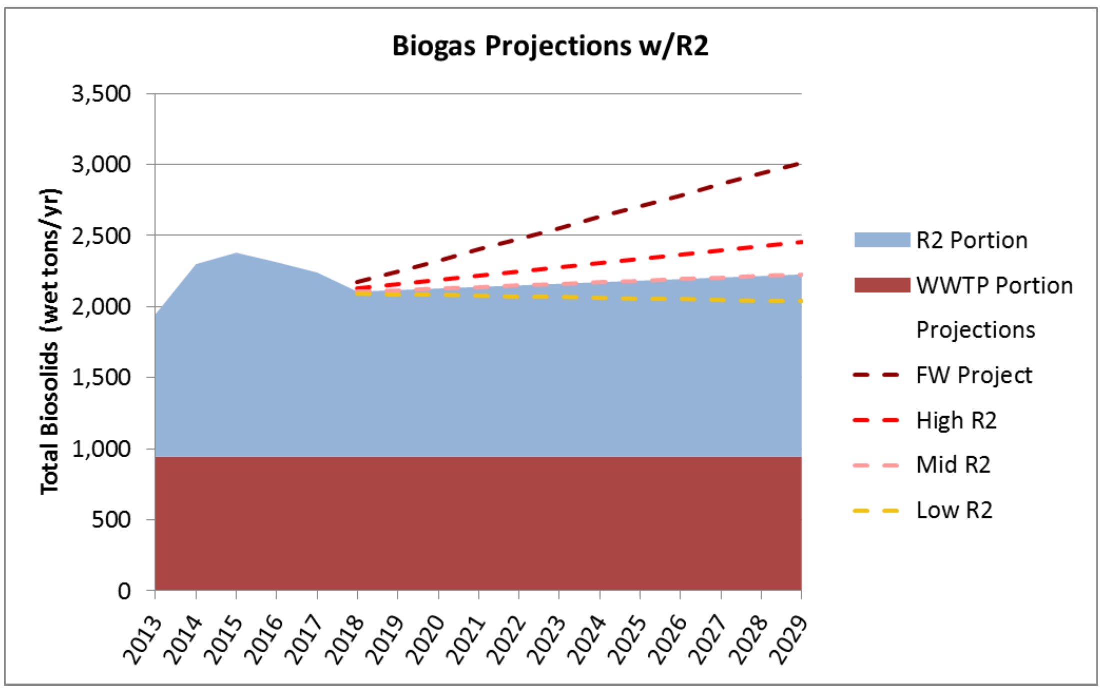


Revenue Projections: Based on a recently completed comprehensive financial analysis for the program covering FY17, estimated profit margins on each waste stream were developed. These margins include the marginal costs associated with expendables (chemicals), O&M, and equipment replacement but do not include non-marginal costs like admin, overhead, depreciation, and interest/amortization charges. These estimated profit margins were combined with the flow projections to estimate the potential profit associated with each waste stream. These are all based on conditions relatively similar to the present. R2 has the capacity to set prices and could choose to raise or lower prices strategically to influence the mix of streams, however, the possible impacts of price setting was not included in this projection.

Feedstock	FY17 Margin $/gal	2017 Profit ($M/yr)	Potential Margin $/gal	Potential Profit Mid Scenario ($/yr)
Brines	$0.04	$3,066,000	**$0.06**	$5,781,600
Process	$0.04	$1,722,800	$0.04	$1,284,800
Septage	$0.05	$930,750	$0.05	$963,600
Winery/Brewery	$0.04	$379,600	$0.04	$256,960
Water Treatment Sludge	$0.01	$69,350	$0.01	$64,240
Liquid Organic	$0.01	$306,600	$0.01	$255,500
Dairy DAF	$0.02	$569,400	$0.02	$343,100
FOG	$0.03	$372,300	$0.03	$328,500
Bloods	$0.02	$167,900	$0.02	$182,500
Winery/Brewery	$0.02	$80,300	$0.02	$14,600
Sludge POTW	$0.01	$10,950	$0.01	$7,300
Solid Food Waste	$ -	$ -	**$0.02**	$430,700
K2	$0.07	$1,073,100	**$0.08**	$1,109,600
Totals		**$8,749,050**		**$11,023,000**

Projected Plant Loadings: R2 feedstock category profiles were used to project plant loadings based on the flow projections. This assumes that the profile of wastes within each category are roughly similar to the past and do not change significantly. The projections for biosolids production and for biogas production are below. Because the trucked in organics are highly digestable, they have a much more significant impact on biogas production than on biosolids production.


Biosolids Projections w/R2
Total Biosolids (wet tons/yr)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
R2 Portion
WWTP Portion
Projections
FW Project
High R2
Mid R2
Low R2


Biogas Projections w/R2
Total Biosolids (wet tons/yr)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
R2 Portion
WWTP Portion
Projections
FW Project
High R2
Mid R2
Low R2

CHAPTER 1 – R2 HISTORICAL DATA

1.1 Introduction

1.1.1 R2 Program at a glance

Historically, the primary responsibilities of wastewater treatment plants revolved around waste disposal issues, principally protecting public health and the aquatic environment. At the East Bay Municipal Utility District (EBMUD), this scope has been expanded to include resource recovery, i.e., finding value in specific wastewater components and extracting those components for beneficial uses. The recovery of resources from wastewater is motivated by cost control and increased operating efficiency. Examples of recoverable resources include recycled water, the nutrients found in treated biosolids for land application as a soil amendment, and the energy contained in digester gas used for electric power production.

Since 1985 EBMUD has operated a cogeneration facility, the Power Generation Station (PGS), to recover the energy contained in raw municipal wastewater solids. The digester gas produced by the anaerobic digestion process is used to fuel the engine-generators at PGS to generate electricity and thermal energy to heat the anaerobic digesters. The advantages to this system are several: the sludges are stabilized and made suitable for land application, cooling water is used to heat the digesters so that the system is self-sustaining, and electric power is generated to meet the treatment plant's needs. Increasing electric power demands at the Main Wastewater Treatment Plant (MWWTP) and higher energy costs were the primary incentives for PGS construction at that time.

The Resource Recovery (R2) Program was a logical next step to increase efficiency and reduce energy costs. Several factors combined around the time of the California Energy Crisis in 2000-2001 to advance resource recovery at EBMUD's wastewater treatment plant: digester capacity became available as industrial dischargers left Oakland, wholesale electric power costs increased significantly, and external power suppliers became less reliable (e.g., rolling blackouts). One response to this situation was to increase on-site electric power generation to decrease reliance on the more expensive, and less reliable imported power. The R2 Program actively solicited the delivery of high-strength industrial and commercial wastes via truck and to be discharged directly to the digesters. Since the R2 Program was implemented, the share of MWWTP power demand met by PGS has increased from about 40 percent to over 130 percent with the excess power being sold to the Port of Oakland. The majority of this increase is due to greater digester gas production from wastes delivered directly to the digesters through the R2 Program. The R2 Program has also grown to include low-strength wastes, wastes that don't have enough energy content to be worth digesting, that are discharged to the head of the plant for full treatment. The R2 Program also accepts a significant amount of brine waste high in TDS including the very pure K2 stream that is discharged to the end of the treatment process.

Over the years, the R2 program has grown significantly. A summary of all the trucked waste brought to the plant in calendar year 2017 is shown in **Table 1**. The program has reached a scale where the flows and loadings are no longer marginal and their impact is relevant to the master planning process. The Low Strength wastes are wastes that are too low in energy content to be worth sending to the digesters. Generally the cutoff is a Chemical Oxygen Demand (COD) of 20,000 mg/l, below this and wastes are considered Low Strength, above this and wastes are considered high strength and sent to the digesters.

Table 1 – R2 Program summary for 2017

Flow Type	Average flow (gpd)	% of Receiving Stream (by volume)	Total Loads (trucks/yr)	Average # of Loads (trucks/day)
Low Strength (< 20,000 mg/l COD)	424,000	0.7%	29,880	82
High Strength (> 20,000 mg/l COD)	242,000	36%	16,749	46
K2 Brine	42,000	0.07%	3,028	8
Total	**708,000**	**-**	**49,657**	**136**

1.1.2 Scope of this Task

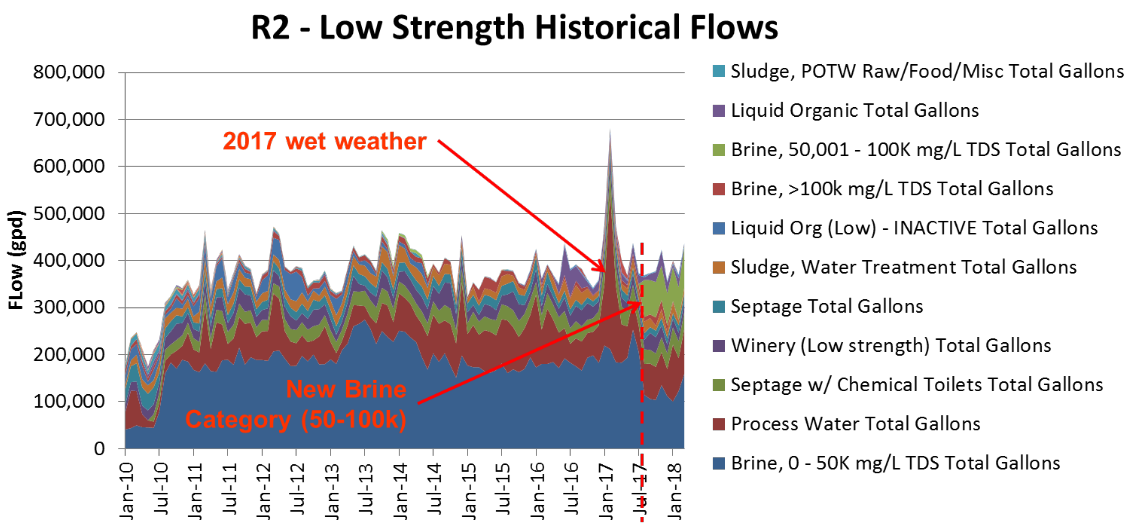
This MWWTP Master Plan Task provides the information about the R2 program needed to evaluate historical and projected flows and loadings to the overall treatment process. This also includes loadings that may be relevant to any new treatment process (like nutrient removal). This task also includes an estimate of the marginal revenue associated with 1 gallon of each waste type in order to evaluate the financial impact of losing a specific waste type. Specifically this task will cover:

- Historical and Projected Low Strength Flows and Loads
- Historical and Projected High Strength Flows and Loads
- Historical and Projected K2 Flows
- Peaking factors (if unscheduled)
- Marginal revenue for each waste type within these categories

1.2 Historical R2 Low Strength Flows and Loadings 2010 – 2018

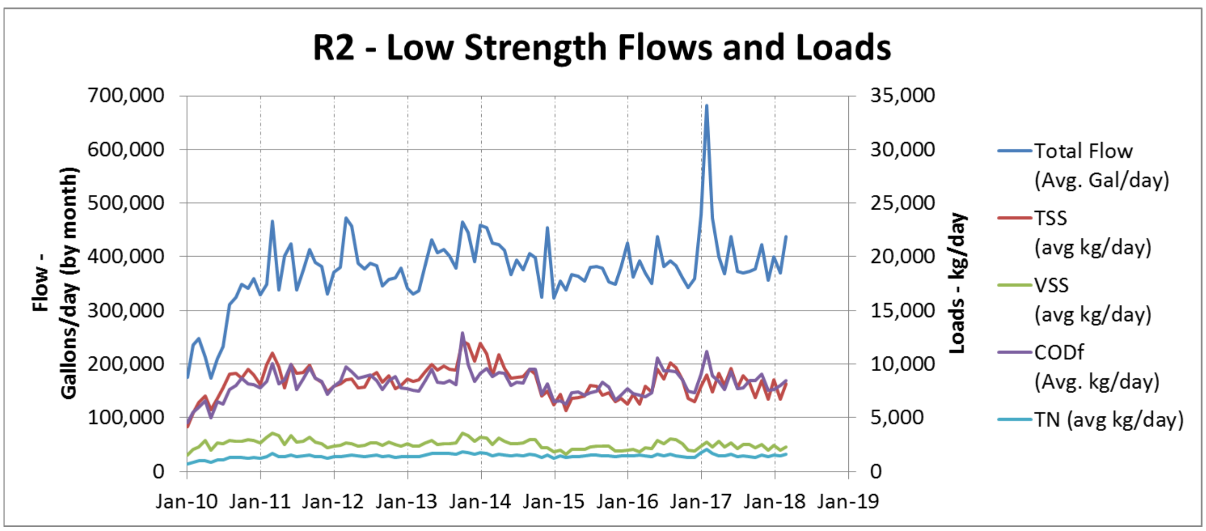
The R2 low strength flows from 2010 to 2018 are presented in **Figure 1.** These flows are broken down by month and shown as average gallons per day for that month. The stacked area chart also shows how the composition of the low strength flows has changed over time. Total flows have remained fairly steady around 350,000 gpd since roughly January of 2011 with a notable exception in the wet season of 2016-2017. This spike in flows corresponds to a large increase in construction site dewatering loads associated with the heavy rainfall in that period. The overall stability reflects the maturity of the program and indicates that the low strength program isn't experiencing any rapid increases or decreases in flow. Also of note is the reorganization of brines in July of 2017. At this time brines under 100,000 mg/L TDS were split into those above 50,000 mg/L and those below. This is reflected in what appears to be a sudden drop in low strength brines but actually corresponds to some of those brines being re-categorized.

Figure 1 – R2 Low Strength flows 2010 – 2018 (by month)



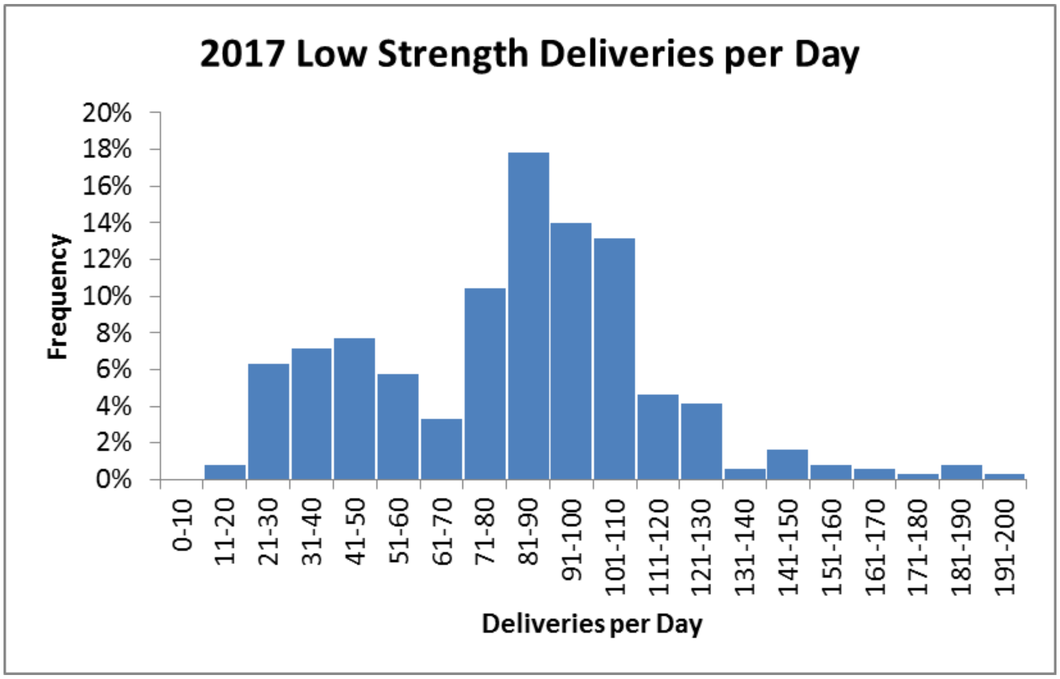
Using category profiles derived from the available sampling data, the estimated loading to the plant was derived for various constituents of note. These estimates can be found in **Figure 2.** Generally these loadings are proportional to the total flow in blue, indicating relatively low variability across the different categories. As these loads are all low strength this is not unexpected. The data used to generate these charts is included in **Appendix B.**

Figure 2 – R2 Low Strength Loadings 2010 – 2018 (by month)



The distribution of loads per day for low strength deliveries in calendar year 2017 is shown in **Figure 3**. As can be seen in this figure, most days EBMUD receives 81 – 90 deliveries per day. The most received in any one day in 2017 was 194 and on 95 percent of the days, there were fewer than 130 deliveries.

Figure 3 – Low Strength Delivery Distribution



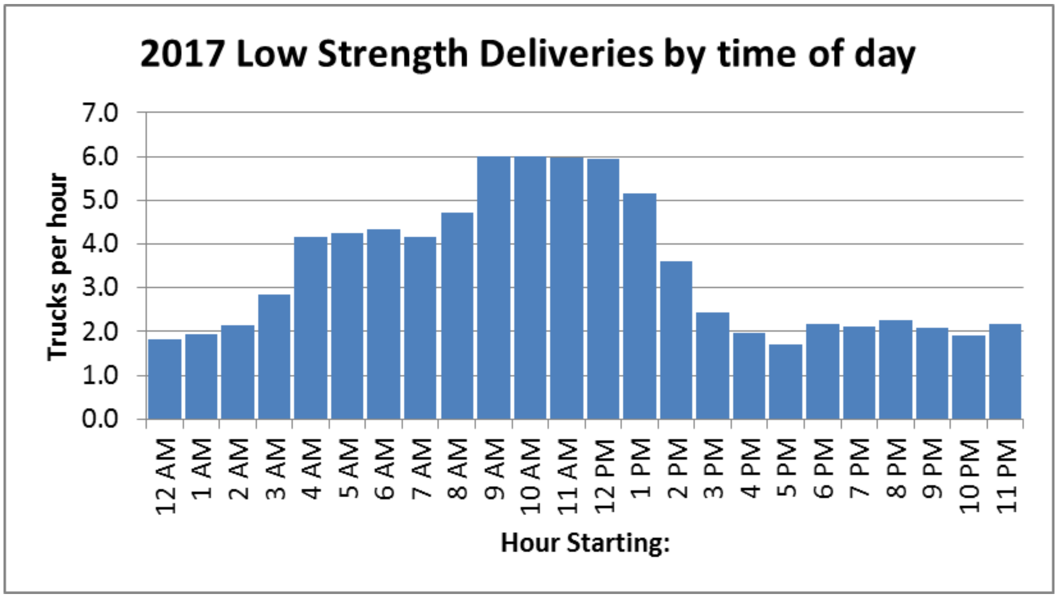
Based on the 2017 low strength delivery data, peaking factors were developed. The data from 2017 is presented in **Table 2.**

Table 2 – R2 Low Strength Wastes Peaking Factors

Flow Type	Average	Daily		Monthly	
		Max	PF	Max	PF
Flow (gpd)	424,000	1,067,631	2.5	681,200	1.6
Trucks (#/day)	82	194	2.4	128	1.6

The average number of trucks per hour over the course of the day from 2017 is also shown in **Figure 4.** Most low strength deliveries occur between 8am and 1pm.

Figure 4 – Low Strength Deliveries by time of day

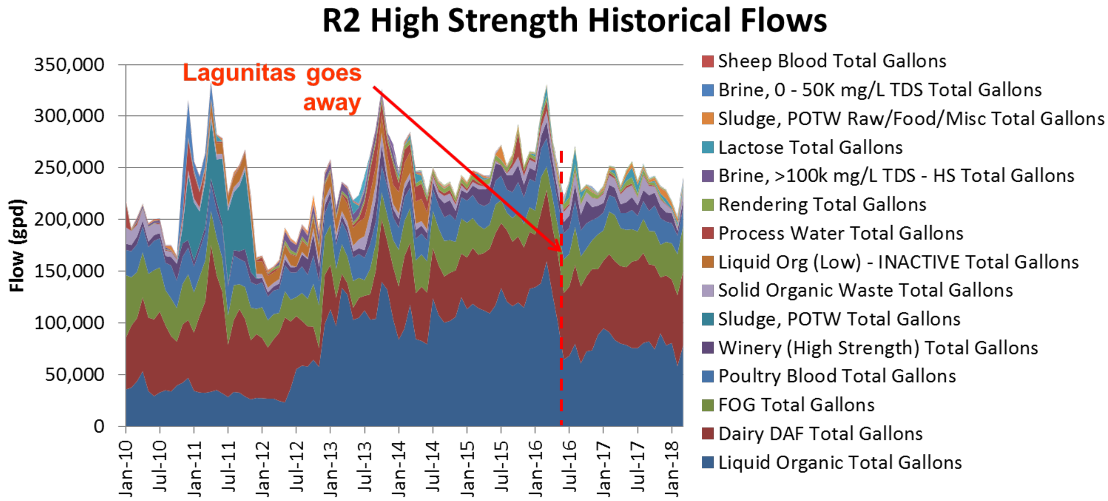


1.3 Historical R2 High Strength Flows and Loadings 2010 - 2018

The R2 high-strength flows from 2010 to 2018 are presented in **Figure 3.** These flows are broken down by month and shown as average gallons per day for that month. The stacked area chart also shows how the composition of the high strength flows have changed over time. As can be seen in the chart, high strength flows have generally been more variable over time, likely reflecting the greater dependence on individual large customers. There a couple of items of note that can be observed in the figure:

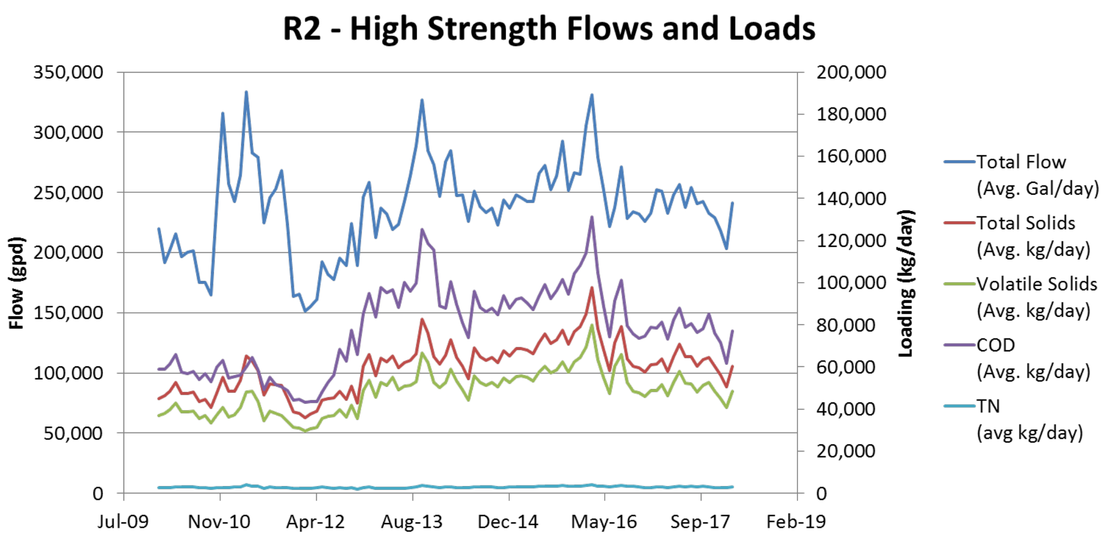
- A large temporary increase in flows can be seen from November 2010 through November 2011. This spike was caused by the diversion of municipal sludges to EBMUD from the Richmond WWTP after they had an issue with their digester cover.
- The Lagunitas Brewing Company was a significant customer for R2. This waste was categorized as liquid organic. The sudden increase in liquid organic flows in mid-2012 was from R2 beginning to receive this waste and the sudden drop in liquid organic flows in mid-2016 was from R2 losing this waste as a high strength feedstock. Lagunitas first installed on-site treatment that significantly reduced the organic content of their waste flows. This moved them from the high strength to the low strength category. Then, after other closer WWTPs began accepting these kinds of wastes, Lagunitas diverted their full flow to the closer options (e.g., Santa Rosa).
- Overall flows have been steady since January 2013, with possibly a slight downtrend in recent years due to the loss of Lagunitas.

Figure 5 – R2 High Strength flows 2010 – 2018 (by month)



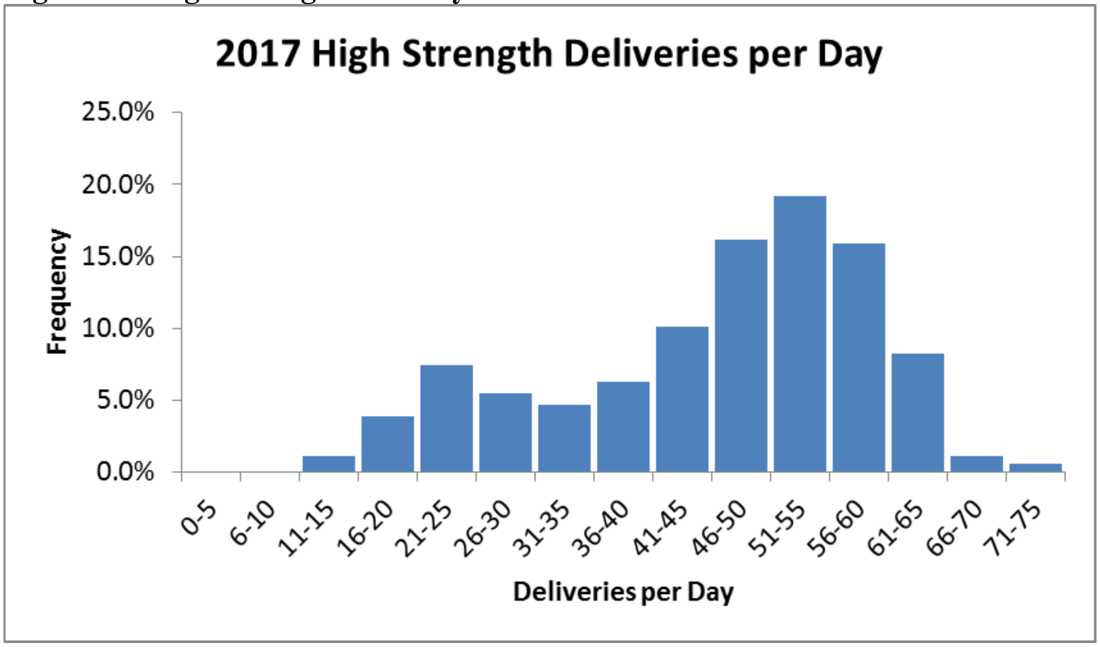
Using category profiles derived from the available sampling data, the estimated loading to the plant was derived for various constituents of note (Total Solids data was generally adjusted to remove the TDS component). The estimated loadings can be found in **Figure 4.** Generally these loadings show significant variations and are not as strictly correlated with flow as for low strength. This increased variation reflects that the strength of the high strength material can vary from a COD of 20,000 to over 1,000,000 across the different categories and the overall loading is very sensitive to the category proportions. The data used to generate these charts is included in **Appendix C.**

Figure 6 – R2 High Strength Loadings 2010 – 2018 (by month)



The distribution of loads per day for high strength deliveries in calendar year 2017 is shown in **Figure 7**. As can be seen in this figure, most days EBMUD receives 51 – 55 deliveries per day. The most received in any one day in 2017 was 72 and on 98 percent of the days, there were fewer than 65 deliveries.

Figure 7 – High Strength Delivery Distribution



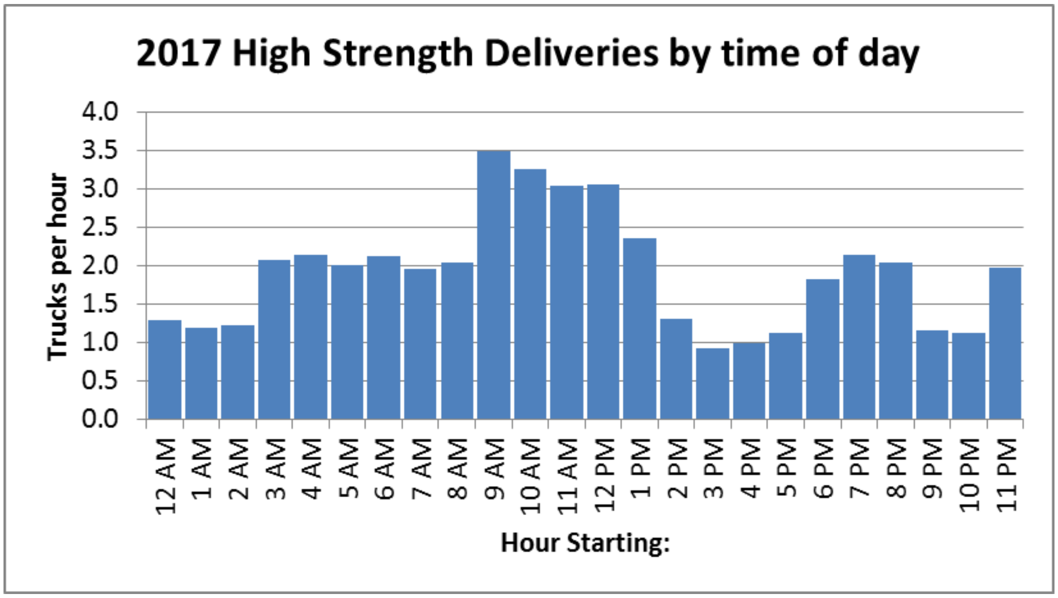
Based on the 2017 high strength delivery data, peaking factors were developed. The data from 2017 is presented in **Table 3.** High Strength waste generally shows significantly less variability with much lower peaking factors than low strength waste.

Table 3 – R2 High Strength Wastes Peaking Factors

Flow Type	Average	Daily		Monthly	
		Max	PF	Max	PF
Flow (gpd)	242,000	369,000	1.5	256,000	1.1
Trucks (#/day)	46	72	1.6	48	1.1

The average number of trucks per hour over the course of the day from 2017 is also shown in **Figure 8.** High strength deliveries showed several peak delivery times over the course of the day including from 9am – 1pm, 6pm – 8pm and 11pm to midnight. Some of the drops are likely explained by drivers avoiding rush hour periods with heavy traffic.

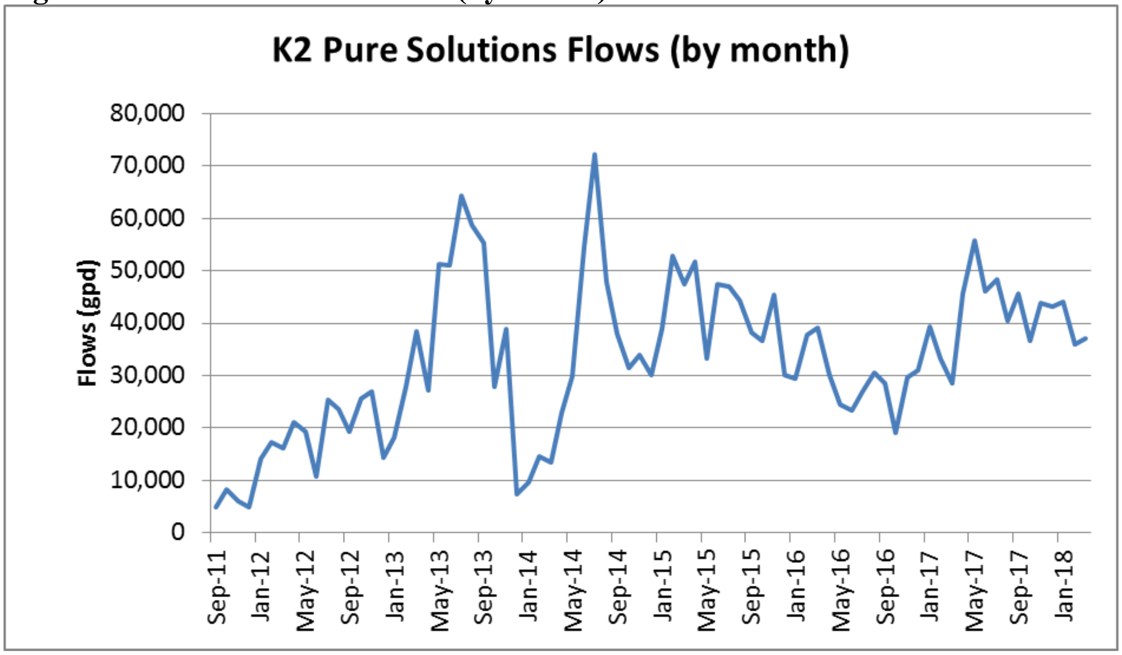
Figure 8 – Low Strength Deliveries by time of day



1.4 Historical K2 Flows 2010 - 2018

The brine loads from K2 Pure Solutions (K2) are discharged to the MWWTP effluent channel immediately upstream of the effluent pump station. This brine is continuously metered in via a K2 owned and operated tank on land that they lease from EBMUD. These flows are limited to 2 percent of average daily plant flow but historically they have not come close to approaching this limit. As this brine is discharged at the tail end of the treatment process, there is no impact to the majority of the plant. Thus these flows are largely not considered in this task. However, the K2 flows from 2010 – 2018 are presented in **Figure 5** for reference. These flows are broken down by month and shown as average gallons per day for that month.

Figure 9 – K2 Flows 2010 – 2018 (by month)

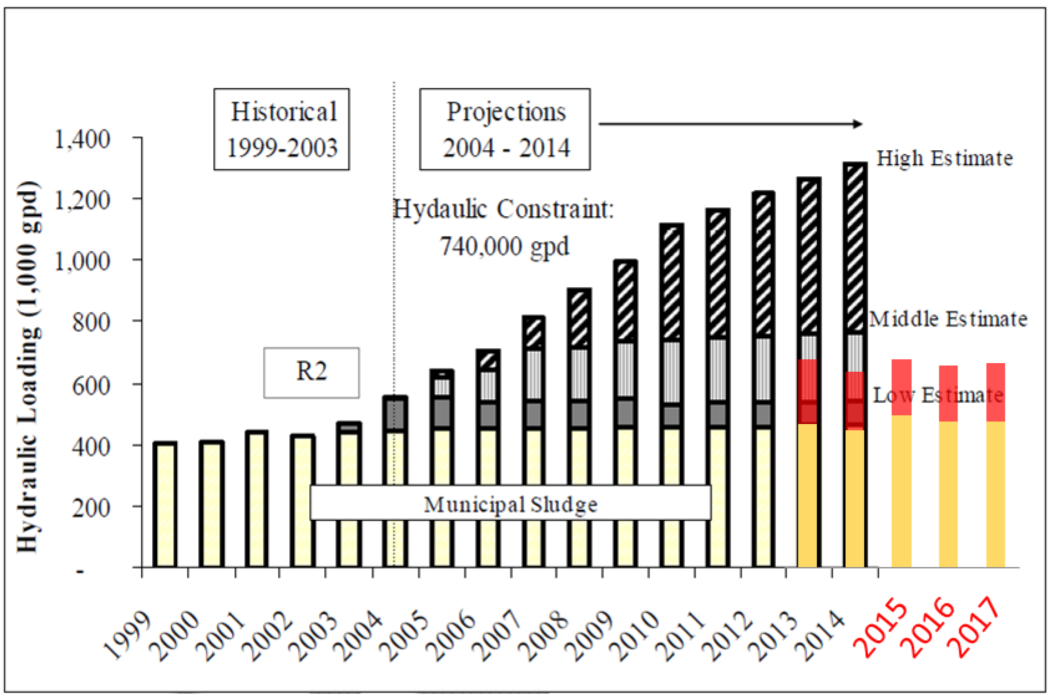


CHAPTER 2 – R2 FLOW PROJECTIONS

2.1 Previous Projections

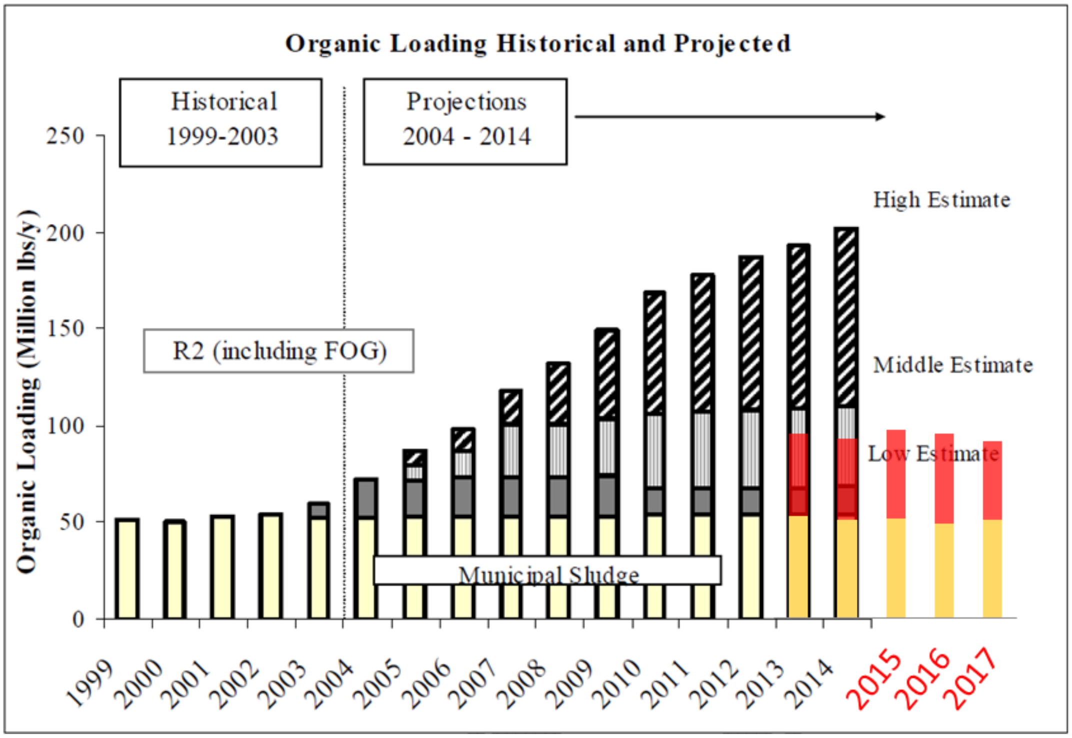
Before making new projections it is useful to review the accuracy of past projections to see how accurate they were and learn from any mistakes made. In 2005, the EBMUD Wastewater Process Engineering Section prepared a Waste-to-Energy study that included 10-year projections for flows and loadings to the digesters. These estimates included a Low, Middle and High projection for the growth of R2 and looked at how this would impact hydraulic loading to the digesters, organic loading to the digesters, and gas production from the digesters. The original figures with the actual values from 2013 – 2017 overlaid are shown in **Figure 6**, **Figure 7**, and **Figure 8**.

Figure 10 – Hydraulic Loading to Digesters – Projection vs actual



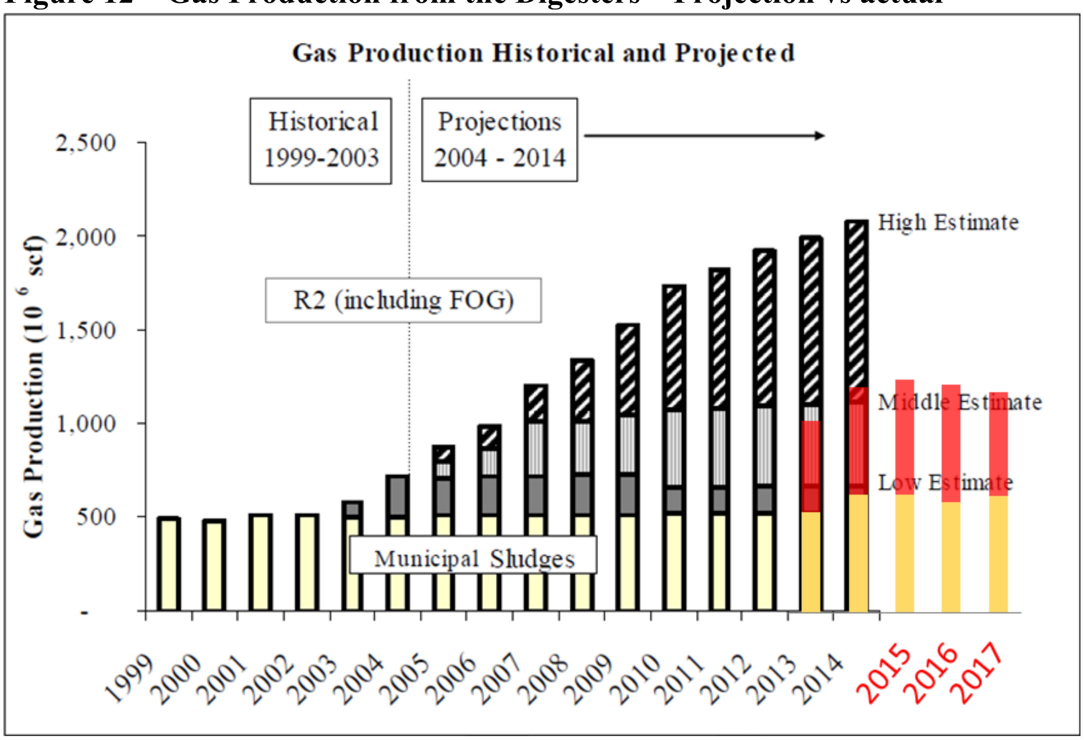
The actual hydraulic loading to the digesters for 2013 to 2017 ended up roughly halfway between the low and middle estimate for growth from R2 with the contribution from municipal sludge being in-line with expectations.

Figure 11 – Organic Loading to Digesters – Projection vs actual



The actual organic loading to the digesters for 2013 to 2017 ended up roughly halfway between the low and middle estimate for growth from R2 with the contribution from municipal sludge again being in-line with expectations.

Figure 12 – Gas Production from the Digesters – Projection vs actual



The actual gas production from the digesters was very close to the middle estimate for R2 growth. This indicates that slightly more gas is being produced than was expected for a given organic loading to the digesters. This result indicates that conservative unit gas production assumptions were used in the projections.

These projections were developed in the early years of the program when little historical data was available. In preparing the low and high estimates of high strength deliveries a number of factors were considered including population growth, market factors, availability of disposal alternatives, and hauling distance, among others. The low and high estimates bracket a coincidence of very pessimistic or optimistic factors and when aggregated are not very probable. The middle estimate as a probable outcome turned out to be about as accurate as it could be. Observing some stability in the deliveries in the last several years suggests that perhaps the program is mature and has captured as much of the high-strength market as it is likely to. However, there are factors that could greatly influence future high-strength deliveries either positively or negatively including regulations (e.g. SB 1383), technology (development of cost-effective on-site treatment), and economic factors (hauling fuel costs) that could have a considerable impact. Some of these factors are almost impossible to predict in both magnitude and timing.

2.2 Background for Projections

The following projections for low strength and high strength wastes over the Master Plan period were primarily based on the following assumptions:

R2 Program is mature: In reviewing the historic flows, there seems to be good evidence that the R2 program is mature with no new customer categories experiencing rapid growth as was seen in the early days of the program. While there can be significant variability within categories, at a high level the program doesn't appear to be changing rapidly. This indicates that future growth is less likely to come from locating new groups of customers with several notable exceptions as discussed in greater detail below. Rather, it seems likely that any growth will occur more slowly as the R2 customers grow their business.

Projections ignore MWWTP limitations: This analysis is intended to identify market potential and ignores any limitations at the MWWTP to receive these wastes. The MWWTP's ability to accept these flows was explicitly excluded from this analysis and will be explored in greater detail in other Master Plan tasks. The impact of MWWTP limitations is likely to be most significant for high strength wastes where there are known bottlenecks in the sludge handling process (i.e. dewatering).

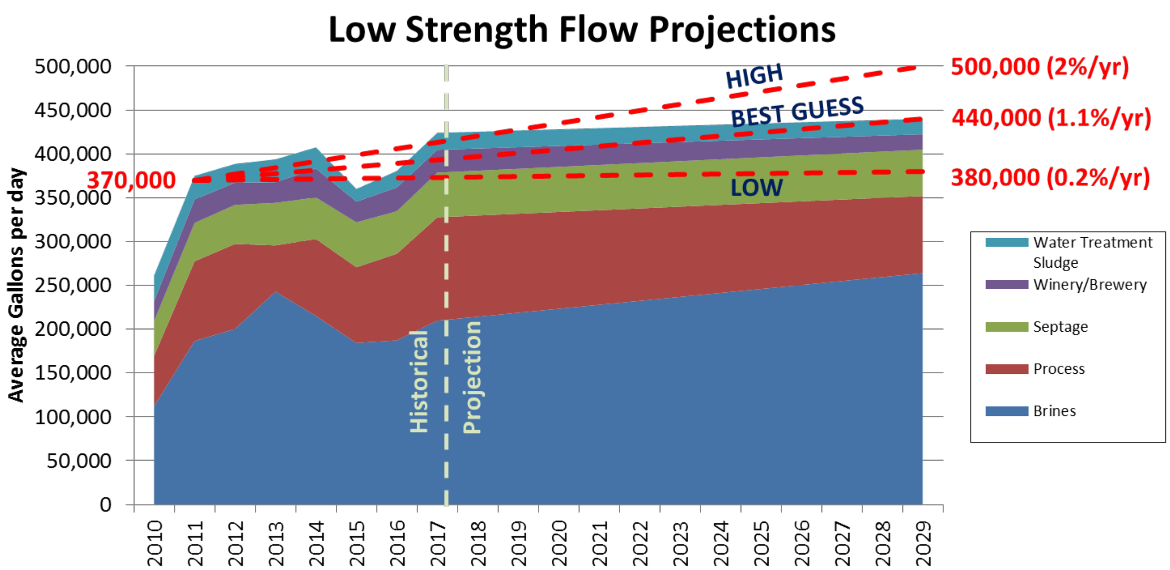
Projections assume relatively stable pricing: Pricing is a powerful tool available to R2 to influence growth within different categories depending on WWTP priorities. If certain categories are deemed undesirable for any reason, increases in price can discourage and reduce deliveries. If there is a need to increase deliveries of a certain feedstock, discounting prices may be an effective tool. A possible scenario where this might occur is if high strength feedstocks were to drop to the point where the existing power generation station (PGS) were underutilized due to insufficient gas production. In order to effectively capture the value of PGS, it might be most cost effective to drop tip fees to increase deliveries and thus gas production.

However, for this analysis, it is assumed that pricing remains steady and relatively close to current pricing. The need to use tip fees to increase/decrease certain categories of feedstock is expected to be informed by the master plan analysis.

2.3 10-Year Low Strength Flow Projections

The projections for low strength flows through 2029 are shown in **Figure 13**. The historical flow data up to 2017 is shown on the left side and the projections under various scenarios are shown on the right. Overall growth under the best guess scenario is expected to be around 1.1 percent annually from recent annual averages. The total volume projected under the low and high scenarios are also shown and anticipated to be 0.2 percent and 2 percent annual growth respectively. Details for all three projections can be found in **Table 4**.

Figure 13 – Low Strength Flow Projections



The stacked areas in **Figure 13** show the anticipated breakdown between the different categories for the best guess scenario. This breakdown anticipates growth in brines and reductions in all the other categories. The reasons for this are:

Brines: Low strength brine disposal is expected to continue to grow over the next 10 years. There are limited disposal options for salty wastes that are high in Total Dissolved Solids (TDS) and EBMUD is well positioned to be able to dispose of these wastes in a sustainable fashion. High TDS wastes are a particular issue in the Central Valley where there are very limited options for disposal. The Central Valley Salinity Coalition (CV-Salts) is a non-profit formed in 2008 to organize, facilitate and fund efforts needed for the efficient management of salinity in the Central Valley. A CV-Salts commissioned study estimates that long term there is a need to dispose of up to 7 million tons annually of salt (CDM Smith, Octobor 2016). EBMUD is well positioned to accept an increasing fraction of these salty wastes.

Winery/Brewery: Winery/Brewery wastes are expected to experience a decline in volumes going forward. High strength wastes are increasingly being converted to low strength wastes via on-site treatment and low strength wastes are often able to be disposed of via a local option. These waste generators are generally not in the East Bay and frequently have other WWTPs in the vicinity that have the potential to accept these wastes. Lagunitas is a good example of this phenomenon where they were a significant high strength customer for several years before putting in on-site treatment and becoming a low strength customer then ultimately diverting all their waste to local WWTPs. There can also be pressure for local jurisdictions to find a home for these wastes. "Napa stemming wine waste trucking flow to Oakland" was the title of a July 2018 article in the Napa Valley Register pushing for more local disposal of these wastes (Napa Valley Register, July 21, 2018).

Process: Process waste is more of a general catch-all category that is expected to experience similar trends to those seen in Winery/Brewery Waste.

Septage: Septage is expected to experience slight growth with increases in population.

Water Treatment Sludge: Water treatment sludge is expected to experience slight growth with increases in population.

Table 4 – R2 Low Strength Flow Projections

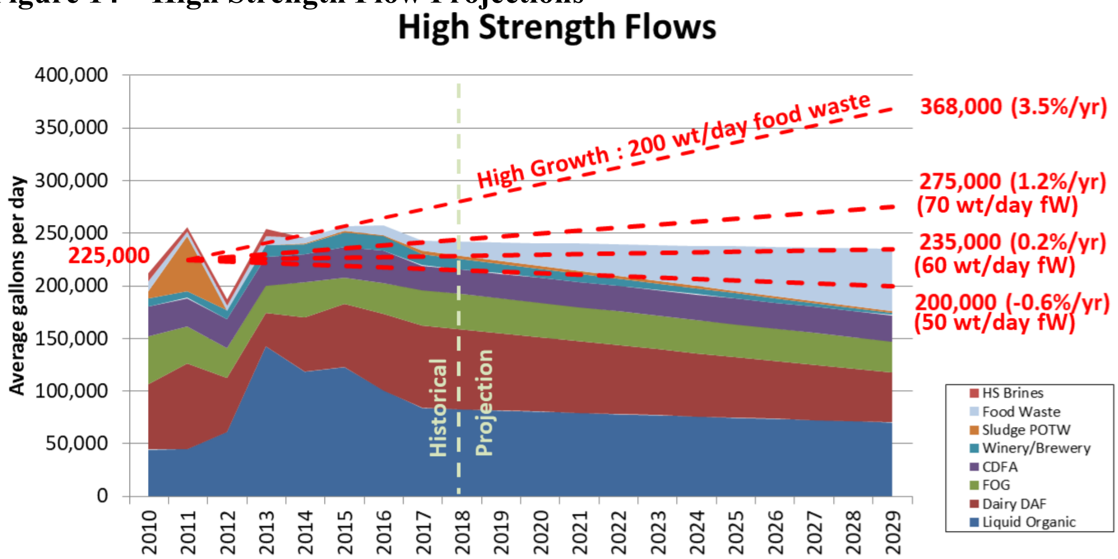
		Current	2029 Projection		
	Feedstock	2017 Average GPD	Low (gpd)	Best Guess (gpd)	FW Project (gpd)
Low Strength	Brines	210,000	228,000	264,000	300,000
	Process	118,000	76,000	88,000	100,000
	Septage	51,000	45,600	52,800	60,000
	Winery/Brewery	26,000	15,200	17,600	20,000
	Water Treatment Sludge	19,000	15,200	17,600	20,000
	Totals	**424,000**	**380,000**	**440,000**	**500,000**

2.4 10-Year High Strength Flow Projections

The projections for low strength flows through 2029 are shown in **Figure 14**. The historical flow data up to 2017 is shown on the left side and the projections under various scenarios are shown on the right. Overall growth under the best guess scenario is expected to be around 0.2 percent annually from recent annual averages. The total volume projected under the low and high scenarios are also shown and anticipate -0.6 percent and 1.2 percent annual growth respectively. **Figure 14** also shows a high growth projection that corresponds to the implementation of a 200 wt/day food waste project. Growing food waste to this degree would be a significant undertaking but does represent a feasible scenario. This type of project is also more likely to be step change in volume rather than a slow growth scenario. Exploring the capacity of the MWWTP to handle this type of project will provide valuable input on whether this type of project is consistent with the long term plan for the MWWTP and whether the R2 program should pursue projects of this scale. There are no analogous large scale projects for low strength wastes that would require a similar analysis of the MWWTPs capacity.

Details for all high strength projections can be found in **Table 5**.

Figure 14 – High Strength Flow Projections



The stacked areas in **Figure 14** show the anticipated breakdown between the different categories for the best guess scenario. This breakdown anticipates growth in brines and reductions in all the other categories. The reasons for this are:

Food Waste: Food waste is expected to grow significantly over the next 10 years from a relatively small fraction currently. Food waste is an attractive high strength feedstock due to its high energy potential and the fact that it is locally available. There is a very significant amount of food waste generated within the EBMUD "wasteshed" where EBMUD is the closest WWTP available for disposal. This is significantly different from most of the other high strength feedstocks that are trucked a significant distance to EBMUD.

Historically food waste has not gone to WWTPs or anaerobic digestion (AD) generally. Landfilling is typically the most cost effective means of disposal with most food waste mixed into the black bin. This is expected to change in the near future with passage of

SB1383 *Short Lived Climate Pollutant Reduction Strategy*. SB 1383 establishes targets to achieve a 50 percent reduction in the level of the statewide disposal of organic waste from the 2014 level by 2020 and a 75 percent reduction by 2025. On January 1st, 2024 the regulations may require local jurisdictions to impose penalties for noncompliance on generators within their jurisdiction. This is expected to dramatically increase the amount of organics that needs to be disposed of via AD and composting. With the increased demand for capacity, EBMUD anticipates composting prices increasing to the point where EBMUD becomes a cost competitive option for disposal of local organics.

EBMUD has been piloting food waste recycling since 2004. Several challenges remain, the largest of which is determining how to cost effectively remove contamination. However, the field is evolving quickly with the passage of SB 1383 and there are a number of promising technologies and methods for addressing the issue of contamination that the R2 program is actively exploring.

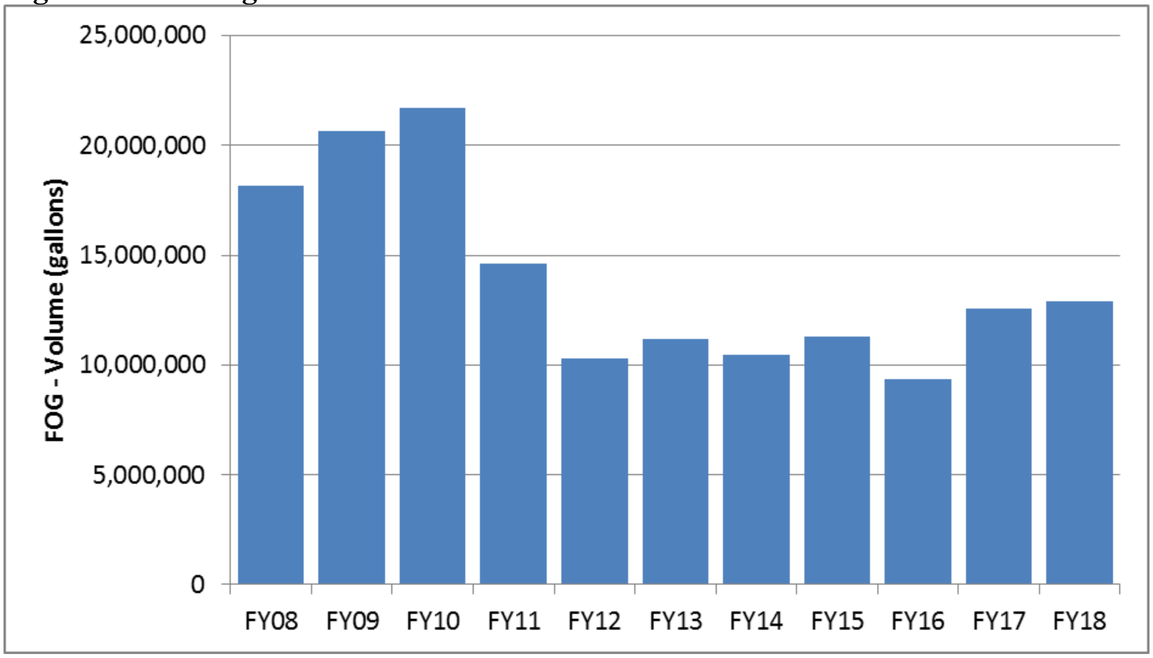
Winery/Brewery: As discussed in the low strength section above, Winery/Brewery wastes are expected to experience a decline in volumes going forward.

Liquid Organic: Similar to process water, liquid organic is a catch-all category. However, most of these wastes are relatively easy to accept and frequently come to EBMUD from some distance. Liquid organic wastes are expected to experience the same pressures as Winery/Brewery waste and are anticipated to decline over time.

Dairy DAF: Dairy DAF wastes tend to come from the Central Valley where the California diary industry is concentrated. These wastes share a number of the same pressures as the liquid organic and winery/brewery wastes and are expected to shrink over time. However, these wastes do tend to be high in TDS which may limit the number of alternatives to disposal at EBMUD.

FOG (Fats, Oil, and Grease): FOG wastes are similar to the other high strength wastes in that a number of FOG sources that previously were coming to EBMUD have gone to other, closer disposal options. However, FOG appears to have already gone through the drop associated with this occurring and now appears to have reached a new stable equilibrium with the closest sources of FOG continuing to come to EBMUD. There may even be evidence of some slow growth in recent years as seen in **Figure 15**. Based on this, FOG is expected to stay relatively stable with the potential for some growth.

Figure 15 – Change in FOG Deliveries



Bloods: The bloods category includes all the various animal wastes accepted by EBMUD including poultry blood, rendering waste, beef blood, swine blood, animal alkaline hydrolysis etc. These wastes for the most part do tend to come from some distance and have the potential to experience similar pressure as the other high strength liquids. However, there are a couple of factors that may make these wastes less likely to be diverted to local treatment options. These wastes are high in nitrogen which may make it difficult for any WWTP doing nitrogen removal to accept. These wastes also require a CDFA render's license in order to accept. Based on this, the acceptance of Blood waste is expected to be relatively stable. These wastes are also projected slightly higher in order for the Master Plan process to identify any limitations around their acceptance.

Sludge/POTW: While these wastes were slightly higher in 2017, this is a relatively small category and it is not expected to grow or shrink significantly in the future.

Table 5 – R2 High Strength Flow Projections

		Current	2029 Projection			
	Feedstock	2017 Average GPD	Low gpd	Best Guess gpd	High gpd	High Growth gpd
High Strength	Liquid Organic	84,000	59,000	70,000	82,000	70,000
	Dairy DAF	78,000	40,000	47,000	55,000	47,000
	FOG	34,000	25,000	30,000	35,000	30,000
	Bloods[1]	23,000	22,000	25,000	30,000	25,000
	Winery/Brewery	11,000	2,000	2,000	3,000	2,000
	Sludge POTW	3,000	2,000	2,000	2,000	2,000
	Food Waste (wtpd)	9,000 (10)	50,000 (50)	59,000 (60)	69,000 (75)	192,000 (200)
	Totals	**242,000**	**200,000**	**235,000**	**276,000**	**368,000**

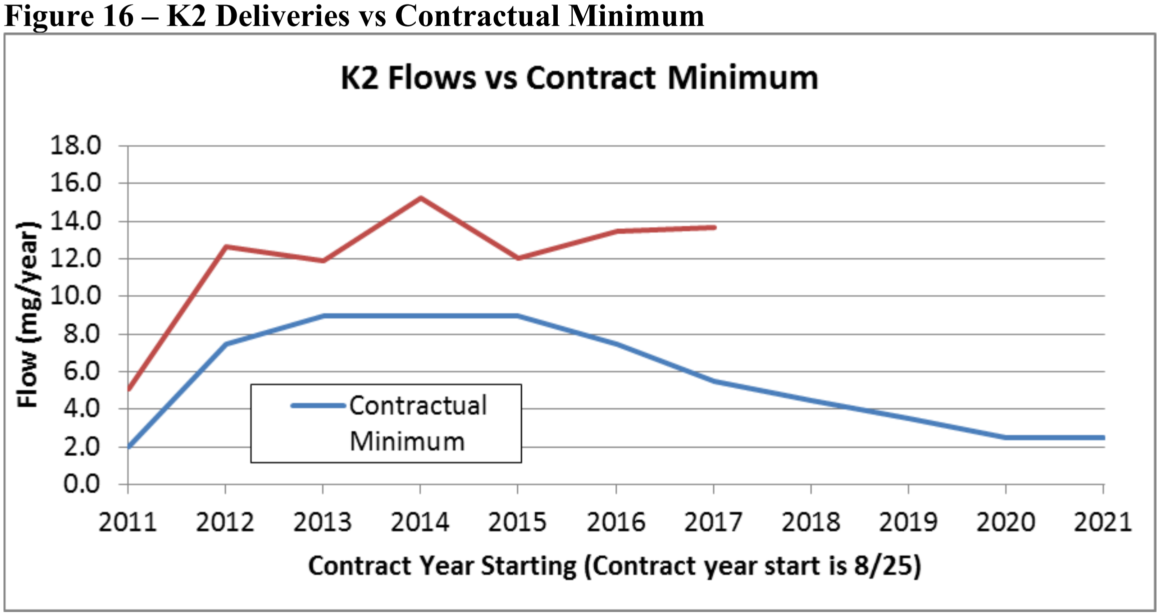
Notes:

1. Bloods includes all the various animal wastes accepted by EBMUD including poultry blood, rendering waste, beef blood, swine blood, animal alkaline hydrolysis etc.

2.5 K2 Flow Projections

The contract with K2 has a ten year initial term ending in late 2021. During this term there is a contractual minimum delivery obligation that K2 has agreed to meet. The delivery obligation peaked in 2015 and declines every year after that as shown in **Figure 16**. After the initial ten year term, the contract automatically renews each year with a 2.5 MG annual minimum delivery obligation unless either party choses to end the contract 6 months prior to the end of the contract year.

Figure 16 – K2 Deliveries vs Contractual Minimum



K2 deliveries have always been well in excess of the contractual minimum as can be seen in **Figure 16**. Based on this K2 deliveries are expected to remain steady with no significant increase or decrease. The projected volumes for K2 are shown in **Table 6**.

Table 6 – K2 Flow Projections

	Current	2029 Projection		
Feedstock	2017 Average GPD	Low (gpd)	Best Guess (gpd)	High (gpd)
K2	42,000	30,000	38,000	47,000

CHAPTER 3 – R2 PROJECTED REVENUES

3.1 Background

The published R2 rates for FY 2019 are included as **Appendix A**. These rates are adjusted periodically depending on the estimated marginal cost to treat and current market conditions. These adjustments are typically done on an annual basis as a part of EBMUD's rate setting process.

The R2 program recently completed a comprehensive financial analysis for the program covering FY17. This analysis was intended to be conservative and cover all possible costs associated with the program including expendables, O&M, Admin, overhead, depreciation and interest/amortization charges. Following this analysis the costs were divided into marginal costs (expendables, O&M, equipment replacement) and non-marginal costs (admin, overhead, depreciation, interest/amortization charges). These marginal costs were then roughly assigned to each waste on a per gallon basis. The difference between the tip fee charged and the marginal cost to treat is the "profit" margin in $/gallon for each waste stream.

This profit margin can be used to evaluate the financial impact of increasing or decreasing each waste stream by some volume. However, there are a couple of critical assumptions made in determining this profit margin:

- **This profit margin is based on current R2 flows and is only valid for flows roughly close to current level.** A major increase or decrease in volume could significantly impact the profit margin absent any other change. For example, if high strength flows dramatically increased without any associated capital investment to better capture and use the biogas produced then the profit margin would drop as that biogas would need to be flared. Alternatively, if the high strength flows dramatically decreased to the point where EBMUD was no longer a net energy producer, the profit margin would increase as avoided power use is worth more per kWh than surplus power sales.
- **This profit margin is based on current WWTP equipment and configuration**. If a change is made to the WWTP equipment, then the profit margin would likely change. For example, if a renewable natural gas (RNG) upgrading system were installed, this would likely increase the profit margin as the biogas is currently worth more converted to RNG than if it is converted to electricity.
- **The profit margin is based on current prices.** To a certain extent the R2 program has control over the profit margin and can vary prices to match market conditions and/or to match internal interests. If there is a need to increase or decrease certain feedstocks, pricing can be adjusted to drive that behavior with the corresponding impact on profit margins.
- **The profit margin is based on current power revenues.** The margins reported below include a credit for high strength wastes based on the amount of biogas/energy these wastes are expected to produce. However, these credits are relatively small and reflect the downward trend in wholesale power prices and Renewable Energy Credit (REC) values due to increased competition from solar, wind, and other renewable energy sources.

3.2 Current estimated "profit" margins on R2 wastes

Based on the detailed analysis done for FY17, the estimated profit margins and 2017 total margin for all the major feedstock categories are shown in **Table 7**. These total estimated margins do not include non-marginal costs like admin and overhead. This analysis indicates that low strength brines bring in nearly 1/3 of the programs profits and that the low strength wastes in general tend to be higher margin than high strength. This in part reflects the downward trend in renewable electricity values.

Solid Food waste is not currently profitable; however, food waste is expected to experience significant growth in the coming years. The current program is providing valuable experience in this challenging sector and will help position the program to capture some of the expected growth in this market. The R2 program is actively exploring ways to treat food waste in a cost effective manner.

Table 7 – Current Estimated R2 Margins

	Feedstock	2017 Average GPD	2017 Tip Fee $/gal	FY17 Profit Margin $/gal	2017 Total Estimated Margin
Low Strength	Brines	210,000	$0.04 - $0.09	$0.04	$3,066,000
	Process	118,000	$0.05	$0.04	$1,722,800
	Septage	51,000	$0.07	$0.05	$930,750
	Winery/Brewery	26,000	$0.05	$0.04	$379,600
	Water Treatment Sludge	19,000	>$0.05	$0.01	$69,350
High Strength	Liquid Organic	84,000	$0.04	$0.01	$306,600
	Dairy DAF	78,000	$0.04	$0.02	$569,400
	FOG	34,000	$0.08	$0.03	$372,300
	Bloods	23,000	$0.08	$0.02	$167,900
	Winery/Brewery	11,000	$0.04	$0.02	$80,300
	Sludge POTW	3,000	>$0.05	$0.01	$10,950
	Solid Food Waste	9,000	$45-$65/wt	$ -	$ -
	K2	42,000	$0.07	$0.07	$1,073,100
Totals		**708,000**			**$8,749,050**

3.3 Projected potential "profit" margins on R2 wastes

The projected potential margin for each of the waste stream categories is shown in **Table 8**. The profit margin is generally within the control of the R2 Program and prices can be increased or decreased to reflect market conditions and/or program priorities. At this point in time, the R2 Program doesn't anticipate seeking higher margins on most of the wastes. The possible exceptions are shown in red in the table below and reflect the potential for increased margins on brines and food waste. The total "profit" number reflects the marginal benefit to EBMUD from each category.

Table 8 – Potential R2 Margins

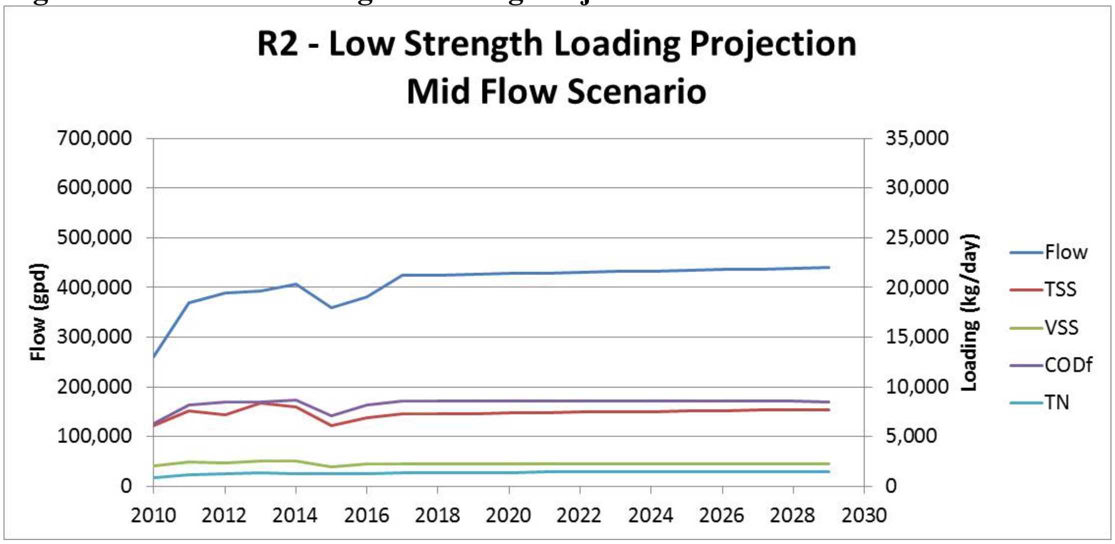
	Feedstock	Potential Margin $/gal	Total "profit" Low Scenario ($/yr)	Total "profit" Mid Scenario ($/yr)	Total "profit" High Scenario ($/yr)	Total "profit" High FW Scenario ($/yr)
Low Strength	**Brines**	$0.06	$4,993,200	$5,781,600	$6,570,000	$5,781,600
	Process	$0.04	$1,109,600	$1,284,800	$1,460,000	$1,284,800
	Septage	$0.05	$832,200	$963,600	$1,095,000	$963,600
	Winery/Brewery	$0.04	$221,920	$256,960	$292,000	$256,960
	Sludge	$0.01	$55,480	$64,240	$73,000	$64,240
High Strength	**Liquid Organic**	$0.01	$215,350	$255,500	$299,300	$255,500
	Dairy DAF	$0.02	$292,000	$343,100	$401,500	$343,100
	FOG	$0.03	$273,750	$328,500	$383,250	$328,500
	Bloods	$0.02	$160,600	$182,500	$219,000	$182,500
	Winery/Brewery	$0.02	$14,600	$14,600	$21,900	$14,600
	Sludge POTW	$0.01	$7,300	$7,300	$7,300	$7,300
	Solid Food Waste	$0.02	$365,000	$430,700	$503,700	$1,401,600
	K2	$0.08	$876,000	$1,109,600	$1,372,400	$1,109,600
Totals			**$9,417,000**	**$11,023,000**	**$12,698,350**	**$11,993,900**

CHAPTER 4 – R2 PROJECTED LOADINGS

4.1 Plant Loadings

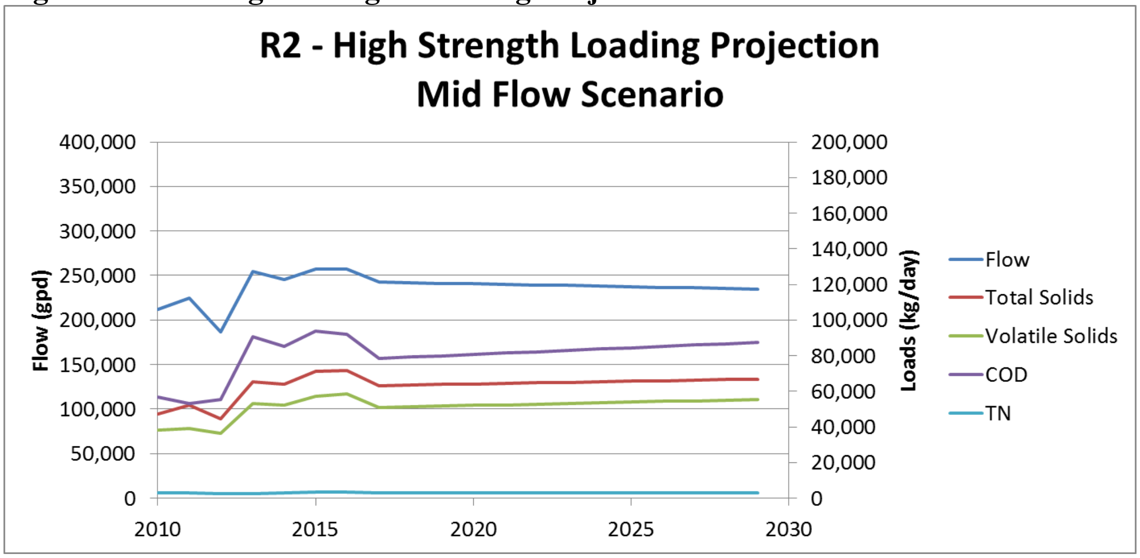
This section uses the R2 feedstock category profiles developed for the historical plant loadings and projects them into the future. These category profiles are included as **Appendix D.** The projected loadings for low strength feedstocks to the plant under the middle projection are shown in **Figure 17.** The data used to generate these charts is included in **Appendix B.**

Figure 17 – R2 Low Strength Loading Projection



Similarly the projected loadings for high strength feedstocks to the plants are shown in **Figure 18.** In general, under the mid flow scenario, increases in high strength food waste are expected to make up for anticipated losses in other high strength categories like liquid organic and dairy DAF. The data used to generate these charts is included in **Appendix C.**

Figure 18 – R2 High Strength Loading Projection



4.2 Biosolids Production

The impact of the R2 High strength deliveries on biosolids production was conservatively estimated by comparing biosolids production from 2001 - 2002 (before significant loading from the R2 Program) and from 2013 – 2017 when R2 high strength deliveries were relatively constant. Some notes on this method:

- This method is conservative if solids loading to the plant from the sewer is constant or has increased. Flows to the WWTP have decreased in recent years, however, on initial inspection solids loading appears to be constant or have increased
- This ignores any impact R2 low strength flows might have on biosolids production

Historical biosolids production and R2 loadings are shown in **Table 9**. There was an unusual increase in 2017 that appears unrelated to R2 activities. However, multi-year averages were used minimizing the impact of that years data. Based on this data, biosolids production has increased by 4,700 dry tons/year while R2 has added a loading of 27,000 dry tons per year to the digesters. This indicates that roughly 18 percent of the R2 solids added to the digesters pass through into the biosolids. This low rate of biosolids production is consistent with the high VS/TS ratio of R2 feedstocks and the expected high volatile solids reduction of these feedstocks in the digesters.

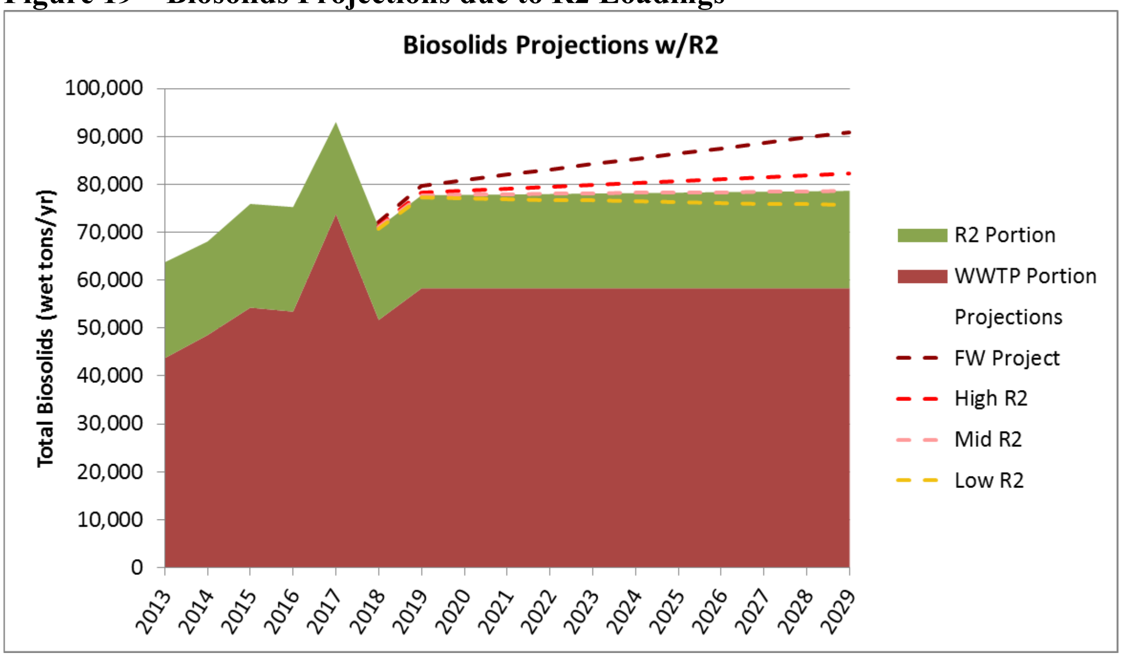
Table 9 – MWWTP Biosolids data

	Total Biosolids (wet tons/yr)	Biosolids TS	Total Biosolids (dry tons/yr)	R2 High Strength Solids Fed (dry tons/yr)
2001	58,468	22%	13,038	0
2002	60,579	22%	13,327	0

Pre-R2 Average	**59,524**		**13,183**	
2013	63,725	23%	14,657	26,478
2014	68,057	25%	17,014	25,843
2015	75,911	23%	17,460	28,627
2016	75,250	24%	18,060	28,865
2017	93,008	24%	22,322	25,427
Post-R2 Average	**75,190**		**17,902**	**27,048**
Post-R2 Increase			4,720	27,048

Using this historical relationship, the biosolids production under the various high strength projections is shown in **Figure 19**. As can be seen in the figure, the range between the high R2 and low R2 scenarios is relatively small. This is a result of a significant portion of the R2 solids being consumed in the digester. Based on this higher consumption, R2 wastes have a disproportionately high impact on biogas production and a disproportionately low impact on biosolids production. The food waste project scenario would result in a significant increase in biosolids produced, roughly 10,000 wet tons per year or a 50 percent increase from the roughly 20,000 wet tons that currently comes from R2. The data used to generate these charts is included in **Appendix D.**

Figure 19 – Biosolids Projections due to R2 Loadings



4.3 Gas Production

The impact of the R2 High strength deliveries on biogas production was estimated by comparing biogas production from 2001 - 2002 (before significant loading from the R2 Program) and from 2013 – 2017 when R2 high strength deliveries were relatively constant. Some notes on this method:

- This method is based on relatively constant solids loading to the digesters from TWAS and PS
- This ignores any impact R2 low strength flows might have on biogas production

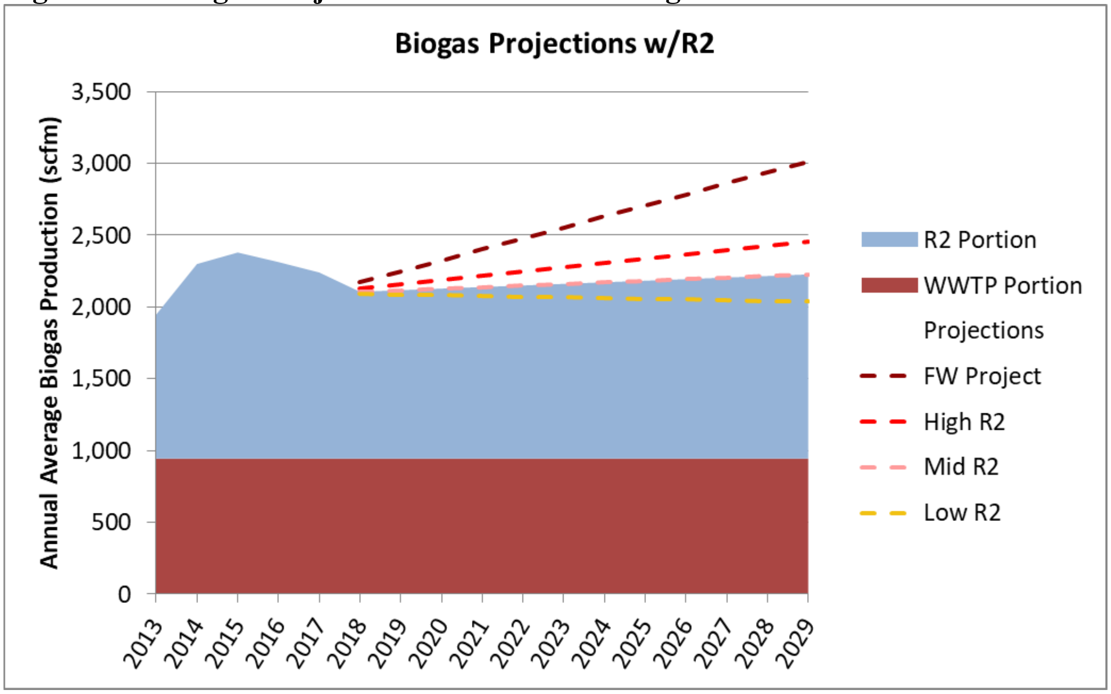
Historical biogas production both before and after the R2 program was initiated is shown in **Table 10**. Biogas production went from an average of around 950 standard cubic feet per minute (scfm) to 2,250 scfm, an increase of 1,300 scfm. This increase is primarily due to the high strength feedstocks being fed to the digesters. The average R2 feed rate over this time period was 88,000 kg COD/day. This yields an aggregate biogas production rate of 21 cubic feet per kg COD.

Table 10 – WWTP Biogas data

	Average Biogas Production (scfm)	R2 High Strength Fed (KG COD/day)
2001	930	0
2002	960	0
Pre-R2 Average	**950**	**0**
2013	1,950	90,600
2014	2,300	85,200
2015	2,380	93,800
2016	2,310	92,100
2017	2,240	78,500
Post-R2 Average	**2,250**	**88,000**
Post-R2 Increase	**1,300**	**88,000**

Using this historical relationship, the biogas production under the various high strength projections is shown in **Figure 20**. As can be seen in the figure, the low R2 scenarios shows roughly a 10 percent drop in gas production to 2,050 scfm while the high R2 scenarios shows roughly a 10 percent increase in gas production to 2,450 scfm. As discussed previously, R2 wastes have a disproportionately high impact on biogas production as compared to biosolids. The food waste project scenario would result in a significant increase in biogas production, roughly a 35 percent increase to 3,000 scfm. A food waste project increases biosolids production by roughly 10,000 wet tons per year or a 50 percent increase from the roughly 20,000 wet tons that currently comes from R2.

Figure 20 – Biogas Projections due to R2 Loadings



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APPENDICES