CLAYTON COUNTY Water AUTHORITY 1600 Battle Creek Road, Morrow, GA 30260	W.B. CASEY WRRF BIOSOLIDS FACILITIES UPGRADE	
	ADDENDUM # 1	
	DATE	Thursday, November 4, 2021
	RFP NUMBER	2021-WR-23
	PRE-PROPOSAL MEETING	Thursday, November 4, 2021, at 10:00 a.m. local time
	RFP OPENING DATE	Monday, December 13, 2021, at 3:00 p.m. local time

QUESTIONS:

1. **What is the overall budget?**

   Answer:

   See Section 2.2 Project Budget and Funding.

2. **Please furnish the Task 6 TM, Part 1 – W.B. Casey WRRF Biosolids Alternatives Evaluation (Jacobs, 2019) that is referenced in the RFP.**

   Answer:

   See Clarification No. 1, 2, and 3.

3. **Please furnish any other TMs developed to support the Preliminary Engineering Report (PER).**

   Answer:

   See Clarification No. 1, 2, and 3

4. **To clarify, the submission format section of the RFP states, "The proposal must not exceed forty (40) total pages…". To help ensure that all competing teams interpret this requirement the same, please confirm that the intent is for the proposal to be limited to forty (40) single-sided pages.**

   Answer:

   See Clarification No. 4.

5. **Since most localities require state licensing compliance (business, corporation commission, general contractor, etc) for Joint Ventures by time of contract award, can you please clarify if Clayton County requires any Joint Venture licenses prior to submittal of the proposal?**

   Answer:

   The proposer need not possess all required licenses prior to submission of a proposal. However, a proposer must possess all required licenses at the time of award and execution of the Design-Build Agreement.

   Moreover, when a proposal is submitted, the proposer must be an existing legal entity, including but not limited to a corporation, limited liability company, general partnership, joint venture, limited partnership, etc. The successful proposer must be the legal entity that will enter into the Design-Build Agreement.

6. **The formula provided for Fee and Rate Proposal Cost (Section 6. Proposal Evaluation and Selection) appears to be calculated based on the highest price (not the lowest) and provides no proposer with the full five points. Is this what you intended?**

   Answer:

   See Clarification No. 5

7. **Article 1.2 - Please clarify if DBIA Document No. 535 will be used as a supplement to what is presented in Attachment B. It is referenced, but not supplied as part of the Attachment.**

   Answer:

   See Clarification No. 6

8. **Article 1.2.1 - Please clarify if DBIA Document No. 545 will supplement what is presented in Attachment B. It is referenced, but not supplied as part of the Attachment.**

   Answer:

   See Clarification No. 6

9. **Article 6.2.1 and Article 2.3 - In Article 6.2.1, Confirm this should read "Substantial Completion of the entire Work shall be achieved no later than eight hundred seventy (870) calendar days after the Date of Commencement of Phase 2"**

   Answer:

   See Clarifications No. 7, 8, and 9

10. **Article 7.5.1.6, Article 7.6.2.5, Section 2.8.2.4 of Exhibit C, Agreement (Exhibit E) and Article 7.7.4 - Please clarify if insurance such as Professional Liability, insurance premiums and bonds are a "Cost of the Work" or a General Conditions cost. Typically, our experience has been to define insurance requirements as a Cost of the Work established once the project as well as overall cost, duration and risks are better defined. The PDB Agreement and Exhibit C appear to be conflicting.**

    Answer:

    All costs, overhead, and profit for Phase 1 should be included in the Phase 1 Contract Price, which is the exclusive compensation for Phase 1. For Phase 2, the premiums for all insurance and bonds are not "Cost of the Work." Instead, those costs are addressed by the "General Conditions Amount," which is a percentage of the Cost of the Work.

11. **Article 7.7 - Please clarify how the General Conditions cost, Design Builder Fee, bonds, and insurance are accounted for in determination of payment for Allowance Items.**

    Answer:

    Costs associated with Allowance Items are handled in the same manner as costs associated with any other Work. Thus, for Allowance Items, costs that qualify as "Cost of the Work" will be reimbursed and will increase Design-Builder's Fee and General Conditions Amount. Costs associated with Allowance Items that qualify as "General Conditions Costs" will not qualify as Cost of the Work and, instead, will be addressed by the General Conditions Amount. The General Conditions Amount is calculated as Cost of the Work multiplied by the General Conditions Percent.

    All of the foregoing compensation is subject to the Guaranteed Maximum Price.

For reference, see the following provisions:

- Allowance Items and Allowance Value: Design-Build Agreement § 7.7
- Cost of the Work: Design-Build Agreement § 7.5
- Design-Builder's Fee: Design-Build Agreement § 7.4.1
- General Conditions Amount: Design-Build Agreement § 7.4
- General Conditions Costs: Design-Build Agreement § 7.5.2.5 & Exhibit C § 2.8.2.4

12. Article 8.1 and Article 8.3 - Please confirm that retainage applies only to Phase 2 of the work.

Answer:

See Clarification No. 10

13. Article 8.1 - Please clarify that Article 8.1 is intended to refer to Phase 1 and Phase 2 services.

Answer:

See Clarification No. 10

CLARIFICATIONS:

1. Add Technical Memorandum Subject: Executive Summary for Memorandums for Tasks 1, 3, 5, and 6 and respective attachments, dated June 22, 2020 (Casey CapacityTMs_FINAL_7-14-2020.pdf) and insert in Exhibit A – Project Background Documents" of Attachment B – Draft Progressive Design-Build Agreement in the Request for Proposals.

2. In the Request for Proposals, Attachment B – Draft Progressive Design-Build Agreement, on page i, delete the statement "Exhibit A – Project Background Documents (PER) and replace with "Exhibit A - Project Background Documents (PER and Technical Memorandum)."

3. In the Request for Proposals, on the divider page for Exhibit A (page 91 of the RFP PDF), delete the statement "Exhibit A – Project Background Documents (PER)" and replace with "Exhibit A - Project Background Documents (PER and Technical Memorandum)."

4. In the Request for Proposals, Page 11, Section 5.2, delete the first sentence in its entirety and replace with the following: "The Proposal must not exceed forty (40) total, single-sided pages (most or all 8½ x 11 inches with 1-inch or greater margins), excluding the transmittal letter, index or table of contents, front and back covers, title pages/separation tabs, fee and rate proposal, and appendices."

5. In the Request for Proposals, Section 6.4, delete the last sentence in its entirety and replace with the following:

   "Up to the five (5) points allowed will be awarded based on the following formula: $V=5*(P_L / P_i)$

   Where:
   P_L = the lowest Total Proposed Fee
   P_i = the Proposer's Total Fee
   V = the points to be awarded"

6. In the Request for Proposals, Attachment B-Draft Progressive Design-Build Agreement, in Article 1-General, Section 1.2, delete Section 1.2 in its entirety and replace with the following: "1.2 Definitions. Terms, words and phrases used in this Agreement shall have the meanings given them in General Conditions of the Contract Between Owner and Design-Builder."

7. In the Request for Proposals, Attachment B – Draft Progressive Design-Build Agreement, Article 6, section 6.1, delete the second sentence in its entirety and replace with the following: "Phase 2 Services shall commence within five (5) days after Design-Builder's receipt of Owner's Notice to Proceed with Phase 2 Services if the Contract Price Amendment is executed, unless at such time, the parties have mutually agreed otherwise in writing."

8. In the Request for Proposals, Attachment B – Draft Progressive Design-Build Agreement, Article 6, section 6.2.1, delete the sentence in its entirety and replace with the following:

"Unless modified by the Contract Price Amendment, Substantial Completion of the entire Work shall be achieved no later than eight hundred seventy (870) calendar days after the date of Owner's Notice to Proceed with Phase 2 Services ("Scheduled Substantial Completion Date")."

9. In the Request for Proposals, Attachment B – Draft Progressive Design-Build Agreement, Article 8, section 8.2.1, delete the first sentence in its entirety and replace with the following: "Unless Owner designates, in writing, another due date, Design-Builder shall submit to Owner on the 20th day of each month, beginning with the first month after the date of Owner's Notice to Proceed with Phase 1 Services, Design-Builder's Application for Payment in accordance with Article 6 of the General Conditions."

10. In the Request for Proposals, Attachment B – Draft Progressive Design-Build Agreement, Article 8, section 8.1, delete the first sentence in its entirety and replace with the following: "Payment for Phase 1 and Phase 2 Services."

Acknowledgment of receipt of this addendum must be signed and included in your submittal response.	
COMPANY NAME	
SIGNATURE	
DATE	

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Memorandum

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Subject	**Executive Summary for Memorandums for Tasks 1,3,5 and 6**
Project Name	W.B. Casey WRRF Capacity Analysis and Plant Expansion Evaluation
Attention	Clayton County Water Authority (CCWA)
From	Kristina Yanosek/Jacobs Engineering Group Inc. (Jacobs)
Date	June 22, 2020

Background

The purpose of the W.B. Casey Water Resource Recovery Facility (Casey WRRF) Capacity Analysis and Plant Expansion Evaluation was to establish an approach for expanding the Casey WRRF from 24 to 32 MGD. While the main plant, referred to as “liquids” facilities, is rated for 24 MGD, the actual capacity based on current loads and operational approach had not been evaluated. With CCWA considering the closure of the Shoal Creek Water Reclamation Facility (SCWRF), and transfer of the Shoal Creek flow to Casey, the additional flow and load from Shoal Creek was considered in this evaluation. Technology alternatives were evaluated to select an approach to expand the liquid stream facilities using the existing infrastructure.

The biosolids facilities, were known to be operating near capacity based on previous evaluations and operating experience. Technology alternatives were evaluated to select a process train to replace the existing biosolids facilities which are at the end of their useful life.

The original intent was to produce a Preliminary Engineering Report (PER) and Class 4 estimate for a full plant expansion. As this project progressed, revised flow projections, reduced urgency to decommission Shoal Creek, and limited funding led CCWA towards the decision to defer the expansion of the Casey liquid stream facilities. Consequently, the PER, to be submitted at the conclusion of this project will only consider the new biosolids facilities.

Task 1 TM – W.B. Casey WRRF Design Basis

The objective of this task was to establish the plant influent and effluent design basis for the subsequent capacity analysis and evaluation of plant expansion alternatives.

The influent design basis was developed using historical data from SCWRF and Casey WRRF and new sampling data. The plant model was initially developed using only existing data. Following difficulty in closing the mass balance, it was determined that new sampling data was needed to accurately characterize the influent raw wastewater without recycles (The permanent Casey WRRF influent sampler is located downstream of recycle flows). A sampling campaign was performed in April 2019 to characterize the Casey WRRF raw wastewater (without recycles) and determine soluble/non-soluble and biodegradable/non-biogradable fractions of COD, TSS, N, and P for improved modeling of biological nutrient removal. This data was used to formulate the influent design basis used for this evaluation.

The effluent design basis was based on the new wasteload allocation provided in September 2019 by the Georgia Environmental Protection Division (GAEPD) to increase the discharge from the Casey WRRF to the Flint River (6.6 to 14.6 MGD).

Task 3 TM – W.B. Casey WRRF Process Model Calibration and Plant Capacity Analysis

The objectives of this task were to 1) develop and calibrate a process simulation model based on current process configuration and performance and 2) use the process simulation model to determine the capacity of the Casey secondary treatment facilities with respect to the existing permit limits. Additionally, the maximum capacity of all liquid stream unit processes was analyzed.

It was confirmed that flows from SCWRF could not be transferred to the Casey WRRF prior to the 32 MGD expansion. Through the analysis, it was also determined that the actual plant capacity of the Casey WRRF was less than the rated capacity of 24 MGD. Specific deficiencies include the influent pumping and aeration systems. It was recommended that CCWA upgrade the Casey and Jackson Raw Sewage Pump Stations and the aeration system in the near-term to bring the plant back to capacity.

Task 5 TM – W.B. Casey WRRF Liquid Stream Process Alternatives Evaluation

The objective of this task was to define an approach for expanding the Casey WRRF liquid stream processes from 24 to 32 MGD based on the design basis established in Task 1.

Wastewater treatment technologies were considered and narrowed down based on existing conditions and treatment objectives defined by the effluent design basis. Of the technologies screened, three were selected for evaluation:

- Status Quo
- Chemically enhanced primary treatment (CEPT)
- Integrated fixed film activated sludge (IFAS).

The calibrated whole-plant process simulator was used to develop process sizing and predict effluent characteristics, chemical requirements, aeration requirements, and biosolids production for each alternative. Capital and lifecycle costs were developed for each of the alternatives. Additionally, conceptual site plans were developed to assess the feasibility of each alternative with respect to the 32 MGD upgrade and a potential build out capacity of 40 MGD. Opportunities for phased implementation were also considered as a means to defer capital cost.

Of the three alternatives, the process intensification options (CEPT and IFAS) offered some capital cost savings. However, lifecycle costs were similar enough that cost would not be a major differentiator in the final alternative selection. CEPT was eliminated from further consideration as CCWA staff preferred to invest in infrastructure rather than high chemical usage. Given success with Status Quo, CCWA staff had no compelling reason to select IFAS. Therefore, Status Quo was selected as the basis of design. While the design of the expansion will be deferred, the mass balance representing the Status Quo alternative will be used as the basis of design for the solids facility design.

Task 6 TM, Part 1 – W.B. Casey WRRF Biosolids Alternatives Evaluation

The objective of this task was to define an approach for new biosolids facilities at the Casey WRRF. Biosolids management alternatives were first considered with respect to biosolids management goals which included a strong preference for resource recovery. Technologies deemed most compatible with CCWA biosolids management goals included thermal hydrolysis process (THP) in conjunction with anaerobic digestion, anaerobic digestion (mesophilic and thermophilic), and rotary drum drying. The following six process train alternatives including various combinations of these technologies were selected for further evaluation:

- 3a – Mesophilic anaerobic digestion (MAD) with 12-day sludge retention time (SRT) and thermal drying
- 3b – MAD [primary sludge (PS) only] with 12-day SRT and thermal drying
- 3c – MAD with 15-day SRT
- 4a – THP [waste activated sludge (WAS) only] and MAD with 12-day SRT and thermal drying
- 4b – THP and MAD with 12-day SRT
- 5 – Thermophilic anaerobic digestion

Process sizing, capital costs, and lifecycle costs were developed for each alternative. Additionally, non-monetary scoring was used to assess factors not captured in the lifecycle costs. One of the most significant non-monetary considerations was the ability of CCWA to remain in control of how they manage biosolids and reduce exposure to high disposal costs associated with unclassified biosolids.

Lifecycle costs ranged from $129M to $166M with the highest costs associated with alternatives including THP. Non-monetary criteria scores ranged from 51 to 73 with alternatives 3a, 3b, and 5 tied at 73. After consideration of the lifecycle costs and scores, staff agreed that they had a strong preference for thermal drying and continued production of pellets. Alternative 3b was ultimately selected as it was the lowest cost alternative that achieved this objective.

Task 6 TM, Part 2 – W.B. Casey WRRF Biosolids Regionalization Analysis

Early in the biosolids alternatives evaluation, the possibility of processing biosolids from the Northeast Water Reclamation Facility (WRF) was considered to reduce cost. This “regionalization” option was not factored into the initial evaluation as it would not have impacted the technology selection. A follow-on analysis was completed to access regionalization variations of the originally selected alternative (3b). As with the original evaluation, alternatives were compared on the basis of lifecycle cost and non-monetary criteria.

Alternative 3b, the “baseline” was compared to two different regionalization alternatives:

- 3b-1 – Casey drying facility upsized to process all Northeast dewatered cake and excess capacity throughout the lifecycle is used to process non-CCWA biosolids. This alternative included a larger cake receiving facility.

- 3b-2 – Casey drying facility size is identical to the baseline and no non-CCWA cake would be accepted. This alternative included a smaller cake receiving facility.

Lifecycle costs of each alternative were highly sensitive to the cost of unclassified cake disposal which was assumed to fall between $79/WT and $100/WT in year 1 of the lifecycle cost evaluation. At the current unclassified cake disposal rate of $79/WT, regionalization did not have a cost advantage. Additionally, non-monetary scoring did not show a strong inclination towards regionalization. However, at a higher initial unclassified cake disposal rate of $100/WT, both regionalization alternatives 3b-1 and 3b-2 had a lower lifecycle cost that the baseline alternative.

While building larger facilities for alternative 3b-1 would enable CCWA to capture more revenue from non-CCWA cake, the additional capital cost was considered unfavorable favorable. Alternative 3b-1 would have the highest lifecycle cost if the initial cost of unclassified cake disposal were $79/WT, whereas it would have the lowest lifecycle cost if the initial cost of unclassified cake disposal were $100/WT.

Given the uncertainty of unclassified cake disposal rates, CCWA was not inclined to spend additional capital required for alternative 3b-1 since it was not needed to process CCWA biosolids. However, CCWA still preferred having the option to maintain multiple options for biosolids management. CCWA therefore selected the lower cost 3b-2 alternative as the basis of design. Following further design development and refinement of the capital cost, CCWA will decide whether or not to construct the cake receiving station.

Next Steps

A PER will be developed for new biosolids management facilities including primary-only anaerobic digestion, dewatering, cake receiving, and thermal drying.

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Memorandum

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Subject	**Task 1 TM – W.B. Casey WRRF Design Basis**
Project Name	W.B. Casey WRRF Capacity Analysis and Plant Expansion Evaluation
Attention	Clayton County Water Authority (CCWA)
From	Scott Levesque/Jacobs Engineering Group Inc. (Jacobs) Kristina Yanosek/Jacobs
Date	February 3, 2020

1. Introduction

This memorandum presents the influent and effluent design basis for expansion of the W.B. Casey Water Resources Recovery Facility (Casey WRRF) from 24 to 32 million gallons per day (MGD) on a maximum monthly average basis.

A special sampling campaign was performed in April 2019. Objectives of the campaign were to characterize raw wastewater (without recycles), monitor biokinetic transformations in the upstream bioreactor zones, quantify volatile fatty acid (VFA) production in the primary sludge blanket and sludge holding tank, and document solids capture in the dewatering process. Results of the special sampling campaign are included in Attachment 1.

2. Influent Design Basis

Flows currently treated at the Shoal Creek Water Reclamation Facility (SCWRF) will be redirected to Casey WRRF. Therefore, the influent design basis for the Casey WRRF expansion considers flows and characteristics of wastewater arriving at each plant. The design basis does not account for alum sludge from the J.W. Smith Water Treatment Plant (adjacent to SCWRF), which could be directed to Casey WRRF if the Shoal Creek plant were decommissioned prior to the decommissioning of the J.W. Smith Water Treatment plant. This possibility and the timing of such is still under consideration and therefore was disregarded in this analysis.

The influent design basis considers operating data from 2016, 2017, and 2018.

Table 1 presents flow rates and peaking factors for each of the two raw wastewater pump stations delivering flow to Casey WRRF—Casey and Jackson. The Casey pump station also receives plant recycles. For each pump station, pumping rate data at 15-minute intervals were analyzed. At each time step, the two measured pumping rates were added, creating a hypothetical combined pump station. Individual pump station results are used to select design peak flow for each pump station, whereas the combined result is used to select design peak flow for treatment processes downstream of raw wastewater pumping.

Table 1 also shows plant effluent data for Casey WRRF and SCWRF. Effluent flow rates do not include plant recycles, and in most cases, are more accurate than raw wastewater flow measurements, including those that do not include recycles. Each plant's daily effluent flow rate data were analyzed. These results were added to create a hypothetical, combined plant effluent.

Table 1. W.B. Casey WRRF and Shoal Creek WRF Historical Flows and Peaking Factors

Parameter	Casey Pump Station	Jackson Pump Station	Combined Pump Station	Casey Effluent	Shoal Creek Effluent	Combined Effluent
2016						
Flows						
Minimum Hour (MGD)	0.00	0.00	0.00	N/A	N/A	N/A
Minimum Day (MGD)	0.00	0.00	0.00	3.95	0.88	4.83
Minimum Month (MGD)	8.20	2.94	11.80	11.48	1.26	12.74
Annual Average (MGD)	10.53	3.93	14.45	14.49	1.65	16.14
Maximum Month (MGD)	14.17	4.99	19.12	20.34	2.32	22.66
Maximum Day (MGD)	19.82	8.53	28.00	32.96	3.54	36.50
Maximum Hour (MGD)	26.92	15.52	34.96	N/A	N/A	N/A
Peaking Factors (unitless)						
Minimum Hour/Annual Average	0.00	0.00	0.00	N/A	N/A	N/A
Minimum Day/Annual Average	0.00	0.00	0.00	0.27	0.53	0.30
Minimum Month/Annual Average	0.78	0.75	0.82	0.79	0.76	0.79
Maximum Month/Annual Average	1.35	1.27	1.32	1.40	1.41	1.40
Maximum Day/Annual Average	1.88	2.17	1.94	2.27	2.15	2.26
Maximum Hour/Annual Average	2.56	3.95	2.42	N/A	N/A	N/A
2017						
Flows						
Minimum Hour (MGD)	0.00	0.00	4.18	N/A	N/A	N/A
Minimum Day (MGD)	0.00	2.92	6.18	9.21	0.78	9.99
Minimum Month (MGD)	9.41	3.40	13.59	11.90	1.48	13.38
Annual Average (MGD)	11.38	4.54	15.92	13.43	1.61	15.04
Maximum Month (MGD)	13.59	6.00	19.03	15.44	1.78	17.22
Maximum Day (MGD)	25.55	10.60	32.66	27.51	3.80	31.31
Maximum Hour (MGD)	30.08	14.65	38.49	N/A	N/A	N/A
Peaking Factors (unitless)						
Minimum Hour/Annual Average	0.00	0.00	0.26	N/A	N/A	N/A
Minimum Day/Annual Average	0.00	0.64	0.39	0.69	0.48	0.66
Minimum Month/Annual Average	0.83	0.75	0.85	0.89	0.92	0.89
Maximum Month/Annual Average	1.19	1.32	1.20	1.15	1.11	1.14
Maximum Day/Annual Average	2.25	2.33	2.05	2.05	2.36	2.08
Maximum Hour/Annual Average	2.64	3.23	2.42	N/A	N/A	N/A
2018						

Table 1. W.B. Casey WRRF and Shoal Creek WRF Historical Flows and Peaking Factors

Parameter	Casey Pump Station	Jackson Pump Station	Combined Pump Station	Casey Effluent	Shoal Creek Effluent	Combined Effluent
Flows						
Minimum Hour (MGD)	6.81	0.00	9.52	N/A	N/A	N/A
Minimum Day (MGD)	10.03	2.94	13.46	9.09	0.92	10.01
Minimum Month (MGD)	11.52	3.60	15.42	12.00	1.64	13.64
Annual Average (MGD)	13.50	4.79	18.29	14.37	1.96	16.33
Maximum Month (MGD)	16.68	6.43	21.55	19.63	2.72	22.35
Maximum Day (MGD)	27.82	9.37	37.18	34.68	4.15	38.83
Maximum Hour (MGD)	34.25	11.63	43.36	N/A	N/A	N/A
Peaking Factors (unitless)						
Minimum Hour/Annual Average	0.50	0.00	0.52	N/A	N/A	N/A
Minimum Day/Annual Average	0.74	0.61	0.74	0.63	0.47	0.61
Minimum Month/Annual Average	0.85	0.75	0.84	0.84	0.84	0.84
Maximum Month/Annual Average	1.24	1.34	1.18	1.37	1.39	1.37
Maximum Day/Annual Average	2.06	1.96	2.03	2.41	2.12	2.38
Maximum Hour/Annual Average	2.54	2.43	2.37	N/A	N/A	N/A

Notes:

Casey Pump Station includes recycles.

Casey and Jackson Pump Station minimums and maximums do not necessarily coincide, hence additive flows do not equal "combined" flow.

Shoal Creek data through August 20, 2018.

"Combined Effluent" is hypothetical, representing the effluent flow rate if Shoal Creek WRF were transferred to Casey WRRF.

N/A = not available

Tables 2 and 3 show raw wastewater (plus recycles) average concentrations, loads, and load peaking factors for Casey WRRF and SCWRF, respectively. Values are shown for chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), ammonia-nitrogen (NH_3-N), and total phosphorus (TP). At each plant, it appears that high maximum day loads are associated with spikes in recycle streams. Maximum day loads that exceed maximum month load by more than 50 percent are indicated in red.

Table 2. Casey WRRF Historical Raw Wastewater Concentration, Loads, and Load Peaking Factors (Includes Recycles)

Parameter	COD		BOD_5		TSS		NH_3-N		TP	
	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d
2016										
Minimum Day	---	22,019	---	10,350	---	11,735	---	811	---	375
Minimum Month	---	59,415	---	24,795	---	33,711	---	1,945	---	950
Annual Average	583	70,527	244	29,471	381	46,094	17.9	2,163	8.7	1,054

Table 2. Casey WRRF Historical Raw Wastewater Concentration, Loads, and Load Peaking Factors (Includes Recycles)

Parameter	COD		BOD_5		TSS		NH_3-N		TP	
	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d
Maximum Month	---	88,348	---	34,580	---	61,152	---	2,436	---	1,139
Maximum Day	---	206,080	---	86,339	---	195,366	---	3,337	---	3,789
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.31	---	0.35	---	0.25	---	0.37	---	0.36
Minimum Month/Annual Average	---	0.84	---	0.84	---	0.73	---	0.90	---	0.90
Maximum Month/Annual Average	---	1.25	---	1.17	---	1.33	---	1.13	---	1.08
Maximum Day/Annual Average(1)	---	2.92	---	2.93	---	4.24	---	1.54	---	3.59
2017										
Minimum Day	---	48,444	---	15,703	---	15,560	---	1,620	---	300
Minimum Month	---	63,175	---	23,278	---	29,731	---	1,981	---	837
Annual Average	635	71,185	238	26,648	332	37,264	19.9	2,229	8.2	924
Maximum Month	---	88,588	---	30,079	---	46,663	---	2,434	---	1,037
Maximum Day	---	154,042	---	57,163	---	99,826	---	2,888	---	2,640
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.68	---	0.59	---	0.42	---	0.73	---	0.32
Minimum Month/Annual Average	---	0.89	---	0.87	---	0.80	---	0.89	---	0.91
Maximum Month/Annual Average	---	1.24	---	1.13	---	1.25	---	1.09	---	1.12
Maximum Day/Annual Average(1)	---	2.16	---	2.15	---	2.68	---	1.30	---	2.86
2018										
Minimum Day	---	29,738	---	2,183	---	4,961	---	1,578	---	579
Minimum Month	---	50,903	---	22,241	---	24,072	---	1,892	---	792
Annual Average	530	63,503	228	27,363	255	30,630	17.7	2,119	8.0	962
Maximum Month	---	76,935	---	33,611	---	41,790	---	2,349	---	1,202
Maximum Day	---	166,625	---	64,859	---	111,084	---	3,100	---	3,359
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.47	---	0.08	---	0.16	---	0.74	---	0.60
Minimum Month/Annual Average	---	0.80	---	0.81	---	0.79	---	0.89	---	0.82
Maximum Month/Annual Average	---	1.21	---	1.23	---	1.36	---	1.11	---	1.25
Maximum Day/Annual Average(1)	---	2.62	---	2.37	---	3.63	---	1.46	---	3.49

Notes:
(1) Observed high maximum day loads and peaking factors (red values) probably resulted from spikes in the recycles streams.

lb/d = pounds per day

mg/L = milligrams per liter

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Table 3. Shoal Creek WRF Historical Influent Concentration, Loads, and Load Peaking Factors (Includes Recycles)

Parameter	COD		BOD_5		TSS		NH_3-N		TP	
	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d
2016										
Minimum Day	---	3,374	---	1,757	---	757	---	191	---	46
Minimum Month	---	6,064	---	3,045	---	2,973	---	291	---	71
Annual Average	577	7,944	261	3,587	304	4,180	24.5	338	6.0	83
Maximum Month	---	12,220	---	4,538	---	5,171	---	406	---	91
Maximum Day	---	20,444	---	8,904	---	9,001	---	540	---	168
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.42	---	0.49	---	0.18	---	0.57	---	0.55
Minimum Month/Annual Average	---	0.76	---	0.85	---	0.71	---	0.86	---	0.86
Maximum Month/Annual Average	---	1.54	---	1.27	---	1.24	---	1.20	---	1.10
Maximum Day/Annual Average	---	2.57	---	2.48	---	2.15	---	1.60	---	2.03
2017										
Minimum Day	---	3,918	---	1,769	---	1,635	---	202	---	27
Minimum Month	---	6,415	---	2,704	---	2,629	---	321	---	71
Annual Average	621	8,337	240	3,229	253	3,399	27.5	369	5.9	80
Maximum Month	---	9,594	---	3,641	---	3,922	---	403	---	89
Maximum Day	---	19,151	---	5,883	---	8,170	---	551	---	120
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.47	---	0.55	---	0.48	---	0.55	---	0.33
Minimum Month/Annual Average	---	0.77	---	0.84	---	0.77	---	0.87	---	0.88
Maximum Month/Annual Average	---	1.15	---	1.13	---	1.15	---	1.09	---	1.12
Maximum Day/Annual Average	---	2.30	---	1.82	---	2.40	---	1.49	---	1.50
2018										
Minimum Day	---	4,547	---	1,993	---	723	---	217	---	44
Minimum Month	---	8,147	---	3,337	---	2,791	---	305	---	80
Annual Average	573	9,378	234	3,830	249	4,076	24.6	402	5.7	93
Maximum Month	---	11,046	---	4,709	---	5,062	---	542	---	123
Maximum Day	---	15,571	---	6,504	---	7,585	---	622	---	201
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.48	---	0.52	---	0.18	---	0.54	---	0.47
Minimum Month/Annual Average	---	0.87	---	0.87	---	0.68	---	0.76	---	0.86
Maximum Month/Annual Average	---	1.18	---	1.23	---	1.24	---	1.35	---	1.32
Maximum Day/Annual Average	---	1.66	---	1.70	---	1.86	---	1.55	---	2.16

Notes:

Shoal Creek data through August 20, 2018

Observed high maximum day loads and peaking factors (red values) probably resulted from spikes in the recycles streams.

In April 2019, a sampling campaign was conducted at Casey WRRF. During the campaign, raw wastewater samples were collected from the Jackson Pump Station and two manholes at the Casey WRRF. The Casey WRRF manholes included one on the new 60-inch Flint River Outfall and one on the 24-inch Rum Creek pipeline. Sample locations are indicated in Attachment 2. Collectively, these sample locations represent all raw wastewater arriving at the plant without recycles. Table 4 lists average estimated flow and measured concentrations for each of the three sample locations, as well as a theoretical combined sample that excludes recycles. Lastly, the table includes concentrations for samples collected downstream of recycle addition.

Together, the “Combined (Excludes Recycles)” and “Combined (Includes Recycles” columns of Table 4 illustrate the change in wastewater characteristics due to recycles. For COD, BOD_5, TSS, and volatile suspended solids (VSS), dilution by recycles results in lower concentration. For total Kjeldahl nitrogen (TKN) and NH_3-N, there is little change suggesting that raw wastewater and recycles have similar concentrations. For TP, recycles raise the concentration considerably, indicating that the TP concentration is plant recycles is much higher than raw wastewater.

Table 4. Casey WRRF Raw Wastewater Characteristics with and without Recycles based on April 2019 Special Sampling

Parameter	Units	Casey Flint River Outfall Manhole	R.L. Jackson Pump Station	Rum Creek Manhole	Combined (Excludes Recycles)	Combined (Includes Recycles)
Flow	MGD	12.05	3.29	0.70	16.04	---
COD	mg/L	603	493	585	580	556
	lb/d	60,636	13,535	3,417	77,589	---
BOD_5	mg/L	268	215	255	257	239
	lb/d	26,949	5,903	1,490	34,342	---
TSS	mg/L	249	247	304	251	221
	lb/d	25,039	6,781	1,776	33,596	---
VSS	mg/L	227	233	276	230	202
	lb/d	22,826	6,397	1,612	30,836	---
TKN	mg/L	35.0	35.6	41.2	35.4	35.9
	lb/d	3,520	977	241	4,738	---
NH_3-N	mg/L	22.7	26.9	28.4	23.8	24.5
	lb/d	2,283	739	166	3,187	---
TP	mg/L	5.4	4.7	5.7	5.3	9.2
	lb/d	544	128	33	705	---
Alkalinity	mg/L	131	145	156	135	143
	lb/d	13,173	3,981	911	18,065	---
Hydrogen Sulfide	mg/L	0.25	0.25	0.25	0.25	N/A
	lb/d	25	7	1	33	N/A

Notes:
"Combined" is the plant's measured effluent flow rate.
R.L. Jackson Pump Station flow rate was measured.
Rum Creek Manhole flow estimated from upstream pump station flow measurement.
Casey Flint River Outfall Manhole flow rate was determined by difference.
Casey Flint River Outfall Manhole, R.L. Jackson Pump Station, and Rum Creek Manhole samples exclude recycles.
"Combined (Includes Recycles)" sample was collected near the plant's routine raw wastewater sample.

Table 5 is analogous to Table 2 (Casey WRRF) and Table 3 (SCWRF), except that it shows information for a hypothetical combined raw wastewater from the two plants. Based on special sampling results, an adjustment has been made to historical Casey WRRF raw wastewater data to "remove" recycles.[1] Where an observed maximum day load for either plant exceeds the corresponding maximum month loads by more than 50 percent (indicating influence of recycles), it was replaced with this cutoff.

Table 5. Casey WRRF and Shoal Creek WRF Combined Historical Influent Concentrations, Loads, and Load Peaking Factors Adjusted to Exclude Recycles

Parameter	COD		BOD_5		TSS		NH_3-N		TP	
	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d
2016										
Minimum Day	---	26,330	---	12,868	---	14,084	---	979	---	260
Minimum Month	---	68,007	---	29,662	---	41,259	---	2,181	---	614
Annual Average	605	81,471	262	35,224	420	56,529	18.1	2,440	5.1	686
Maximum Month	---	104,326	---	41,659	---	74,621	---	2,773	---	742
Maximum Day	---	156,489	---	62,488	---	111,932	---	3,783	---	1,013
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.32	---	0.37	---	0.25	---	0.40	---	0.38
Minimum Month/Annual Average	---	0.83	---	0.84	---	0.73	---	0.89	---	0.90
Maximum Month/Annual Average	---	1.28	---	1.18	---	1.32	---	1.14	---	1.08
Maximum Day/Annual Average	---	1.92	---	1.77	---	1.98	---	1.55	---	1.48
2017										
Minimum Day	---	54,423	---	18,626	---	19,307	---	1,776	---	198
Minimum Month	---	72,277	---	27,692	---	36,395	---	2,246	---	550
Annual Average	658	82,550	254	31,835	364	45,720	20.2	2,535	4.8	609
Maximum Month	---	101,951	---	35,930	---	56,917	---	2,768	---	683
Maximum Day	---	152,926	---	53,895	---	85,376	---	3,358	---	828
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.66	---	0.59	---	0.42	---	0.70	---	0.33
Minimum Month/Annual Average	---	0.88	---	0.87	---	0.80	---	0.89	---	0.90
Maximum Month/Annual Average	---	1.24	---	1.13	---	1.24	---	1.09	---	1.12
Maximum Day/Annual Average	---	1.85	---	1.69	---	1.87	---	1.32	---	1.36
2018										
Minimum Day	---	35,550	---	4,336	---	6,357	---	1,751	---	375
Minimum Month	---	61,215	---	27,212	---	30,130	---	2,144	---	533
Annual Average	555	75,582	244	33,204	285	38,863	18.1	2,461	4.7	643
Maximum Month	---	91,254	---	40,790	---	52,523	---	2,825	---	811

[1] An analogous adjustment could not be made for SCWRF. However, SCWRF flow is much less than Casey WRRF, making such adjustment less important. Applying the Casey WRFF correction factors to SCWRF is not appropriate because characteristics of recycle streams are expected to be different at the two plants, especially TP concentration.

Table 5. Casey WRRF and Shoal Creek WRF Combined Historical Influent Concentrations, Loads, and Load Peaking Factors Adjusted to Exclude Recycles

Parameter	COD		BOD_5		TSS		NH_3-N		TP	
	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d
Maximum Day	---	135,883	---	60,625	---	78,776	---	3,635	---	1,043
Peaking Factors (unitless)										
Minimum Day/Annual Average	---	0.47	---	0.13	---	0.16	---	0.71	---	0.58
Minimum Month/Annual Average	---	0.81	---	0.82	---	0.78	---	0.87	---	0.83
Maximum Month/Annual Average	---	1.21	---	1.23	---	1.35	---	1.15	---	1.26
Maximum Day/Annual Average	---	1.80	---	1.83	---	2.03	---	1.48	---	1.62

Notes:

Shoal Creek data through 20 August 20, 2018.
Special sampling results (Table 4) used to adjust W.B. Casey average concentrations to remove recycles.
For COD, BOD_5, TSS, and NH_3-N, maximum day loads have been limited to 1.5 times maximum month loads to remove recycles.
For TP, maximum day to maximum month load factor (not shown explicitly) has been limited to corresponding factor for NH_3-N.

Table 6 considers information in the previous tables and presents the overall influent design basis (without recycles) for the Casey WRFF at 32-MGD maximum monthly average flow. From Table 1, information for the "combined pump station" was used to develop hourly flow rate peaking factors, while information for the "combined effluent" was used to develop peaking factors for longer duration flows.

Table 6. Casey WRRF Design Flows, Concentrations, Loads, and Peaking Factors (Excludes Recycles)

	Flow	COD		BOD_5		TSS		NH_3-N		TP	
Parameter	MGD	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d	mg/L	lb/d
Minimum Hour	6.4	---	---	---	---	---	---	---	---	---	---
Minimum Day	12.9	---	59,987	---	18,638	---	20,285	---	2,323	---	429
Minimum Month	20.5	---	104,061	---	43,648	---	55,903	---	3,396	---	875
Annual Average	24.5	606	123,872	253	51,725	356	72,879	18.8	3,843	4.9	999
Maximum Month	32.0	---	153,721	---	61,032	---	95,143	---	4,325	---	1,154
Maximum Day	54.9	---	230,036	---	91,258	---	142,709	---	5,574	---	1,485
Maximum Hour	76.9	---	---	---	---	---	---	---	---	---	---
Peaking Factors (unitless)											
Minimum Hour/Annual Average	0.26	---	---	---	---	---	---	---	---	---	---
Minimum Day/Annual Average	0.53	---	0.48	---	0.36	---	0.28	---	0.60	---	0.43
Minimum Month/Annual Average	0.84	---	0.84	---	0.84	---	0.77	---	0.88	---	0.88
Maximum Month/Annual Average	1.31	---	1.24	---	1.18	---	1.31	---	1.13	---	1.15
Maximum Day/Annual Average	2.24	---	1.86	---	1.76	---	1.96	---	1.45	---	1.49
Maximum Hour/Annual Average	2.40	---	---	---	---	---	---	---	---	---	---

Notes:

Design flow peaking factors based on 2016 to 2018 data (Table 1).

Design average concentrations and load peaking factors based on 2016 to 2018 data for both plants (Table 5).

3. Effluent Design Basis

Georgia Environmental Protection Division has provided a new wasteload allocation (WLA) for increased discharge from Casey WRRF to the Flint River (6.6 to 14.6 MGD) as well as from the Huie Wetlands to tributaries to Blalock Reservoir. Parameters and values, which reflect the effluent requirements for the 32 MGD Casey WRRF (with 14.6 MGD directed to the Flint River) are summarized in Table 7.

The effluent design basis for Casey WRRF is detailed in Table 8. Values are based on the new WLA and expected weekly average limits based on the existing CCWA National Pollutant Discharge Elimination System (NPDES) permit.

For discharge to the Flint River, several parameters had notable decreases relative to the current permit (not shown in Table 8):

- BOD_5 from 8 to 5 milligrams per liter (mg/L)
- NH_3-N from 2.0 to 1.0 mg/L
- Fecal coliform from 200 to 23 most probably number of viable cells in 100 milliliters (MPN/100 mL)

Achieving lower NH_3-N will be addressed in secondary treatment design. Achieving lower BOD_5 will be addressed in secondary treatment design as well as the amount of flow to be treated by the DensaDeg process (which removes particulate BOD_5). Achieving lower fecal coliform will be addressed in ultraviolet (UV) disinfection system design. The UV channel that is being constructed now will be de-rated to achieve higher UV dose, and additional channel(s) will be added.

Table 7. Casey WRRF and Huie Wetlands Wasteload Allocations (provided September 2019)

Parameter	Units	Casey WRRF Discharge to Flint River	Huie Wetlands Discharge to Tributaries to Blalock Reservoir	Notes
Flow Rate	MGD	14.6	17.4	Monthly Average
BOD_5	mg/L	5.0	10	Monthly Average
NH_3-N	mg/L	1.0	0.5 (May-Oct) 1.4 (Nov-Apr)	Monthly Average
Dissolved Oxygen	mg/L	6.0	6.0	Daily Minimum(1)
Total Residual Chlorine	mg/L	0.01	0.01	Daily Maximum
Fecal Coliform	#/100 mL	23	200(2)	
pH	s.u.	6.0-8.5	6.0-8.5	Daily Grab(1)
TP	mg/L	0.3	(3)	Monthly Average
Orthophosphate (as P)	mg/L	Monitor	Monitor	
TKN	mg/L	Monitor	Monitor	
Nitrate + Nitrate (as N)	mg/L	Monitor	Monitor	
Organic Nitrogen	mg/L	Monitor	Monitor	

Notes:

(1) WLA does not state averaging basis. Assumed from existing NPDES permit.

(2) WLA is incorrect. 100/100 mL fecal coliform will be required, matching existing NPDES permit.

(3) Rolling annual average is 0.6 mg/L. A monthly average of 0.38 mg/L is triggered by a TP of 0.15 mg/L at Blalock Reservoir.

Table 8. Casey WRRF Effluent Design Basis

Parameter	Units	To Flint River		To Huie Wetlands		Notes
		Monthly Average	Weekly Average	Monthly Average	Weekly Average	
Flow Rate	MGD	14.6	18.25	17.4	21.75	
BOD_5	mg/L	5.0	7.5	---	---	
TSS	mg/L	15	22.5	---	---	
TP	mg/L	0.3	0.45	0.3(1)	---	
NH_3-N	mg/L	1.0	1.5	---	---	
Fecal Coliform Bacteria	#/100 mL	23	50	100(1)	---	
pH	s.u.	6.0-8.5		---	---	Daily Grab
Dissolved Oxygen	mg/L	6.0		---	---	Daily Minimum

Notes:

(1) Plant target to ensure sufficiently low value leaving wetlands. TP of 0.3 mg/L TP the basis for the aluminum chlorohydrate (ACH) feed system design.

Attachment 1
Special Sampling Campaign Results

Table A.1 - WB Casey WRRF Special Sampling - Influent, Flint River Outfall Manhole Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

Date	TSS				COD										BOD5							COD/BOD5				
	TSS	VSS	ISS	VSS/TSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	(F-FF)/F	VFA	VFA/FF	pCOD/ VSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	FF/F	U (tot.)	F (sol.)	U-F (part.)	FF (truly sol.)	F-FF (coll.)
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L		mg/L	mg/L		mg/L			mg/L	mg/L	mg/L		mg/L	mg/L						
4/2/2019	190	170	20	0.89	599	254	345	0.42	138	116	0.46			2.03	247	131	116	0.53	66	65	0.50	2.43	1.94	2.97	2.09	1.78
4/3/2019	188	168	20	0.89	741	240	501	0.32	139	101	0.42	69	0.49	2.98	260	118	142	0.45	69	49	0.58	2.85	2.03	3.53	2.01	2.06
4/4/2019	340	322	18	0.95	646	252	394	0.39	134	118	0.47			1.22	256	127	129	0.50	59	68	0.46	2.52	1.98	3.05	2.27	1.74
4/5/2019	226	194	32	0.86	613	266	347	0.43	186	---	---	64	---	1.79	303	129	174	0.43	63	---	---	2.02	2.06	1.99	---	---
4/6/2019	232	214	18	0.92	648	242	406	0.37	142	100	0.41			1.90	294	120	174	0.41	64	56	0.53	2.20	2.02	2.33	2.22	1.79
4/7/2019	300	284	16	0.95	536	223	313	0.42	130	93	0.42			1.10	263	121	142	0.46	62	59	0.51	2.04	1.84	2.20	2.10	1.58
4/8/2019	188	182	6	0.97	482	210	272	0.44	110	100	0.48	57	0.52	1.49	212	107	105	0.50	38	69	0.36	2.27	1.96	2.59	2.89	1.45
4/9/2019	214	186	28	0.87	453	165	288	0.36	91	74	0.45			1.55	205	76	129	0.37	36	40	0.47	2.21	2.17	2.23	2.53	1.85
4/10/2019	234	214	20	0.91	658	262	396	0.40	153	109	0.42	90	0.59	1.85	281	135	146	0.48	72	63	0.53	2.34	1.94	2.71	2.13	1.73
4/11/2019	226	198	28	0.88	650	282	368	0.43	157	125	0.44			1.86	302	158	144	0.52	80	78	0.51	2.15	1.78	2.56	1.96	1.60
4/12/2019	244		244		674	280	394	0.42	156	124	0.44	61	0.39		302	119	183	0.39	66	53	0.55	2.23	2.35	2.15	2.36	2.34
4/13/2019	288	266	22	0.92	649	258	391	0.40	136	122	0.47			1.47	335	136	199	0.41	69	67	0.51	1.94	1.90	1.96	1.97	1.82
4/14/2019	214	200	14	0.93	561	246	315	0.44	141	105	0.43			1.58	282	127	155	0.45	57	70	0.45	1.99	1.94	2.03	2.47	1.50
4/15/2019	408	354	54	0.87	536	186	350	0.35	90	96	0.52	94	1.05	0.99	203	91	112	0.45	37	54	0.41	2.64	2.04	3.13	2.43	1.78
4/16/2019																										
Percentile																										
0.00	188	168	6	0.86	453	165	272	0.32	90	74	0.41	57	0.39	0.99	203	76	105	0.37	36	40	0.36	1.94	1.78	1.96	1.96	1.45
0.10	189	172	15	0.87	498	193	296	0.35	95	94	0.42	59	0.43	1.13	207	96	113	0.40	37	50	0.42	2.00	1.86	2.01	1.98	1.52
0.20	204	184	17	0.87	536	218	314	0.37	118	98	0.42	61	0.47	1.32	233	114	124	0.41	46	53	0.46	2.03	1.92	2.10	2.05	1.59
0.30	214	191	18	0.89	559	238	342	0.39	132	100	0.42	62	0.50	1.48	255	119	129	0.42	58	55	0.47	2.14	1.94	2.20	2.09	1.68
0.40	226	197	20	0.89	602	243	348	0.40	136	101	0.44	64	0.51	1.54	261	120	142	0.45	61	58	0.50	2.21	1.95	2.25	2.12	1.73
0.50	**229**	200	20	**0.91**	630	249	359	**0.41**	138	105	**0.44**	66	**0.52**	**1.58**	**272**	124	143	0.45	64	63	0.51	2.22	1.97	2.44	2.22	1.78
0.60	234	214	22	0.92	648	254	386	0.42	139	110	0.45	69	0.55	1.80	282	127	146	0.46	66	65	0.51	2.27	2.01	2.58	2.29	1.78
0.70	248	235	28	0.93	649	258	394	0.43	141	117	0.46	79	0.57	1.85	295	129	157	0.48	67	67	0.52	2.35	2.03	2.74	2.39	1.80
0.80	293	277	30	0.94	653	264	395	0.43	149	120	0.47	90	0.68	1.88	302	133	174	0.50	69	69	0.53	2.46	2.05	3.01	2.46	1.84
0.90	328	314	47	0.95	669	276	403	0.44	155	124	0.48	92	0.86	2.00	303	136	180	0.52	71	70	0.55	2.61	2.14	3.10	2.52	2.02
1.00	408	354	244	0.97	741	282	501	0.44	157	125	0.52	94	1.05	2.98	335	158	199	0.53	80	78	0.58	2.85	2.35	3.53	2.89	2.34
Average	249	227	39	0.91	603	240	363	0.40	132	106	0.45	72	0.61	1.68	268	121	146	0.45	60	61	0.49	2.27	2.00	2.53	2.26	1.77

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.1 (Cont.) - WB Casey WRRF Special Sampling - Influent, Flint River Outfall Manhole Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

	TKN								TP												
Date	U (tot.)	F (sol.)	U-F (part.)	F/U	NH3-N	NH3N/U	F-NH3N (sol. orgN)	NOx-N	U (tot.)	F (sol.)	U-F (part.)	PO4-P	F-PO4P (other sol.)	pTP/ TSS	ALK	pH	Ca	Mg	Fe	temp.	sol. S
	mg/L	mg/L	mg/L		mg/L		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		mg/L	s.u.	mg/L	mg/L	mg/L	Deg. C	mg/L
4/2/2019	37.0	26.7	10.3	0.72	23.00	0.62	3.7		4.88	3.19	1.69	2.05	1.14	0.009	122	6.60	14.3	6.46			0.25
4/3/2019	35.2	30.5	4.7	0.87	21.20	0.60	9.3		6.00	2.94	3.06	1.80	1.14	0.016	100	6.50				19	0.25
4/4/2019	39.7	25.6			23.90	0.60	1.7		5.38	2.81	2.57	2.25	0.56	0.008	128	6.80				20	0.25
4/5/2019	30.3	27.1	3.2	0.89	24.40	0.81	2.7		5.00	2.69	2.31	2.15	0.54	0.010	139	6.60				23	0.25
4/6/2019	41.7				22.70	0.54			5.13	2.94	2.19	1.90	1.04	0.009	135	6.90				20	0.25
4/7/2019	44.3				23.20	0.52			5.50	2.62	2.88	2.00	0.62	0.010	115	6.90				22	0.25
4/8/2019	31.4	19.9	11.5	0.63	19.30	0.61	0.6		5.25	2.38	2.87	1.65	0.73	0.015	119	6.70				19	0.25
4/9/2019	34.8				23.00	0.66		<0.05	6.38	3.56	2.82	2.35	1.21	0.013	135	6.70				21	0.25
4/10/2019	32.7	27.3	5.4	0.83	21.50	0.66	5.8		5.50	2.69	2.81	1.90	0.79	0.012	136	6.70	16.8	6.83	2.53	23	0.25
4/11/2019	32.2				22.80	0.71		<0.05	4.88	2.50	2.38	1.90	0.60	0.011	145	6.80				23	0.25
4/12/2019	38.9	29.5	9.4	0.76	24.50	0.63	5.0		5.13	2.81	2.32	1.85	0.96	0.010	153	7.00				21	0.25
4/13/2019	32.0				24.30	0.76			6.00	3.38	2.62	2.05	1.33	0.009	142	6.90				21	0.25
4/14/2019	30.9				23.20	0.75			5.13	2.63	2.50	2.63	0.00	0.012							
4/15/2019	29.5	21.8	7.7	0.74	20.70	0.70	1.1		5.63	2.31	3.32	2.25	0.06	0.008	122					21	0.25
4/16/2019															139	6.80				21	0.25
Percentile																					
0.00	29.5	19.9	3.2	0.63	19.30	0.52	0.6		4.88	2.31	1.69	1.65	0.00	0.008	100	6.50	14.3	6.5	2.5	19	0.25
0.10	30.5	21.2	4.1	0.69	20.85	0.56	1.0		4.92	2.42	2.23	1.82	0.20	0.008	116	6.60	14.6	6.5	2.5	19	0.25
0.20	31.2	23.3	4.8	0.73	21.38	0.60	1.3		5.08	2.57	2.32	1.88	0.55	0.009	121	6.64	14.8	6.5	2.5	20	0.25
0.30	31.9	25.7	5.3	0.74	22.58	0.61	1.8		5.13	2.63	2.37	1.90	0.60	0.009	122	6.70	15.1	6.6	2.5	21	0.25
0.40	32.3	26.5	6.3	0.75	22.84	0.62	2.5		5.15	2.69	2.51	1.92	0.64	0.010	129	6.70	15.3	6.6	2.5	21	0.25
0.50	**33.8**	26.9	7.7	0.76	23.00	**0.64**	3.2		**5.32**	2.75	2.60	**2.03**	0.76	0.010	**135**	6.80	15.6	6.6	2.5	21	0.25
0.60	35.1	27.1	8.7	0.80	23.16	0.66	4.0		5.48	2.81	2.77	2.05	0.93	0.010	136	6.80	15.8	6.7	2.5	21	0.25
0.70	37.2	27.3	9.6	0.84	23.27	0.70	4.9		5.51	2.94	2.83	2.16	1.05	0.012	139	6.84	16.1	6.7	2.5	21	0.25
0.80	39.2	28.6	10.1	0.86	24.06	0.73	5.5		5.78	3.04	2.87	2.25	1.14	0.012	140	6.90	16.3	6.8	2.5	23	0.25
0.90	41.1	29.8	10.8	0.88	24.37	0.76	6.9		6.00	3.32	3.01	2.32	1.19	0.015	144	6.90	16.6	6.8	2.5	23	0.25
1.00	44.3	30.5	11.5	0.89	24.5	0.81	9.3		6.38	3.56	3.32	2.63	1.33	0.016	153	7.00	16.8	6.8	2.5	23	0.25
Average	35.0	26.1	7.5	0.78	22.7	0.66	3.7		5.41	2.82	2.60	2.05	0.77	0.011	131	6.76	15.6	6.6	2.5	21	0.25

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.2 - WB Casey WRRF Special Sampling - Influent, Jackson Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

Date	TSS				COD										BOD5							COD/BOD5				
	TSS	VSS	ISS	VSS/TSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	(F-FF)/F	VFA	VFA/FF	pCOD/ VSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	FF/F	U (tot.)	F (sol.)	U-F (part.)	FF (truly sol.)	F-FF (coll.)
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L		mg/L	mg/L		mg/L			mg/L	mg/L	mg/L		mg/L	mg/L						
4/2/2019	378	348	30	0.92	628	148	480	0.24	60	88	0.59			1.38	265	76	189	0.29	29	47	0.38	2.37	1.95	2.54	2.07	1.87
4/3/2019	256	238	18	0.93	520	158	362	0.30	60	98	0.62	32	0.53	1.52	247	76	171	0.31	26	50	0.34	2.11	2.08	2.12	2.31	1.96
4/4/2019	276	266	10	0.96	520	174	346	0.33	44	130	0.75			1.30	215	74	141	0.34	22	52	0.30	2.42	2.35	2.45	2.00	2.50
4/5/2019	236	218	18	0.92	530	189	341	0.36	126	---	---	105	---	1.56	251	69	182	0.27	23	---	---	2.11	2.74	1.87	---	---
4/6/2019	230	222	8	0.97	489	147	342	0.30	55	92	0.63			1.54	239	69	170	0.29	25	44	0.36	2.05	2.13	2.01	2.20	2.09
4/7/2019	212	208	4	0.98	455	150	305	0.33	56	94	0.63			1.47	215	72	143	0.33	26	46	0.36	2.12	2.08	2.13	2.15	2.04
4/8/2019	162	152	10	0.94	480	168	312	0.35	54	114	0.68	67	1.23	2.05	182	75	107	0.41	22	53	0.29	2.64	2.24	2.92	2.45	2.15
4/9/2019	234	232	2	0.99	414	131	283	0.32	42	89	0.68			1.22	179	67	112	0.37	18	49	0.27	2.31	1.96	2.53	2.33	1.82
4/10/2019	200	182	18	0.91	452	148	304	0.33	41	107	0.72	105	2.57	1.67	198	66	132	0.33	16	50	0.24	2.28	2.24	2.30	2.56	2.14
4/11/2019	228	224	4	0.98	431	146	285	0.34	43	103	0.71			1.27	189	65	124	0.34	15	50	0.23	2.28	2.25	2.30	2.87	2.06
4/12/2019	288	262	26	0.91	516	154	362	0.30	49	105	0.68	91	1.85	1.38	241	89	152	0.37	56	33	0.63	2.14	1.73	2.38	0.88	3.18
4/13/2019	322	304	18	0.94	534	137	397	0.26	38	99	0.72			1.31	214	65	149	0.30	14	51	0.22	2.50	2.11	2.66	2.71	1.94
4/14/2019	246	232	14	0.94	515	165	350	0.32	50	115	0.70			1.51	203	73	130	0.36	18	55	0.25	2.54	2.26	2.69	2.78	2.09
4/15/2019	190	176	14	0.93	418	155	263	0.37	45	110	0.71	108	2.40	1.49	167	58	109	0.35	13	45	0.22	2.50	2.67	2.41	3.46	2.44
4/16/2019																										
Percentile																										
0.00	162	152	2	0.91	414	131	263	0.24	38	88	0.59	32	0.53	1.22	167	58	107	0.27	13	33	0.22	2.05	1.73	1.87	0.88	1.82
0.10	193	178	4	0.91	422	140	284	0.27	41	90	0.62	49	0.81	1.28	180	65	110	0.29	14	44	0.23	2.11	1.95	2.04	2.01	1.89
0.20	207	198	6	0.92	444	147	296	0.30	42	93	0.63	67	1.09	1.30	186	66	119	0.30	15	45	0.24	2.11	2.03	2.13	2.10	1.95
0.30	226	217	10	0.93	455	148	305	0.30	44	96	0.66	79	1.36	1.37	197	67	129	0.31	17	47	0.24	2.14	2.08	2.28	2.18	2.01
0.40	231	222	11	0.93	482	148	318	0.32	45	99	0.68	91	1.60	1.40	205	69	134	0.33	18	49	0.26	2.28	2.11	2.32	2.29	2.06
0.50	**235**	228	14	**0.94**	502	152	342	**0.32**	49	103	**0.68**	98	**1.85**	**1.48**	**215**	71	142	0.34	22	50	0.29	2.30	2.19	2.40	2.33	2.09
0.60	244	232	17	0.94	516	155	345	0.33	51	105	0.70	105	2.07	1.51	215	73	148	0.34	23	50	0.31	2.36	2.24	2.45	2.48	2.10
0.70	258	240	18	0.96	520	159	351	0.34	54	108	0.71	105	2.29	1.52	239	74	154	0.35	25	50	0.35	2.43	2.25	2.53	2.62	2.14
0.80	281	264	18	0.97	524	166	362	0.34	56	112	0.72	105	2.43	1.55	243	75	170	0.36	26	52	0.36	2.50	2.30	2.59	2.75	2.33
0.90	312	293	24	0.98	533	172	387	0.35	59	115	0.72	107	2.50	1.64	250	76	179	0.37	28	53	0.38	2.53	2.58	2.68	2.85	2.49
1.00	378	348	30	0.99	628	189	480	0.37	60	130	0.75	108	2.57	2.05	265	89	189	0.41	56	55	0.63	2.64	2.74	2.92	3.46	3.18
Average	247	233	14	0.94	493	155	338	0.32	49	103	0.68	85	1.72	1.48	215	71	144	0.33	23	48	0.31	2.31	2.20	2.38	2.37	2.18

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.2 (Cont.) - WB Casey WRRF Special Sampling - Influent, Jackson Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

	TKN								TP												
Date	**U (tot.)**	**F (sol.)**	**U-F (part.)**	**F/U**	**NH3-N**	**NH3N/U**	**F-NH3N (sol. orgN)**	**NOx-N**	**U (tot.)**	**F (sol.)**	**U-F (part.)**	**PO4-P**	**F-PO4P (other sol.)**	**pTP/ TSS**	**ALK**	**pH**	**Ca**	**Mg**	**Fe**	**temp.**	**sol. S**
	mg/L	**mg/L**	**mg/L**		**mg/L**		**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**		**mg/L**	**s.u.**	**mg/L**	**mg/L**	**mg/L**	**Deg. C**	**mg/L**
4/2/2019	34.8	27.1	7.7	0.78	27.70	0.80	-0.60		5.38	2.62	2.76	2.00	0.62	0.007	141	6.82	10	<5			0.25
4/3/2019	36.0	25.2	10.8	0.70	24.50	0.68	0.70		5.00	2.31	2.69	1.90	0.41	0.011	122	6.93				24	0.25
4/4/2019	11.7	25.5	---	---	25.40	2.17	0.10		5.13	2.38	2.75	2.20	0.18	0.010	154	6.81				20	0.25
4/5/2019	31.1	24.8	6.3	0.80	27.40	0.88	-2.60		5.00	2.31	2.69	2.00	0.31	0.011	205	6.65				21	0.5
4/6/2019	37.3				26.30	0.71			4.88	2.50	2.38	1.85	0.65	0.010	137	6.68				20	0.25
4/7/2019	36.6				25.80	0.70			4.13	2.44	1.69	1.85	0.59	0.008	120	6.73				21	0.25
4/8/2019	39.4	25.3	14.1	0.64	22.80	0.58	2.50		4.50	2.44	2.06	1.80	0.64	0.013	132	6.64				21	0.25
4/9/2019	38.4				29.00	0.76		<0.05	5.25	2.75	2.50	1.65	1.10	0.011	130	6.80				20	0.25
4/10/2019	35.0	26.7	8.3	0.76	26.40	0.75	0.30		3.75	2.31	1.44	1.70	0.61	0.007	181	6.54	12.2	<5	1.10	22	0.25
4/11/2019	41.7				28.00	0.67		<0.05	4.50	2.94	1.56	1.80	1.14	0.007	134	6.58				22	0.25
4/12/2019	39.4	27.5	11.9	0.70	29.40	0.75	-1.90		4.38	2.19	2.19	1.85	0.34	0.008	145	6.83				24	0.25
4/13/2019	28.3				31.10	1.10			4.75	2.50	2.25	1.90	0.60	0.007	136	6.81				21	0.25
4/14/2019	30.5				29.80	0.98			4.50	2.69	1.81	2.05	0.64	0.007							
4/15/2019	34.8	22.0	12.8	0.63	22.70	0.65	-0.70		3.88	2.81	1.07	1.75	1.06	0.006	142	6.53				17	0.25
4/16/2019															144	6.64				23	0.25
Percentile																					
0.00	28.3	22.0	6.3	0.63	22.7	0.58	-2.60		3.75	2.19	1.07	1.65	0.18	0.006	120	6.53	10.00			17	0.25
0.10	30.6	24.0	7.1	0.64	23.3	0.66	-2.11		3.96	2.31	1.48	1.72	0.32	0.007	124	6.55	10.22			20	0.25
0.20	32.6	25.0	7.8	0.65	25.0	0.68	-1.42		4.28	2.31	1.64	1.78	0.38	0.007	131	6.62	10.44			20	0.25
0.30	34.8	25.2	8.2	0.69	25.8	0.70	-0.69		4.49	2.37	1.80	1.80	0.57	0.007	134	6.64	10.66			21	0.25
0.40	35.0	25.3	9.3	0.70	26.3	0.71	-0.62		4.50	2.44	2.09	1.85	0.60	0.007	136	6.66	10.88			21	0.25
0.50	**36.0**	25.4	10.8	0.70	26.9	**0.75**	-0.25		**4.63**	2.47	2.22	**1.85**	0.62	0.008	**139**	6.71	11.10			21	0.25
0.60	36.7	25.7	11.5	0.74	27.6	0.76	0.14		4.85	2.50	2.35	1.89	0.64	0.010	142	6.79	11.32			21	0.25
0.70	37.7	26.6	12.1	0.77	28.1	0.80	0.28		5.00	2.63	2.52	1.91	0.64	0.010	144	6.81	11.54			22	0.25
0.80	39.0	26.9	12.6	0.78	29.2	0.92	0.54		5.05	2.71	2.69	2.00	0.81	0.011	149	6.81	11.76			23	0.25
0.90	39.4	27.2	13.3	0.79	29.7	1.06	1.24		5.21	2.79	2.73	2.04	1.09	0.011	173	6.83	11.98			24	0.25
1.00	41.7	27.5	14.1	0.80	31.1	2.17	2.50		5.38	2.94	2.76	2.20	1.14	0.013	205	6.93	12.20			24	0.5
Average	35.6	25.5	10.3	0.72	26.9	0.87	-0.27		4.65	2.51	2.13	1.88	0.64	0.009	145	6.71	11.10	#DIV/0!	1.1	21	0.267857

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.3 - WB Casey WRRF Special Sampling - Influent, Rum Creek Manhole Sample Location
Design Basis for 32 MGD W.B. Casey WRRF Expansion

	TSS				COD										BOD5							COD/BOD5				
Date	TSS	VSS	ISS	VSS/TSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	(F-FF)/F	VFA	VFA/FF	pCOD/ VSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	FF/F	U (tot.)	F (sol.)	U-F (part.)	FF (truly sol.)	F-FF (coll.)
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L		mg/L	mg/L		mg/L			mg/L	mg/L	mg/L		mg/L	mg/L						
4/2/2019	288	222	66	0.77	605	155	450	0.26	81	74	0.48			2.03	245	80	165	0.33	40	40	0.50	2.47	1.94	2.73	2.03	1.85
4/3/2019	354	324	30	0.92	641	162	479	0.25	67	95	0.59	31	0.46	1.48	281	72	209	0.26	37	35	0.51	2.28	2.25	2.29	1.81	2.71
4/4/2019	358				694	155	539	0.22	71	84	0.54				257	79	178	0.31	34	45	0.43	2.70	1.96	3.03	2.09	1.87
4/5/2019	360	328	32	0.91	513	209	304	0.41	117	---	---	17	---	0.93	324	89	235	0.27	41	---	---	1.58	2.35	1.29	---	---
4/6/2019	356	330	26	0.93	678	173	505	0.26	82	91	0.53			1.53	278	71	207	0.26	47	24	0.66	2.44	2.44	2.44	1.74	3.79
4/7/2019	270	256	14	0.95	558	184	374	0.33	84	100	0.54			1.46	245	92	153	0.38	46	46	0.50	2.28	2.00	2.44	1.83	2.17
4/8/2019	332	308	24	0.93	697	204	493	0.29	76	128	0.63	32	0.42	1.60	290	94	196	0.32	41	53	0.44	2.40	2.17	2.52	1.85	2.42
4/9/2019	364	356	8	0.98	660	157	503	0.24	20	137	0.87			1.41	267	88	179	0.33	41	47	0.47	2.47	1.78	2.81	0.49	2.91
4/10/2019	254	232	22	0.91	531	198	333	0.37	61	137	0.69	25	0.41	1.44	252	72	180	0.29	33	39	0.46	2.11	2.75	1.85	1.85	3.51
4/11/2019	302	284	18	0.94	533	142	391	0.27	60	82	0.58			1.38	225	73	152	0.32	34	39	0.47	2.37	1.95	2.57	1.76	2.10
4/12/2019	218	204	14	0.94	481	179	302	0.37	76	103	0.58	51	0.67	1.48	227	83	144	0.37	41	42	0.49	2.12	2.16	2.10	1.85	2.45
4/13/2019	274	254	20	0.93	575	190	385	0.33	80	110	0.58			1.52	242	77	165	0.32	35	42	0.45	2.38	2.47	2.33	2.29	2.62
4/14/2019	286	262	24	0.92	540	171	369	0.32	74	97	0.57			1.41	217	79	138	0.36	32	47	0.41	2.49	2.16	2.67	2.31	2.06
4/15/2019	244	222	22	0.91	489	172	317	0.35	69	103	0.60	38	0.55	1.43	221	75	146	0.34	32	43	0.43	2.21	2.29	2.17	2.16	2.40
4/16/2019																										
Percentile																										
0.00	218	204	8	0.77	481	142	302	0.22	20	74	0.48	17	0.41	0.93	217	71	138	0.26	32	24	0.41	1.58	1.78	1.29	0.49	1.85
0.10	247	222	14	0.91	496	155	308	0.24	60	82	0.53	21	0.42	1.38	222	72	145	0.26	32	36	0.43	2.11	1.94	1.92	1.75	1.91
0.20	264	226	16	0.91	524	156	327	0.25	63	87	0.54	25	0.42	1.41	226	73	150	0.28	33	39	0.43	2.18	1.96	2.14	1.78	2.08
0.30	274	245	19	0.91	533	162	365	0.26	68	93	0.56	28	0.43	1.42	241	75	153	0.31	34	40	0.45	2.27	2.00	2.28	1.82	2.15
0.40	286	256	22	0.92	544	171	376	0.27	71	97	0.57	31	0.44	1.43	245	77	165	0.32	35	42	0.46	2.30	2.16	2.35	1.84	2.35
0.50	**295**	262	22	**0.93**	567	173	388	**0.30**	74	100	**0.58**	31	**0.46**	**1.46**	**249**	79	172	0.32	37	42	0.47	2.37	2.17	2.44	1.85	2.42
0.60	326	289	24	0.93	599	178	438	0.33	76	103	0.58	32	0.49	1.48	256	80	179	0.33	40	43	0.47	2.40	2.23	2.50	1.89	2.49
0.70	354	314	25	0.93	643	185	480	0.33	78	106	0.59	35	0.53	1.49	268	84	182	0.33	41	45	0.50	2.44	2.30	2.58	2.05	2.66
0.80	357	326	28	0.94	667	193	497	0.36	81	121	0.62	38	0.57	1.52	279	88	200	0.35	41	47	0.50	2.47	2.38	2.70	2.13	2.83
0.90	359	330	32	0.95	689	202	504	0.37	82	135	0.68	44	0.62	1.59	287	91	208	0.37	45	47	0.51	2.48	2.46	2.79	2.26	3.39
1.00	364	356	66	0.98	697	209	539	0.41	84	137	0.87	51	0.67	2.03	324	94	235	0.38	47	53	0.66	2.70	2.75	3.03	2.31	3.79
Average	304	276	25	0.92	585	175	410	0.30	69	103	0.60	32	0.50	1.47	255	80	175	0.32	38	42	0.48	2.31	2.19	2.37	1.85	2.53

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.3 (Cont.) - WB Casey WRRF Special Sampling - Influent, Rum Creek Manhole Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

	TKN								TP												
Date	**U (tot.)**	**F (sol.)**	**U-F (part.)**	**F/U**	**NH3-N**	**NH3N/U**	**F-NH3N (sol. orgN)**	**NOx-N**	**U (tot.)**	**F (sol.)**	**U-F (part.)**	**PO4-P**	**F-PO4P (other sol.)**	**pTP/ TSS**	**ALK**	**pH**	**Ca**	**Mg**	**Fe**	**temp.**	**sol. S**
	mg/L	**mg/L**	**mg/L**		**mg/L**		**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**		**mg/L**	**s.u.**	**mg/L**	**mg/L**	**mg/L**	**Deg. C**	**mg/L**
4/2/2019	35.8	29.8	6.0	0.83	27.0	0.75	2.80		5.88	3.00	2.88	2.20	0.80	0.010	154	7.40	9.7	12.6	1.59		0.25
4/3/2019	40.0	26.3	13.7	0.66	26.4	0.66	-0.10		6.00	2.88	3.12	2.15	0.73	0.009	170	7.20				20	0.25
4/4/2019	39.6	27.2	12.4	0.69	28.0	0.71	-0.80		6.25	2.63	3.62	2.45	0.18	0.010	143	7.35				20	0.25
4/5/2019	41.5	23.1	18.4	0.56	28.3	0.68	-5.20		6.00	2.75	3.25	2.55	0.20	0.009	156					20	0.25
4/6/2019	40.1				27.8	0.69			6.88	3.19	3.69	2.40	0.79	0.010	151	7.30				21	0.25
4/7/2019	49.4				29.6	0.60			5.88	3.06	2.82	2.50	0.56	0.010	132	7.12				21	0.25
4/8/2019	41.0	23.7	17.3	0.58	25.6	0.62	-1.90		6.00	2.69	3.31	2.00	0.69	0.010	141	7.03				19	0.25
4/9/2019	51.6				28.1	0.54		<0.05	6.38	3.31	3.07	2.15	1.16	0.008	147	7.20				20	0.25
4/10/2019	40.8	28.4	12.4	0.70	26.6	0.65	1.80		5.25	2.56	2.69	2.10	0.46	0.011	152	7.28	12.6	16.8	1.59	21	0.25
4/11/2019	37.9				29.6	0.78		<0.05	5.13	2.69	2.44	2.10	0.59	0.008	155	7.40				21	0.25
4/12/2019	46.1	32.4	13.7	0.70	32.5	0.70	-0.10		4.88	2.88	2.00	2.00	0.88	0.009		7.47				22	0.25
4/13/2019	38.0				31.4	0.83			5.75	3.06	2.69	2.25	0.81	0.010	178	7.53				21	0.25
4/14/2019	42.4				31.2	0.74			4.13	3.13	1.00	2.35	0.78	0.003							
4/15/2019	32.4	28.0	4.4	0.86	25.2	0.78	2.80		4.75	2.75	2.00	2.05	0.70	0.008	186	7.52				19	0.25
4/16/2019															158	7.42				21	0.25
Percentile																					
0.00	32.4	23.1	4.4	0.56	25.2	0.54	-5.20		4.13	2.56	1.00	2.00	0.18	0.003	132	7.03	9.7	12.6	1.6	19	0.25
0.10	36.4	23.5	5.5	0.57	25.8	0.61	-2.89		4.79	2.65	2.00	2.02	0.28	0.008	141	7.14	10.0	13.0	1.6	19	0.25
0.20	38.0	24.7	8.6	0.61	26.5	0.64	-1.46		5.03	2.69	2.26	2.08	0.52	0.008	145	7.20	10.2	13.4	1.6	20	0.25
0.30	39.4	26.4	12.4	0.66	27.0	0.66	-0.73		5.24	2.74	2.67	2.10	0.59	0.009	149	7.25	10.5	13.9	1.6	20	0.25
0.40	40.0	27.0	12.4	0.68	27.8	0.68	-0.24		5.78	2.78	2.72	2.15	0.69	0.009	152	7.30	10.8	14.3	1.6	20	0.25
0.50	**40.5**	27.6	13.1	0.69	28.1	**0.70**	-0.10		**5.88**	2.88	2.85	**2.18**	0.72	0.009	**154**	7.35	11.1	14.7	1.6	21	0.25
0.60	41.0	28.1	13.7	0.70	28.3	0.71	0.28		5.98	2.98	3.03	2.24	0.77	0.010	155	7.40	11.4	15.1	1.6	21	0.25
0.70	41.6	28.4	13.7	0.70	29.6	0.74	1.61		6.00	3.06	3.13	2.36	0.79	0.010	157	7.41	11.7	15.5	1.6	21	0.25
0.80	43.9	29.2	15.9	0.78	30.2	0.76	2.40		6.10	3.09	3.27	2.42	0.80	0.010	165	7.45	12.0	16.0	1.6	21	0.25
0.90	48.4	30.6	17.6	0.84	31.3	0.78	2.80		6.34	3.17	3.53	2.49	0.86	0.010	176	7.51	12.3	16.4	1.6	21	0.25
1.00	51.6	32.4	18.4	0.86	32.5	0.83	2.80		6.88	3.31	3.69	2.55	1.16	0.011	186	7.53	12.6	16.8	1.6	22	0.25
Average	41.2	27.4	12.3	0.70	28.4	0.70	-0.09		5.65	2.90	2.76	2.23	0.67	0.009	156	7.32	11.1	14.7	1.6	20	0.25

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.4 - WB Casey WRRF Special Sampling - Primary Influent Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

Date	TSS				COD										BOD5							COD/BOD5				
	TSS	VSS	ISS	VSS/TSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	(F-FF)/F	VFA	VFA/FF	pCOD/ VSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	FF/F	U (tot.)	F (sol.)	U-F (part.)	FF (truly sol.)	F-FF (coll.)
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L		mg/L	mg/L		mg/L			mg/L	mg/L	mg/L		mg/L	mg/L						
4/2/2019	218	182	36	0.83	601	213	388	0.35	119	94	0.44			2.13	246	109	137	0.44	59	50	0.54	2.44	1.95	2.83	2.02	1.88
4/3/2019	234	216	18	0.92	611	231	380	0.38	144	87	0.38			1.76	254	120	134	0.47	76	44	0.63	2.41	1.93	2.84	1.89	1.98
4/4/2019	226	218	8	0.96	576	196	380	0.34	99	97	0.49			1.74	212	95	117	0.45	45	50	0.47	2.72	2.06	3.25	2.20	1.94
4/5/2019	224	204	20	0.91	643	295	348	0.46	187	---	---			1.71	272	127	145	0.47	62	---	---	2.36	2.32	2.40	---	---
4/6/2019	234	216	18	0.92	572	234	338	0.41	140	94	0.40			1.56	269	127	142	0.47	60	67	0.47	2.13	1.84	2.38	2.33	1.40
4/7/2019	230	208	22	0.90	533	195	338	0.37	115	80	0.41			1.63	243	105	138	0.43	59	46	0.56	2.19	1.86	2.45	1.95	1.74
4/8/2019	216	200	16	0.93	511	174	337	0.34	86	88	0.51			1.69	209	89	120	0.43	38	51	0.43	2.44	1.96	2.81	2.26	1.73
4/9/2019	214	198	16	0.93	471	192	279	0.41	100	92	0.48			1.41	228	104	124	0.46	45	59	0.43	2.07	1.85	2.25	2.22	1.56
4/10/2019	232	214	18	0.92	489	158	331	0.32	88	70	0.44			1.55	235	72	163	0.31	39	33	0.54	2.08	2.19	2.03	2.26	2.12
4/11/2019	214	194	20	0.91	632	218	414	0.34	127	91	0.42			2.13	261	124	137	0.48	65	59	0.52	2.42	1.76	3.02	1.95	1.54
4/12/2019	214	194	20	0.91	536	220	316	0.41	157	63	0.29			1.63	209	~~22~~	---	---	65	---	---	2.56	---	1.69	2.42	---
4/13/2019	224	210	14	0.94	594	222	372	0.37	123	99	0.45			1.77	265	108	157	0.41	66	42	0.61	2.24	2.06	2.37	1.86	2.36
4/14/2019	214	194	20	0.91	543	207	336	0.38	120	87	0.42			1.73	242	112	130	0.46	53	59	0.47	2.24	1.85	2.58	2.26	1.47
4/15/2019	202	178	24	0.88	478	183	295	0.38	92	91	0.50			1.66	196	83	113	0.42	36	47	0.43	2.44	2.20	2.61	2.56	1.94
4/16/2019																										
5/6/2019												78														
5/8/2019												63														
5/14/2019												107														
5/15/2019												55														
5/17/2019												28														
Percentile																										
0.00	202	178	8	0.83	471	158	279	0.32	86	63	0.29	28		1.41	196	72	113	0.31	36	33	0.43	2.07	1.76	1.69	1.86	1.40
0.10	214	186	15	0.89	481	177	301	0.34	89	72	0.38	39		1.55	209	84	118	0.41	38	42	0.43	2.09	1.84	2.10	1.91	1.48
0.20	214	194	16	0.91	502	188	325	0.34	95	83	0.41	50		1.60	211	91	122	0.42	41	44	0.44	2.17	1.85	2.32	1.95	1.55
0.30	214	194	18	0.91	531	195	336	0.35	100	87	0.41	57		1.63	226	100	128	0.43	45	46	0.47	2.24	1.85	2.38	1.99	1.61
0.40	216	198	18	0.91	537	198	337	0.37	112	88	0.42	60		1.66	236	105	133	0.44	51	48	0.47	2.27	1.91	2.41	2.16	1.73
0.50	**221**	202	19	**0.92**	558	210	338	**0.38**	119	91	**0.44**	63		**1.70**	**243**	108	137	0.45	59	50	0.50	2.38	1.95	2.52	2.22	1.81
0.60	224	207	20	0.92	575	217	346	0.38	121	91	0.44	69		1.73	245	110	137	0.46	59	51	0.53	2.42	1.98	2.61	2.26	1.91
0.70	226	210	20	0.92	595	220	373	0.39	125	93	0.46	75		1.74	255	115	140	0.46	62	57	0.54	2.44	2.06	2.81	2.26	1.94
0.80	231	215	21	0.93	605	226	380	0.41	135	94	0.49	84		1.76	263	122	144	0.47	65	59	0.56	2.44	2.14	2.83	2.31	1.97
0.90	233	216	23	0.93	626	233	386	0.41	143	96	0.50	95		2.02	268	126	155	0.47	66	59	0.61	2.53	2.20	2.97	2.40	2.11
1.00	234	218	36	0.96	643	295	414	0.46	157	99	0.51	107		2.13	272	127	163	0.48	76	67	0.63	2.72	2.32	3.25	2.56	2.36
Average	221	202	19	0.91	556	210	347	0.38	116	87	0.43	66		1.72	239	106	135	0.44	54	51	0.51	2.34	1.99	2.54	2.17	1.80

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.4 - WB Table A.4 (Cont.) - WB Casey WRRF Special Sampling - Primary Influent Sample Location

Design Basis f Design Basis for 32 MGD W.B. Casey WRRF Expansion

Date	Date	TKN (mg/L) U (tot.)	NH3-N	NH3N/U	TP (mg/L) U (tot.)	PO4-P	ALK	pH
		mg/L	mg/L		mg/L	mg/L	mg/L	mg/L
4/2/2019	4/2/2019	36.3			8.50	4.8		
4/3/2019	4/3/2019	42.0	29.5	0.70	10.00			
4/4/2019	4/4/2019	36.0	22.6	0.63	9.63	7.6	141	6.9
4/5/2019	4/5/2019	36.3	24.7	0.68	10.00		177	6.8
4/6/2019	4/6/2019	36.0			10.25		133	6.8
4/7/2019	4/7/2019	33.1			8.63		115	6.7
4/8/2019	4/8/2019	34.2	20.2	0.59	7.75	4.0	134	6.7
4/9/2019	4/9/2019	33.8	21.5	0.64	10.75	4.7	155	6.9
4/10/2019	4/10/2019	29.1	20.8	0.71	8.75	4.4	131	6.8
4/11/2019	4/11/2019	40.0	29.2	0.73	9.00	4.5	150	6.8
4/12/2019	4/12/2019	45.1	27.7	0.61	8.75	5.2	149	6.9
4/13/2019	4/13/2019	31.2	26.8	0.86	9.88	5.4	136	6.9
4/14/2019	4/14/2019	38.7	24.5	0.63	9.25	5.4		
4/15/2019	4/15/2019	30.8	21.9	0.71	7.63	4.7	138	6.7
4/16/2019	4/16/2019						160	6.8
5/6/2019	5/6/2019							
5/8/2019	5/8/2019							
5/14/2019	5/14/2019							
5/15/2019	5/15/2019							
5/17/2019	5/17/2019							
Percentile	**Percentile**							
0.00	0.00	29.1	20.2	0.59	7.63	4.0	115	6.7
0.10	0.10	30.9	20.8	0.61	7.98	4.4	131	6.7
0.20	0.20	32.3	21.5	0.63	8.58	4.5	133	6.7
0.30	0.30	33.7	21.9	0.63	8.74	4.6	135	6.8
0.40	0.40	34.6	22.6	0.64	8.80	4.7	137	6.8
0.50	0.50	**36.0**	24.5	**0.68**	**9.13**	**4.8**	**140**	6.8
0.60	0.60	36.2	24.7	0.70	9.55	5.0	146	6.8
0.70	0.70	36.5	26.8	0.71	9.89	5.3	150	6.9
0.80	0.80	39.2	27.7	0.71	10.00	5.4	154	6.9
0.90	0.90	41.4	29.2	0.73	10.18	5.6	160	6.9
1.00	1.00	45.1	29.5	0.86	10.75	7.6	177	6.9
Average	**Average**	35.9	24.5	0.68	9.20	5.1	143	6.8

TSS = Total sus TSS = Total suspended solids
VSS = Volatile s VSS = Volatile suspended solids
ISS = Inorganic ISS = Inorganic suspended solids
COD = Chemica COD = Chemical oxygen demand
pCOD = Particu pCOD = Particulate COD
BOD = Biologic BOD = Biological oxygen demand
U = Unfiltered (U = Unfiltered (Total)
F = Filtered frac F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulat U-F = Particulate fraction
FF = "Truly" sol FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal parti
F-FF = Colloidal F-FF = Colloidal fraction
VFA = Volatile f VFA = Volatile fatty acids
TKN = Total kje TKN = Total kjeldahl nitrogen
NH3-N = Ammo NH3-N = Ammonia as nitrogen
NOx-N = Nitrog NOx-N = Nitrogen oxides
TP = Total phos TP = Total phosphorus
PO4-P = Ortho PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity Alk = Alkalinity
Ca = Calcium, N Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.5 - WB Casey WRRF Special Sampling - Primary Effluent Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

Date	TSS				COD										BOD5							COD/BOD5				
	TSS	VSS	ISS	VSS/TSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	(F-FF)/F	VFA	VFA/FF	pCOD/ VSS	U (tot.)	F (sol. + coll.)	U-F (part.)	F/U	FF (truly sol.)	F-FF (coll.)	FF/F	U (tot.)	F (sol.)	U-F (part.)	FF (truly sol.)	F-FF (coll.)
	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L		mg/L	mg/L		mg/L			mg/L	mg/L	mg/L		mg/L	mg/L						
4/2/2019	130	98	32	0.75	402	196	206	0.49	110	86	0.44			2.10	175	99	76	0.57	51	48	0.52	2.30	1.98	2.71	2.16	1.79
4/3/2019	102	94	8	0.92	408	214	194	0.52	140	74	0.35			2.06	202	116	86	0.57	74	42	0.64	2.02	1.84	2.26	1.89	1.76
4/4/2019	104	90	14	0.87	402	228	174	0.57	127	101	0.44			1.93	185	122	63	0.66	59	63	0.48	2.17	1.87	2.76	2.15	1.60
4/5/2019	94	84	10	0.89	399	266	133	0.67	177	---	---			1.58	185	110	75	0.59	55	---	---	2.16	2.42	1.77	---	---
4/6/2019	108	96	12	0.89	395	209	186	0.53	133	76	0.36			1.94	190	100	90	0.53	67	33	0.67	2.08	2.09	2.07	1.99	2.30
4/7/2019	96	94	2	0.98	356	201	155	0.56	106	95	0.47			1.65	191	109	82	0.57	55	54	0.50	1.86	1.84	1.89	1.93	1.76
4/8/2019	126	114	12	0.90	362	186	176	0.51	87	99	0.53			1.54	191	91	100	0.48	36	55	0.40	1.90	2.04	1.76	2.42	1.80
4/9/2019	122	114	8	0.93	348	198	150	0.57	96	102	0.52			1.32	170	98	72	0.58	57	41	0.58	2.05	2.02	2.08	1.68	2.49
4/10/2019	86	70	16	0.81	371	205	166	0.55	118	87	0.42			2.37	164	102	62	0.62	56	46	0.55	2.26	2.01	2.68	2.11	1.89
4/11/2019	104				414	215	199	0.52	116	99	0.46				190	113	77	0.59	62	51	0.55	2.18	1.90	2.58	1.87	1.94
4/12/2019	92	76	16	0.83	405	217	188	0.54	133	84	0.39			2.47	194	106	88	0.55	55	51	0.52	2.09	2.05	2.14	2.42	1.65
4/13/2019	114	108	6	0.95	394	220	174	0.56	127	93	0.42			1.61	202	117	85	0.58	62	55	0.53	1.95	1.88	2.05	2.05	1.69
4/14/2019	92	90	2	0.98	344	200	144	0.58	122	78	0.39			1.60	168	105	63	0.63	52	53	0.50	2.05	1.90	2.29	2.35	1.47
4/15/2019	126	102	24	0.81	353	172	181	0.49	89	83	0.48			1.77	157	73	84	0.46	32	41	0.44	2.25	2.36	2.15	2.78	2.02
4/16/2019																										
5/6/2019												60														
5/8/2019												76														
5/14/2019												79														
5/15/2019												57														
5/17/2019												34														
Percentile																										
0.00	86	70	2	0.75	344	172	133	0.49	87	74	0.35	34		1.32	157	73	62	0.46	32	33	0.40	1.86	1.84	1.76	1.68	1.47
0.10	92	78	3	0.81	350	189	146	0.50	90	76	0.37	44		1.55	165	93	63	0.49	39	41	0.45	1.91	1.85	1.81	1.88	1.61
0.20	93	86	7	0.82	355	197	153	0.52	100	80	0.39	53		1.59	169	99	68	0.54	51	41	0.49	1.99	1.88	1.98	1.91	1.66
0.30	96	90	8	0.85	361	200	165	0.52	108	84	0.41	58		1.61	175	100	75	0.56	54	44	0.50	2.04	1.90	2.06	1.96	1.73
0.40	102	93	10	0.88	376	202	174	0.53	115	86	0.42	59		1.64	185	103	76	0.57	55	48	0.51	2.05	1.92	2.09	2.04	1.76
0.50	**104**	94	12	**0.89**	395	207	175	**0.54**	118	87	**0.44**	60		**1.77**	**188**	106	80	0.58	56	51	0.52	2.08	1.99	2.15	2.11	1.79
0.60	107	96	12	0.91	398	213	180	0.56	123	93	0.45	66		1.93	190	108	84	0.58	57	51	0.53	2.14	2.02	2.24	2.15	1.82
0.70	115	100	15	0.93	402	215	186	0.56	127	97	0.47	73		1.99	191	110	85	0.59	60	53	0.55	2.17	2.04	2.32	2.23	1.91
0.80	124	106	16	0.94	403	218	190	0.57	131	99	0.48	77		2.09	192	114	87	0.61	62	55	0.57	2.21	2.06	2.62	2.39	1.99
0.90	126	113	22	0.97	407	226	198	0.58	133	101	0.51	78		2.32	200	117	89	0.62	66	55	0.63	2.26	2.28	2.70	2.42	2.25
1.00	130	114	32	0.98	414	266	206	0.67	140	102	0.53	79		2.47	202	122	100	0.66	74	63	0.67	2.30	2.42	2.76	2.78	2.49
Average	107	95	12	0.89	382	209	173	0.55	116	89	0.44	61		1.84	183	104	79	0.57	55	49	0.53	2.09	2.02	2.23	2.14	1.86

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.5 (Cont.) - WB Casey WRRF Special Sampling - Primary Effluent Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

Date	TKN (mg/L)			TP (mg/L)				
	U (tot.)	NH3-N	NH3N/U	U (tot.)	PO4-P	ALK	pH	Temp.
	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	Deg. C
4/2/2019	34.2	28.00	0.82	7.50	4.30			
4/3/2019	36.9	29.80	0.81	8.63	5.80			
4/4/2019	38.8	23.80	0.61	9.00	7.50	144	7.00	
4/5/2019	28.5	24.00	0.84	9.13	5.50	141	6.60	23
4/6/2019	21.8	22.60	1.04	8.88	5.50	148	6.90	22
4/7/2019	31.3	23.00	0.73	7.25	4.90	117	7.10	24
4/8/2019	32.6	20.40	0.63	7.13	4.30	131	6.70	21
4/9/2019	34.1	22.00	0.65	8.50	5.10	140	6.80	
4/10/2019	31.7	21.80	0.69	6.88	4.50	131	6.70	20
4/11/2019	33.1	27.00	0.82	7.88	5.00	145	6.80	
4/12/2019	32.6	26.80	0.82	8.50	5.70	140	6.80	21
4/13/2019	30.0	25.20	0.84	8.75	5.90	132	6.80	20
4/14/2019	38.7	26.20	0.68	7.63	5.30			
4/15/2019	27.2	19.90	0.73	7.38	4.70	143	6.60	19
4/16/2019						145	6.70	21
5/6/2019								
5/8/2019								
5/14/2019								
5/15/2019								
5/17/2019								
Percentile								
0.00	21.8	19.90	0.61	6.88	4.30	117	6.60	19
0.10	27.6	20.82	0.63	7.17	4.36	131	6.61	20
0.20	29.4	21.92	0.66	7.33	4.62	131	6.70	20
0.30	31.2	22.54	0.69	7.49	4.88	134	6.70	20
0.40	31.9	23.16	0.73	7.68	5.02	140	6.74	21
0.50	**32.6**	23.90	**0.77**	**8.19**	**5.20**	**141**	6.80	21
0.60	33.0	24.96	0.81	8.50	5.46	142	6.80	21
0.70	34.1	26.26	0.82	8.64	5.52	144	6.80	22
0.80	35.3	26.88	0.83	8.80	5.74	145	6.88	22
0.90	38.2	27.70	0.84	8.96	5.87	145	6.99	23
1.00	38.8	29.80	1.04	9.13	7.50	148	7.10	24
Average	32.3	24.32	0.76	8.07	5.29	138	6.79	21

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.6 - WB Casey WRRF Special Sampling - Secondary Effluent Sample Location

Design Basis for 32 MGD W.B. Casey WRRF Expansion

		COD	BOD5		TKN				TP				
Date	TSS	F (sol.)	F (sol.)	F (sol.)	NH3-N	F-NH3N (sol. orgN)	NOx-N	F (sol.)	PO4-P	F-PO4P (other sol.)	ALK	pH	Filtered Fe
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
4/2/2019	3	16	1.3	1.6	0.37	1.23	5.14	0.23	0.15	0.08			
4/3/2019	4	14	2.0	1.8		1.80		0.22	0.14	0.08			0.11
4/4/2019	4	17	1.6	2.0	0.31	1.69	5.22	0.31	0.16	0.15	56	6.4	0.12
4/5/2019	4	46	1.6	1.3	0.10	1.20		0.25	0.14	0.11	58	6.3	
4/6/2019	5	26	2.2		0.10		5.76	0.30	0.14	0.16	56	6.4	
4/7/2019	4	10	1.8		0.10		5.97	0.23	0.13	0.10	53	6.7	
4/8/2019	9	10	1.6	1.5	0.10	1.40		0.18	0.08	0.10	50	6.2	
4/9/2019	9	14	1.8		0.10		5.30	0.27	0.11	0.16	55	6.3	
4/10/2019	4	28	2.1	1.3	0.10	1.20	5.39	0.21	0.12	0.09	56	6.4	0.05
4/11/2019	6	22	2.6		0.98		4.45	0.26	0.15	0.11	56	6.3	
4/12/2019	5	29	2.6	1.7	0.53	1.17		0.27	0.16	0.11	55	6.3	
4/13/2019	5	18	1.7		0.10		5.68	0.16	0.10	0.06	60	6.4	
4/14/2019	4	28	2.0		0.10		5.64	0.24	0.13	0.11			
4/15/2019	6	50	1.7		2.41			0.27	0.18	0.09	53	6.2	
4/16/2019											60	6.4	
Percentile													
0.00	3.0	10	1.3	1.3	0.10	1.17	4.45	0.16	0.08	0.06	50	6.2	0.05
0.10	4.0	11	1.6	1.3	0.10	1.19	5.00	0.19	0.10	0.08	53	6.2	0.06
0.20	4.0	14	1.6	1.3	0.10	1.20	5.19	0.22	0.12	0.09	53	6.3	0.08
0.30	4.0	16	1.7	1.5	0.10	1.20	5.25	0.23	0.13	0.09	55	6.3	0.09
0.40	4.0	17	1.7	1.5	0.10	1.21	5.32	0.23	0.13	0.10	55	6.3	0.10
0.50	**4.5**	20	1.8	1.6	0.10	1.23	5.39	0.25	**0.14**	0.11	**56**	6.4	0.11
0.60	5.0	25	2.0	1.7	0.14	1.33	5.59	0.26	0.14	0.11	56	6.4	0.12
0.70	5.1	28	2.0	1.7	0.33	1.46	5.66	0.27	0.15	0.11	56	6.4	0.12
0.80	6.0	28	2.1	1.8	0.47	1.63	5.71	0.27	0.15	0.13	58	6.4	0.12
0.90	8.1	41	2.5	1.9	0.89	1.73	5.80	0.29	0.16	0.16	60	6.4	0.12
1.00	9.0	50	2.6	2.0	2.41	1.80	5.97	0.31	0.18	0.16	60	6.7	0.12

TSS = Total suspended solids
VSS = Volatile suspended solids
ISS = Inorganic suspended solids
COD = Chemical oxygen demand
pCOD = Particulate COD
BOD = Biological oxygen demand
U = Unfiltered (Total)
F = Filtered fraction. Sample was filtered through 0.45 microns. Includes soluble + colloidal.
U-F = Particulate fraction
FF = "Truly" soluble fraction. Sample was flocculated prior to filtering to remove colloidal particles.
F-FF = Colloidal fraction
VFA = Volatile fatty acids
TKN = Total kjeldahl nitrogen
NH3-N = Ammonia as nitrogen
NOx-N = Nitrogen oxides
TP = Total phosphorus
PO4-P = Orthophosphate as phosphorus
Alk = Alkalinity
Ca = Calcium, Mg = Magnesium, Fe = Iron

Table A.7 - WB Casey WRRF Special Sampling - Grab Sample Analytical Results

Design Basis for 32 MGD W.B. Casey WRRF Expansion

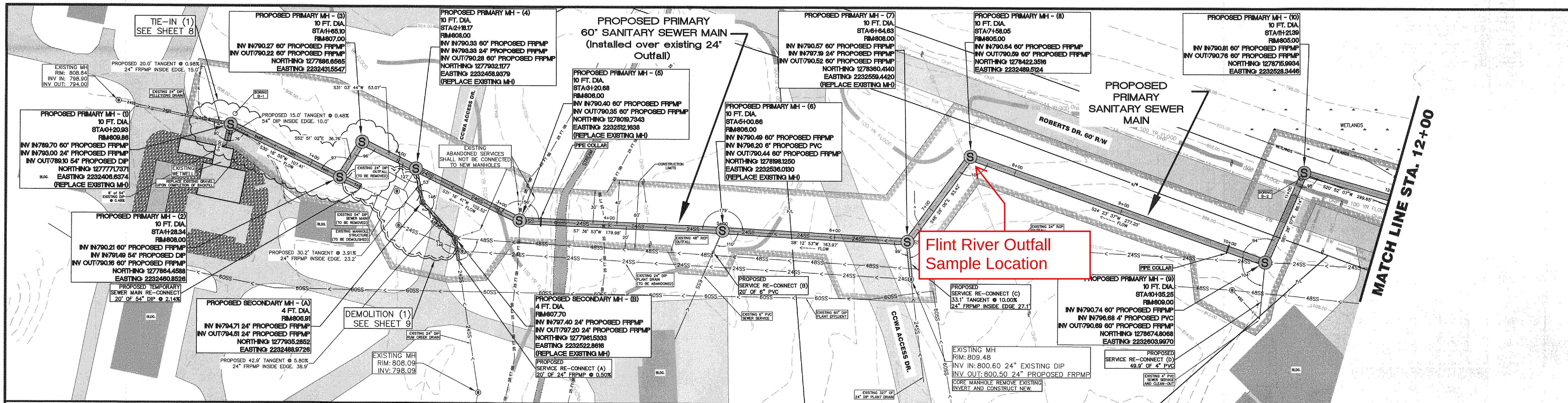
Parameter	Units	4/2/2019	4/3/2019	4/4/2019	4/5/2019	4/6/2019	4/7/2019	4/8/2019	4/9/2019	4/10/2019	4/11/2019	4/12/2019	4/13/2019	4/14/2019	4/15/2019	4/16/2019	5/6/2019	5/8/2019	5/14/2019	5/15/2019	5/17/2019	Min	Avg	Med	Max	Count
Primary Sludge																										
TSS	mg/L	21,933	25,567	24,600	23,033	28,900	29,433	26,067	21,800	30,300	24,933	28,633	33,400		41,200							21,800	27,677	26,067	41,200	13
VSS	mg/L	19,533		22,533				23,500		27,200		25,767			35,633											
VSS/TSS	---	0.89		0.92				0.90		0.90		0.90			0.86							0.86	0.90	0.90	0.92	6
VFA	mg COD/L		769		1,017			216		526		461			323		412	650	307	274	473	216	493	461	1,017	11
pH	s.u.			6.3	6.2			6.2		6.1		6.0			6.4							6.0	6.2	6.2	6.4	6
BRB Zone 1 (Start of Unaerated Zone)																										
COD (filtered)	mg/L		104	56					41	67	50			84								41	67	62	104	6
NOx-N (filtered)	mg/L		1.2	0.8				0.1		0.2	0.4				0.1							0.1	0.5	0.3	1.2	6
PO4-P (filtered)	mg/L		16	13					12	33	11			19								11	17	15	33	6
DO	mg/L		0.3	0.3					0.3	0.3	0.3				0.4							0.3	0.3	0.3	0.4	6
BRB Zone 3 (End of Unaerated Zone)																										
COD (filtered)	mg/L		152	54					59	78	66			85								54	82	72	152	6
NOx-N (filtered)	mg/L		0.5	0.6				0.2		0.2	0.2				0.1							0.1	0.3	0.2	0.6	6
PO4-P (filtered)	mg/L		47	20					27	28	18			19								18	26	24	47	6
DO	mg/L		0.4	0.3					0.2	0.2	0.2				0.3							0.2	0.3	0.3	0.4	6
BRB Zone 4 (Start of Aerated Zone)																										
PO4-P (filtered)	mg/L		5.1	7.6					7.7	7.0	7.3			9.6								5.1	7.4	7.4	9.6	6
DO	mg/L		2.7	2.4					0.8	2.6	0.8				0.7							0.7	1.7	1.6	2.7	6
Secondary Clarifier Feed (Mixed Liquor)																										
TSS	mg/L	3,670	3,730	3,795	3,635	3,880	3,550	3,580	3,088	3,750	3,345	3,665	3,765		3,615							3,088	3,621	3,665	3,880	13
VSS	mg/L	2,875		3,030				2,800		2,955		2,845			2,845											
VSS/TSS	---	0.78		0.80				0.78		0.79		0.78			0.79							0.78	0.79	0.79	0.80	6
COD	mg/L	4,820	5,270	5,360			4,920		4,700	4,630				5,080								4,630	4,969	4,920	5,360	7
TKN	mg/L		264							298												264	281	281	298	2
TP	mg/L		148	138						148		65		144								65	129	144	148	5
Fe	mg/L		63.5							41.5												42	53	53	64	2
temperature	C				20	22	21	20	21	22	23		22		22	21						20	21	22	23	10
COD/VSS	---	1.7	1.8	1.8			1.8		1.9	1.6												1.6	1.8	1.8	1.9	6
TKN/COD	---		0.050							0.064												0.050	0.057	0.057	0.064	2
TP/COD	---		0.028	0.026						0.032				0.028								0.026	0.029	0.028	0.032	4
TP/TSS	---		0.040	0.036						0.039												0.036	0.039	0.039	0.040	3
Fe/TSS	---		0.017							0.011												0.011	0.014	0.014	0.017	2
RAS																										
TSS @ 9 AM	mg/L	10,600	10,910	11,210	10,940	10,770	10,350	11,080	10,730	10,130	10,710	10,700	10,760	10,490	10,280							10,130	10,690	10,720	11,210	14
TSS @ 5 PM	mg/L		10,650			10,630	10,240	10,480		10,450	10,300	10,260	10,080									10,080	10,386	10,375	10,650	8
TSS @ 3 AM	mg/L		10,930			10,750	10,770	10,620	10,600	10,620	10,380	10,660	10,780	10,280	10,270							10,270	10,605	10,620	10,930	11
DAFT Overflow																										
TSS	mg/L	120	146	130	116	124		96	92	100	120	104	100	98	92							92	111	104	146	13
DAFT Underflow																										
TSS	mg/L	17,000	17,867	17,133	19,067	19,933		21,033	20,433	18,067	20,933	20,533	20,400	20,867	26,500							17,000	19,982	20,400	26,500	13
VSS	mg/L		14,533						16,400		17,000															
VSS/TSS	---		0.81						0.80		0.81											0.80	0.81	0.81	0.81	3

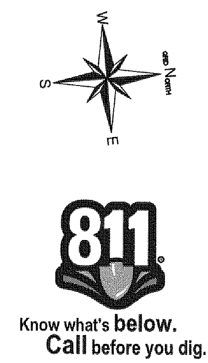
Table A.7 (Cont.) - WB Casey WRRF Special Sampling - Grab Sample Analytical Results

Design Basis for 32 MGD W.B. Casey WRRF Expansion

Dewatering Feed	Units	4/2/2019	4/3/2019	4/4/2019	4/5/2019	4/6/2019	4/7/2019	4/8/2019	4/9/2019	4/10/2019	4/11/2019	4/12/2019	4/13/2019	4/14/2019	4/15/2019	4/16/2019	5/6/2019	5/8/2019	5/14/2019	5/15/2019	5/17/2019	Min	Avg	Med	Max	Count
TSS	mg/L	16,840	18,867	18,633	19,733	20,800		18,467	19,833	19,067	19,933	18,433		19,967	19,667							16,840	19,187	19,367	20,800	12
VSS	mg/L	14,260	16,366	16,100	17,233	18,133		17,100	17,267	16,233	17,433	15,733		16,866	16,500											
VSS/TSS	---	0.85	0.87	0.86	0.87	0.87		0.87	0.87	0.85	0.87	0.85		0.84	0.84							0.84	0.86	0.87	0.87	12
VFA	mg COD/L		3,510					1,618		1,903	2,106	2,152			2,587							1,618	2,313	2,129	3,510	6
TP	mg/L		950	810			670	676	1,176	1,125				750								670	880	810	1,176	7
PO4-P	mg/L		380	260			267	400	440	720				510								260	425	400	720	7
TP - PO4-P	mg/L		570	550			403	276	736	405				240								240	454	405	736	7
(TP - PO4-P)/TSS	---		0.030	0.030				0.015	0.037	0.021				0.012								0.012	0.024	0.025	0.037	
pH	s.u.				5.2			5.0		5.1		5.0										5.0	5.1	5.1	5.2	4
temperature	C					22	23	21		23	22	23			22	23						21	22	23	23	8
Dewatering Filtrate																										
TSS	mg/L	634	500	648	576	648		308	456	532	480	204			708							204	518	532	708	11
Dewatering Cake																										
TS	---	15%	17%	17%	16%	16%		14%	13%	16%	14%	14%			15%							13%	15%	15%	17%	11
VS	---	13%	16%	15%	14%	14%		12%	12%	14%	13%	12%			13%							12%	13%	13%	16%	11
VS/TS	---	87%	91%	89%	90%	86%		88%	89%	86%	90%	89%			89%							86%	89%	89%	91%	11
Pellets																										
TS	---	96%	96%	95%	94%	94%		94%	94%	93%	91%	95%			95%							91%	94%	94%	96%	11
VS	mg/L	72%	78%	73%	71%	74%		78%	73%	76%	72%	72%			75%							71%	74%	73%	78%	11
VS/TS	---	75%	81%	77%	76%	79%		83%	78%	81%	79%	76%			78%							75%	78%	78%	83%	11
TKN/TS	---		6.0%							5.3%												5.3%	5.6%	5.6%	6.0%	2
TP/TS	---		1.6%							1.9%												1.6%	1.7%	1.7%	1.9%	2
Fe/TS	---		1.0%							1.0%												1.0%	1.0%	1.0%	1.0%	2
K/TS	---		0.26%							0.37%												0.26%	0.31%	0.31%	0.37%	2
temperature	C							50								48						48	49	49	50	2

Attachment 2
Sample Locations





GRAPHIC SCALE

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

THE GRAPHICAL SCALE IS SHOWN ONLY FOR PERMITTING REQUIREMENTS. THE GRAPHICAL SCALE SHALL NOT BE USED FOR CONSTRUCTION PURPOSES.

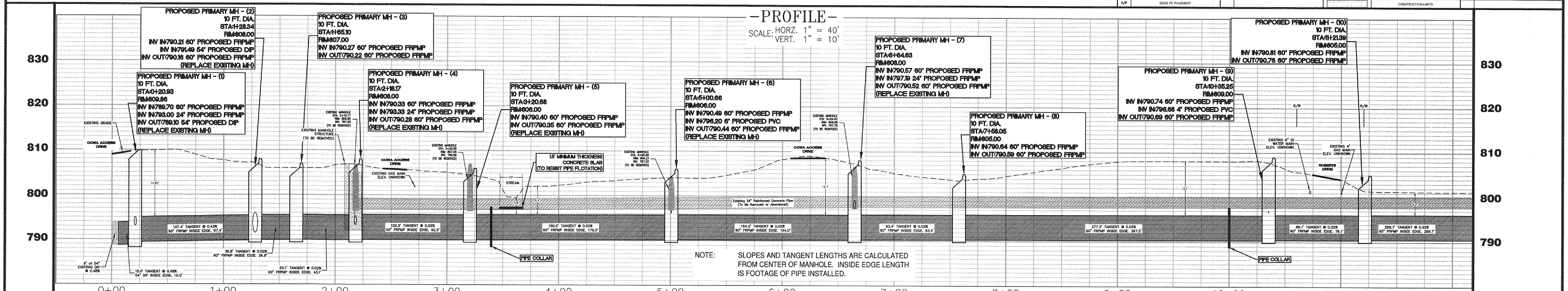
—PLAN—
SCALE: 1" = 40'

NOTES: 1) SLOPES AND TANGENT LENGTHS ARE CALCULATED FROM CENTER OF MANHOLE. INSIDE EDGE LENGTH IS FOOTAGE OF PIPE INSTALLED.

LEGEND

	EXISTING SANITARY SEWER MANHOLE	MB	EXISTING MAIL BOX	—6G— —6G—	EXISTING GAS MAIN & SIZE	Mb	EROSION MATTING AND BLANKETS
	PROPOSED SANITARY SEWER MANHOLE	WM	EXISTING WATER METER	— 25 FT SB —	25' STREAM BUFFER	Co	CONSTRUCTION EXIT
WV	EXISTING WATER VALVE	WMV	EXISTING WATER METER VAULT	— X — X —	EXISTING FENCE	Cd-Hb	HAY BALE CHECK DAM
	EXISTING FIRE HYDRANT	CMP	CORRUGATED METAL PIPE	—LLL— —LLL—	LAND LOT LINE	Ch-Rp	CHANNEL STABILIZATION WITH RIP-RAP
	EXISTING STREET SIGN	RCP	REINFORCED CONCRETE PIPE	—OTS— —OTS—	EXISTING OVERHEAD TRAFFIC SIGNAL LINES	Sb	STREAM BANK STABILIZATION RIP-RAP & LIVE STAKING
	EXISTING LAMP POST	DIP	DUCTILE IRON PIPE	—UTS— —UTS—	EXISTING UNDERGROUND TRAFFIC SIGNAL LINES	Rt-B	PIPE INLET SEDIMENT TRAP
	EXISTING UTILITY POLE	CTV	EXISTING CABLE TV BOX	— FO — FO —	EXISTING FIBER OPTIC CABLE	St	PIPE OUTLET TO FLAT AREA
	EXISTING POWER TRANSFORMER			—UGP— —UGP—	EXISTING UNDERGROUND POWER LINES	Ds4	DISTURBED AREA STABILIZATION W/SOD
JB	EXISTING STORM JUNCTION BOX			—OHP— —OHP—	EXISTING OVERHEAD POWER LINES	Sd2	DROP INLET SEDIMENT TRAP
HW	EXISTING STORM HEADWALL			—UGT— —UGT—	EXISTING UNDERGROUND TELEPHONE CONDUIT	Ds2 Ds3	TEMPORARY/PERMANENT VEGETATION COVER
CB	EXISTING STORM CATCH BASIN			—UGTV— —UGTV—	EXISTING UNDERGROUND CABLE TV		
DI	EXISTING STORM DROP INLET			— SFM — SFM —	EXISTING SEWER FORCE MAIN		
TB	EXISTING TELEPHONE SWITCH BOX			—8SS— > —8SS— >	EXISTING SEWER MAIN, SIZE & FLOW DIRECTION		
TM	TELEPHONE CABLE MARKER			— 8W — 8W —	EXISTING WATER MAIN & SIZE		
GW	EXISTING GUIDE WIRE			— W — W —	EXISTING WATER MAIN OR SERVICE		
IP	IRON PIN/PROPERTY CORNER MARKER				PROPOSED SEWER MAIN		
TSB	EXISTING TRAFFIC SIGNAL BOX			—12SD→ —12SD→	EXISTING STORM MAIN SIZE & FLOW DIRECTION		
GM	EXISTING GAS METER				DEMOLITION / REMOVE PIPE AND MANHOLE		
GV	EXISTING GAS VALVE				DEMOLITION / GROUT FILL		
R/W	RIGHT OF WAY				DEMOLITION / GRAVEL FILL		
P/L	PROPERTY LINE			— Sd1 —	SILT FENCE TYPE AS SPECIFIED		
E/P	EDGE OF PAVEMENT				CONSTRUCTION LIMITS		

—PROFILE—
SCALE: HORZ. 1" = 40' VERT. 1" = 10'



PLANS PREPARED BY:

CLAYTON COUNTY WATER AUTHORITY
1600 BATTLE CREEK ROAD
MORROW, GEORGIA 30260

PROJECT NAME:

FLINT RIVER OUTFALL REPLACEMENT PHASE 1A

LAND LOT 243 DISTRICT 13 &
LAND LOT 243 DISTRICT 5
CLAYTON COUNTY, GEORGIA

GEORGIA REGISTERED PROFESSIONAL ENGINEER CLIFFORD W. BEROSET

FLINT RIVER OUTFALL REPLACEMENT - PHASE 1A

SEAL:

REVISIONS:

DATE:	NO.:	DESCRIPTION:

SHEET TITLE: PLAN AND PROFILE

DESIGN BY: CCWA	DATE: 04/15/2015
DRAWN BY: WWB	JOB #: 814-08
CHECKED BY:	DRAWING #: P-1
	SCALE: 1" = 40'

SHEET NUMBER 4 OF 18

MATCH LINE SEE DRAWING Y-13

MATCH LINE SEE DRAWING Y-15

NOTES:

1. CONSTRUCT NEW MANHOLE C5 OVER EXISTING 24" SANITARY SEWER AND INSTALL NEW 24" RAW SEWAGE LINE TO NEW MANHOLE C4. AFTER NEW MANHOLE C4 , NEW 54" RS PIPELINE AND CASEY RAW SEWAGE PUMP STATION ARE COMPLETE AND OPERATIONAL BREAK TOP OF EXISTING PIPE AND GROUT MANHOLE BOTTOM TO DIRECT FLOW SOUTHEAST TO NEW MANHOLE.
2. SEE PROCESS DRAIN MANHOLE SCHEDULE ON DRAWING Y-32 FOR MANHOLE DIAMETER, ELEVATIONS AND DETAIL REFERENCES.
3. INSTALL NEW 1" NG PRIOR TO DEMOLISHING EXISTING 1" GAS LINE OR COMMENCING ANY OTHER WORK.
4. SEE STORM DRAINAGE STRUCTURE SCHEDULE ON DRAWING Y-31 FOR STORM DRAIN PIPE ELEVATIONS.

RECORD DRAWINGS

Revisions Drawn By SMP Date 05/05

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT NOR MANNER OF CONSTRUCTION. THE ENGINEER WILL NOT BE RESPONSIBLE FOR ANY ERRORS OR OMISSIONS WHICH HAVE BEEN INCORPORATED INTO THE RECORD DRAWINGS.

RECORD DRAWING

DSGN	W. MURPHY					
DR	950700y14d.dgn A. ZILBERMAN					
CHK	M.F. OSBORNE		05/2005	RECORD DRAWING		
APVD		NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

CLAYTON COUNTY WATER AUTHORITY
W.B. CASEY WATER RECLAMATION FACILITY
EXPANSION AND UPGRADE PROJECT
CLAYTON COUNTY, GEORGIA

YARD PIPING
CASEY
SITE PIPING PLAN

DWG Y-14
DATE MAY 2005
PROJ 161430.CD

25-MAY-2001 13:50:07 950700y14d.dgn

JACOBS

Memorandum

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Subject	**Task 3 TM – W.B. Casey WRRF Process Model Calibration and Plant Capacity Analysis**
Project Name	W.B. Casey WRRF Capacity Analysis and Plant Expansion Evaluation
Attention	Clayton County Water Authority (CCWA)
From	Scott Levesque/Jacobs Engineering Group Inc. (Jacobs) Kristina Yanosek/Jacobs
Date	April 17, 2020

1. Introduction

The purpose of this evaluation was to determine the capacity of the existing W.B. Casey Water Resources Recovery Facility (Casey WRRF) liquid stream processes. This capacity assessment is based on the current operating conditions with the new phosphorus polishing facilities. The capacity assessment assumes that new solids processing facilities are not in place.

Jacobs developed a simulation model of the Casey WRRF using Jacobs' proprietary Professional Process Design and Dynamics (Pro2D2) software. Pro2D2's underlying activated sludge model is based on the International Water Association's Activated Sludge Model 2d.

The Casey WRRF model was calibrated using 2018 operating data and results of a special sampling campaign conducted in April 2019. The calibrated model was used to assess capacity of the secondary treatment process, including its bioreactors, secondary clarifiers, return activated sludge (RAS) pumps, blowers, and diffusers.

Pump stations and other treatment processes were evaluated using criteria specific to the process. For example, preliminary treatment process capacities are based on ability to handle peak flow. Using peaking factors developed under another task, peak flow capacities were converted to corresponding maximum monthly average flow to facilitate comparison of all processes on a common basis.

This memorandum only addresses capacity of liquid-stream plant facilities. It has already been determined that the solids side of the plant operates beyond capacity; the drying process operates more hours per week than desired and is at the end of its useful life.

2. Process Simulator Calibration

Pro2D2 was configured to represent treatment processes at Casey WRRF, including primary clarifiers, bioreactors, secondary clarifiers, waste activated sludge (WAS) thickening, unaerated sludge holding, dewatering, and drying. Preliminary treatment and disinfection are not reflected in Pro2D2 process simulations. Pro2D2 PBNR (biological nutrient removal) modules were included to model fermentation in the primary sludge blanket and sludge holding tank, both of which were observed during April 2019 special sampling. The Pro2D2 process flow diagram shown in Figure 1 also includes modules for tertiary chemical phosphorus removal (used when assessing plant capacity) and filtration (not used for this initial simulation work).

In Pro2D2, flow and characteristics of raw wastewater without recycles are inputs, but Casey WRRF "raw wastewater" samples also include recycles from solids handling processes and odor control. Raw wastewater without recycles was characterized in the April 2019 special sampling campaign, and these characteristics were the starting point for calibration to 2018 conditions. Small adjustments to special sampling wastewater fractions were made to match apparent soluble chemical oxygen demand (COD) and 5-day biochemical oxygen demand (BOD_5) fractions during 2018. The plant effluent flow measurement was used as a surrogate for unmeasured plant influent flow.

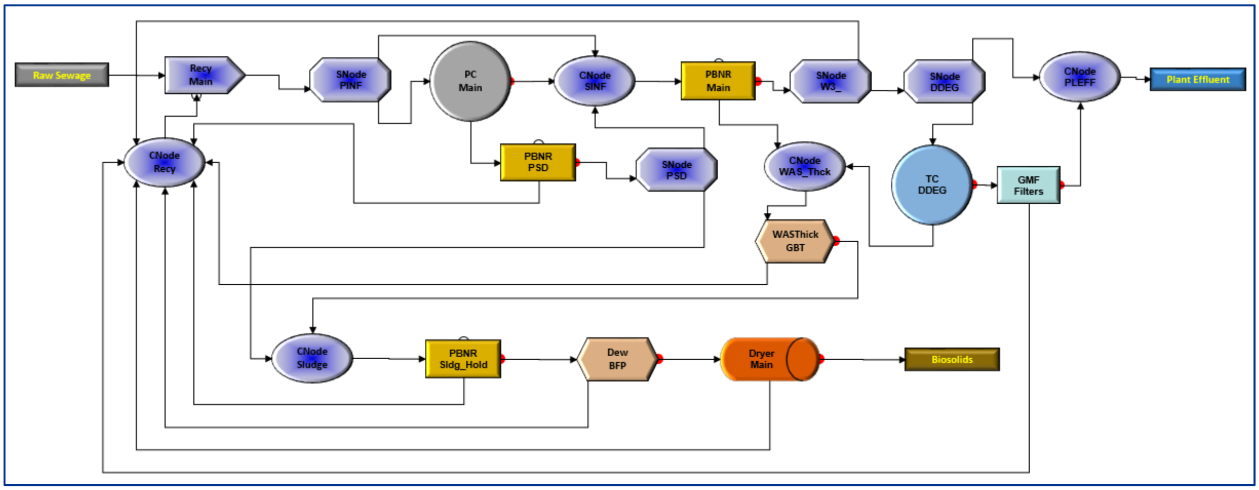

Figure 1. Pro2D2 process flow diagram for W.B. Casey WRRF

Most simulator inputs were set to match average measurements during 2018. Data from the sampling campaign were used for many inputs for parameters, which are not routinely measured, such as volatile fatty acids (VFAs) production. Key points on inputs and parameter adjustments are as follows:

- Primary clarifiers were not used on 80 days of 2018. This was represented as 22 percent liquid stream bypass around the primary clarifiers. An additional 5 percent liquid stream bypass was included to represent undocumented occasions when primary clarifier(s) were in service and partial liquid stream bypass was used.

- Primary clarifier total suspended solids (TSS) removal was adjusted to match 2018 average primary effluent TSS concentration.

- Primary sludge blanket volume was calculated using clarifier surface area and reported sludge blanket depth. This became the volume of the primary sludge fermentation reactor ("PBNR PSD" in Figure 1). Heterotroph maximum fermentation rate was adjusted in a "pre-calibration" step using special sampling campaign conditions to match measured and simulated VFAs in primary sludge. The fermentation rate was decreased from a default of 3 to 0.8 g COD/g COD/d.

- Some solids destruction occurs during fermentation. The input value for primary sludge concentration leaving the primary clarifier model unit was adjusted such that the concentration after fermentation matched the measured value.

- Plant operating data for 2018 show zero primary sludge (PS) diversion to the bioreactors on 80 percent of the days (including those when no primary clarifier was in service) and average diversion of approximately 2,000 gallons per day. Anecdotally, significant PS diversion is used to ensure acceptable pellet quality. Plant staff report that they direct 95 gallons per minute (gpm) of primary sludge to the bioreactors for 9 hours per day (51,000 gallons). The objective of directing some of the primary sludge to the bioreactors is to achieve 75 percent secondary sludge/ 25 percent primary sludge on a mass basis. Further, plant operating data show overall PS flow (sum of flows directed to solids handling and the bioreactors) that is too low based on solids mass balance across the primary clarifiers. Assuming reported PS diversion to the bioreactors to be incorrect, this simulator input was adjusted until reported and simulated WAS flow rates matched.

- Secondary treatment solids retention time (SRT) was adjusted to match 2018 average mixed liquor suspended solids (MLSS) concentration.
- RAS flow was adjusted to match 2018 average RAS concentration.
- Staff indicated that mixed liquor recycle is maintained at approximately 50 percent of pump capacity and that bioreactor swing zones are only aerated occasionally to contend with elevated effluent ammonia. Therefore, mixed liquor recycle was directed to Zone 1 at 50 percent of pump capacity. This corresponds to 220 percent of forward flow, although flow pacing is not used. The bioreactor swing zone was unaerated.
- A diffuser fouling factor of 0.8 was assumed. Dissolved oxygen concentration in aerated zones was adjusted such that the total airflow matched the reported airflow, and airflow per diffuser was made equal in the various zones.
- Reported ferric sulfate solution feed rate was used initially, along with solution specific gravity and iron concentration, to calculate the iron feed rate. Iron feed rate was converted to a ferric chloride feed rate, which is used in Pro2D2. However, it was found that using 85 percent of reported solution feed rate in the simulator resulted in a better match between reported and predicted primary effluent total phosphorus (TP).
- Plant W3 use was based on reported quantities for preliminary screening, scrubbers, caustic push, belt filter press (BFP) spray water, biofilters, secondary clarifier surface sprays, and sodium hypochlorite mixing.
- No change to default sludge holding tank fermentation kinetics was required to match observed VFA production during the April 2019 special sampling.
- Dewatering solids capture, which is not routinely measured, was set to match performance during April 2019 special sampling.
- The dryer module was modified such that VFA and ammonia entering the process would not appear in the cake or condensate. These constituents would be volatilized and emitted to the atmosphere.

Attachment 1 summarizes the results of simulator calibration, comparing observations to simulator predictions. Some discrepancies are described below:

- As mentioned, reported primary sludge diversion to the bioreactors was too low to be reasonable.
- The simulator does not predict an increase in ammonia concentration across the primary clarifiers as observed, and it would not do so without modifying the underlying model. Biokinetic transformations in the primary sludge blanket (hydrolysis and ammonification) could result in ammonia production, some of which could reach the primary effluent. Reported and predicted primary effluent ammonia-nitrogen matched more closely than primary influent, which is considered more important for accuracy of secondary treatment simulation.
- Primary effluent COD concentration was underpredicted; however, primary effluent BOD_5 concentration matched.

- Reported dewatering feed volume and mass flows are too high to be consistent with reported pellet production and reasonable BFP solids capture. Inaccuracy of the dewatering feed flow meter is the most likely explanation.

Despite these discrepancies, there is general agreement between observations and simulation results, for example, overall biosolids production. This calibrated model served as the basis for the following process capacity analysis.

3. Process Simulator Configuration for Capacity Evaluation

Following calibration, the Casey WRRF model was modified to add the tertiary chemical phosphorus removal process (DensaDeg) now under construction. Loads of raw wastewater aggregate parameters (COD, BOD_5, etc.) were changed from calibration values to the design basis values for loads and load peaking factors as summarized in *Task 1 TM – W.B. Casey WRRF Design Basis.* Raw wastewater constituent fractionization was the same as calibration to 2018 operating data.

Secondary treatment process capacity was determined using the B.1 limits for Huie Wetlands discharge. These limits include 0.60 milligram per liter (mg/L) monthly average TP. Ammonia-nitrogen (NH_3-N) limits are seasonal. May through October, monthly and weekly average NH_3-N limits are 0.5 and 0.75 mg/L, respectively. November through April, monthly and weekly average NH_3-N limits are 1.4 and 2.1 mg/L, respectively.

B.2 limits were used for the portion of flow discharged to the Flint River. Monthly and weekly average TP limits are 0.3 and 0.45 mg/L, respectively.

Process capacity was based on near-term operation of the plant, that is, before solids process improvements (anaerobic digestion and new thermal drying facility) are implemented that will eliminate the need to maintain a high ratio of secondary to primary solids. For the capacity analysis, the target blend of secondary and primary solids was 75 percent secondary and 25 percent primary on a mass basis.

Simulations were performed at maximum month flow, maximum month loads, and winter temperature (16.6 degrees Celsius). Simulations were performed at different flows, and therefore loads, until a capacity-limiting condition was reached. Potential limiting conditions include secondary clarifier thickening failure, ability to satisfy aeration requirements, or ability to meet effluent requirements.

Two of three primary clarifiers, three of three bioreactors, and three of four secondary clarifiers were in service for the simulated condition to match previously established redundancy criteria for these unit processes.

To achieve the target winter NH3-N limit (1.3 mg/L monthly average), a nitrification safety factor of 1.5 was selected and appropriate effluent ammonia concentration was confirmed using the simulator. In 2018, bioreactor pH averaged 6.4 standard units (s.u.), which is too low for optimal nitrification under design conditions and would require excessive SRT. For the capacity analysis, bioreactor pH of 6.8 s.u. was assumed, which would be achieved using caustic feed. The resulting total SRT required was 9.3 days.

In March 2017, reported secondary effluent TSS was 9.9 mg/L For the capacity analysis, secondary effluent TSS of 10 mg/L was used.

The bioreactors were simulated in anaerobic-anoxic-oxic (A2O) mode (versus current operation in Modified Ludzack-Ettinger [MLE] mode), that is, with internal mixed liquor recycle directed to the second zone. The A2O mode was used because it was expected to result in better enhanced biological phosphorus removal than MLE. The bioreactor swing zone was aerated, albeit at lower dissolved oxygen concentration (0.8 mg/L) than other aerated zones (2 mg/L) to optimize airflow. The mixed liquor recycle pumping rate was set to the pump capacity to maximize denitrification and minimize aeration requirements.

Secondary effluent flow split to the DensaDeg process was set to the permitted discharge to the Flint River (6.6 million gallons per day [MGD]), with the balance directed to the E.L. Huie wetlands. The simulator predicts that discharge to the river would have 0.07 mg/L TP, which is below the B.2 limit of 0.3 mg/L. Discharge to the wetlands would have 0.23 mg/L TP, which is below the operational target of 0.3 mg/L TP.

For DensaDeg, ferric chloride dose was set at 10 mg/L, and underflow concentration was set to 30,000 mg/L. Chemical solids and WAS were co-thickened by rotary drum thickeners. Incomplete solids capture by rotary drum thickeners (95 percent), BFPs (97.5 percent), and dryers (99 percent) resulted in chemical solids in plant recycles, and these solids have the capacity to bind additional orthophosphate. It was found that with the DensaDeg process in service, iron feed (ferric chloride or sulfate), to secondary treatment was unnecessary.

4. Unit Process Capacity Results

4.1 Influent Pumping

Pumping capacity of each raw sewage pump station (Casey and Jackson) is based on one pump out of service (that is, firm capacity) with online pumps operating at the design point. Recent data (2016 to 2018) indicated peak hour to maximum monthly average flow peaking factors of 2.06 and 2.45 for the Casey and Jackson pump stations, respectively. Using these peaking factors, the corresponding maximum monthly average flow was determined.

Maximum monthly average capacity of the Casey Raw Sewage Pump Station reflects recycle flow, which is combined with the influent flow to this pump station. While the actual pumping capacity is higher, a fraction of it is used to pump recycle flows. Relative recycle and influent flow was based on the process capacity simulation described in Section 3. The Jackson Raw Sewage Pump Station only handles raw wastewater, hence no allocation for recycles was necessary.

For raw wastewater pumping, the maximum monthly average flow capacities of the Casey and Jackson Raw Sewage Pumps Stations are 16.7 and 4.7 MGD, respectively, for a combined maximum monthly average capacity of 21.4 MGD (versus rated plant capacity of 24 MGD). During most months of 2016, 2017, and 2018, the Jackson Raw Sewage Pump Station operated above its firm peak flow capacity of 11.5 MGD during 29 of 36 months. Over the same time period, the Casey Raw Sewage Pump Station operated above its firm peak flow capacity of 40.4 MGD during 2 of 36 months, If another pump were installed in the available space at each pump station, combined maximum monthly average capacity would increase from 21.4 to 29.2 MGD. These capacities consider a best-case scenario, not accounting for the capacity needs in the specific collection systems at the Casey and Jackson Raw Sewage Pump Stations. Flow projections from the separate collection areas should be further considered prior to pump station improvements.

Downstream of the raw wastewater pump stations, the lower peaking factor of 1.83 used in Attachment 2 reflects combined flow from the pump stations, for which peaks do not coincide.

4.2 Preliminary Treatment

Preliminary treatment facilities are designed for peak flow conditions (peak hour flow). In preliminary treatment, there are two screening facilities (two front-fed band screens with a manually-cleaned bar rack in a bypass channel, and one drum screen with a bypass channel in parallel). These screening facilities cannot operate in parallel without bypassing grit removal. The drum screen was added as part of the Casey WRRF 2015 Improvements project. The purpose was to provide improved screening for most of the influent conditions with the intent of adding another drum screen when the plant is expanded to treat all peak flows.

After converting the drum screen peak flow capacity (35 MGD) to a maximum monthly average basis (19.1 MGD) using a peaking factor and subtracting an allowance for plant recycles (2.3 MGD), the drum screen capacity is 16.8 MGD. After converting the front-fed band screen capacity (66 MGD) to a maximum monthly average basis (36 MGD) using a peaking factor and subtracting an allowance for plant recycles (2.3 MGD), the front-fed band screen capacity with both units in service is 33.7 MGD. While performance is reduced at higher flows, overall screening capacity is sufficient for the current rated maximum month plant capacity of 24 MGD.

4.3 Primary Treatment

The impact of the primary clarifiers on secondary treatment capacity was considered using process simulations described in the previous section. In Attachment 2, peak flow capacity of the primary clarifiers is addressed. After converting the peak flow capacity (52.6 MGD) to a maximum monthly average basis (28.7 MGD) using a peaking factor and subtracting an allowance for plant recycles (3.4 MGD), primary treatment capacity is 25.3 MGD. The primary sludge pumps are not the limiting factor.

The WAS pumps were not evaluated as part of the overall secondary treatment process; however, they were evaluated as a separate pump system. The WAS pumps have a maximum month capacity of 30.4 MGD and therefore are not the limiting factor with respect to secondary treatment capacity.

The Parshall flume is not capacity limiting with a maximum month capacity of 36.5 MGD and a peak flow capacity of 66.9 MGD.

4.4 Secondary Treatment Capacity

Secondary treatment capacity is 15.4 MGD on a maximum monthly average basis.[1] The limiting factor is ability to meet maximum day aeration requirements using two of three blowers (that is, firm blower capacity). This was design intent for the 2005 expansion and upgrade project. Based on bioreactor air pipe diameters and the diffuser specification, the design does not appear to allow three blowers to operate, at least not at capacity.[2] Detailed analysis would be required to determine pressure drops in bioreactor air piping and ability of three blowers to deliver airflow at required pressure.[3] Alternatively, plant staff could test the actual blower system.[4]

The range of acceptable diffuser unit airflow is 0.5 to 4 standard cubic feet per minute (scfm) per diffuser for long-term operation and up to 7 scfm per diffuser for short-term operation. At the maximum day conditions, diffuser unit airflows are moderate (1.5 to 2.3 scfm), suggesting that the peak airflow limitation could not be relieved by installing additional diffusers.

State point analysis was used to evaluate theoretical secondary clarifier operation with respect to hydraulic and thickening failure. Real clarifiers have inefficiencies and cannot operate at 100 percent of

[1] At the workshop on August 9, 2019, Jacobs presented a capacity of 16.4 MGD. After the workshop, it was discovered that a recent change to a Pro2D2 function relating to aeration airflow (specifically conversion from actual to standard oxygen requirements) had been incorrect. When this was corrected, the resulting secondary treatment capacity was slightly lower.

[2] Plant staff indicated that on the one occasion three blowers were operated, and some diffuser assemblies and submerged polyvinyl chloride (PVC) air pipe broke. The reason this happened is unclear.

[3] Since the workshop, CCWA has asked Jacobs to proceed with a blower analysis to determine the maximum airflow that can be achieved by changing the blow configuration to two duty blowers.

[4] Temporary pipe modifications (for example, at a grooved expansion coupling on the blower discharge header) would be used to dedicate one blower to one bioreactor for testing, with the other two blowers serving the other two bioreactors. With the test bioreactor full of liquid (mixed liquor or clean water), its swing zone aerated, and dropleg isolation butterfly valves fully open, staff would start the blower at two-thirds of capacity and gradually increase airflow until an alarm condition occurred or the blower reached maximum speed. The maximum airflow observed during the test would match the maximum airflow to each bioreactor with three blowers supplying air to three bioreactors.

theoretical failure. Therefore, in this analysis, 85 percent of theoretical failure was regarded as the limit. A sludge volume index of 120 milliliters per gallon was used based on plant performance data. At 15.4 MGD maximum monthly average flow, there is considerable reserve clarifier capacity. Under the simulated condition, three of four secondary clarifiers operate at less than 50 percent of theoretical failure. At corresponding maximum day flow, four of four secondary clarifiers operate at less than 45 percent of theoretical failure.

4.5 Jackson Transfer Pump Station

The downstream Jackson Transfer Pump Station (a different pump station than the Jackson Raw Sewage Pump Station) has a capacity of 22.0 MGD maximum monthly average, which exceeds the permitted 17.4 MGD discharge to the wetlands. The peak flow limitation however is around 40 MGD, which is currently problematic during storm flows. This limitation will be partially or fully mitigated when the new phosphorus polishing facility comes online in 2020. The balance of the peak flow will be sent to the Flint River.

4.6 Tertiary Treatment

The DensaDeg process, ultraviolet disinfection, Flint River Parshall flume, and cascade aerator (now under construction) were designed for 8 MGD maximum monthly average flow, which exceeds the permitted 6.6 MGD discharge to the Flint River. These processes are intended to treat a portion of the Casey WRRF secondary effluent for discharge to the Flint River. .

5. Summary and Recommendations

The Casey WRRF process simulation model was developed and calibrated to 2018 operating data. The calibrated model was then used to assess secondary treatment capacity. Major findings as summarized in Table 1 are as follows:

- The Casey and Jackson Raw Sewage Pump Stations limit maximum monthly average flow to 21.4 MGD. This could be addressed by adding a pump to the available space in each pump station.
- The rotary drum screening process has a peak flow limit of 35 MGD (corresponding to average flow of 16.8 MGD). The rotary drum screen offers higher performance screening than the front-fed band screens. Currently, peak flows exceeding the capacity of the drum screen are bypassed and still receive screening in the older front-fed band screens. Operations staff report improved plant since the construction of the new screening facility. It is recommended that the rotary drum screening process be upgraded as part of the next major plant expansion to 32 MGD.
- Secondary treatment capacity is limited by blower system capacity, specifically, ability of the blower system to meet the firm airflow requirement under maximum day loads. The corresponding maximum monthly average flow rate is 15.4 MGD.

Table 1. W.B. Casey WRRF Treatment Process Capacity Summary

Process	Capacity, Maximum Month Average-Basis (MGD)		Near Term Upgrade Required
	Actual	Required	
Influent Pumping	21.4	24	
Casey Raw Sewage Pump Station	16.7	(1)	Y
Jackson Raw Sewage Pump Station	4.7	(1)	Y
Preliminary Treatment			
Rotary Drum Screen	16.8	24	N(2)
Front-Fed Band Screens	33.8	24	N
Primary Treatment	25.3	24	N
Secondary Treatment	15.4	24	Y
Jackson Transfer Pump Station	22.0	17.4	N

Notes:
(1)Required combined capacity of two influent pump stations is 24 MGD. Flow projections for individual collection areas should be considered in determining added capacity required for each.
(2)Rotary drum screen was installed to improve screening under most flow conditions. Flows exceeding rotary drum screen capacity still receive screening in front-fed band screens. Therefore, no near-term upgrade is required.

Based on the analysis described herein, Jacobs recommends that CCWA complete the following upgrades in the near term to bring the Casey WRRF back to a maximum month capacity of 24 MGD:

- Increase influent pump station capacity by adding additional pump in both Casey and Jackson Raw Sewage Pump Stations. Consider flow projections of individual collection areas prior to selecting pump to confirm if the following meets the specific needs of the respective collection system areas:
  - Add a fourth pump (in kind) to the existing Jackson Raw Sewage Pump Station to increase capacity from 4.7 to 7.0 MGD.
  - Add a fifth pump (in kind) to the existing Casey Raw Sewage Pump Station to increase capacity from 16.7 to 22.2 MGD.
- Modify the aeration system as to meet the peak air aeration requirements.

Attachment 1
Results of Simulator Calibration

Attachment 1 - W.B. Casey WRRF Summary of Simulator Calibration to 2018 Operating Data

Parameter	Units	Typical/ Reported	Simulated	Comparison/ Relative Diff.
Kinetics & Stoichiometry Settings [based on April 2019 Special Sampling]				
BODU/BOD5 Ratio		1.40-1.65	1.53	in range
Non-Biodegradable VSS, % of Total VSS		20%-40%	30.0%	in range
Soluble COD Fraction (included colloidal)		10%-40%	42.0%	slightly over
Heterotrophic Fraction of the Influent VSS		1%-30%	10.0%	in range
Xe as a Fraction of the Heterotrophs		75%	75%	same
Volatile Content of Part. Organic Matter, % of TSS		85%-90%	95%	slightly over
COD of the Part. Non-Biodeg. VSS, mg COD/mg VSS		1.42	1.42	same
Filtrate Non-Biodegradable COD, % of Total COD		5%-10%	5.0%	in range
Volatile Fatty Acid (VFA) Content of Truly Soluble COD		5%-50%	50.8%	slightly over
Portion of Filtrate COD that is Colloidal, % of Filtrate COD		40%	48.8%	slighly over
Colloidal Non-Biodegradable Fraction (% of Colloidal COD)		21%	2.8%	under
Sol., Non-Biodeg. Org. N, % of Filtrate Non-Bio COD		4%-8%	5.2%	in range
Phosphorus Content of VSS, P/VSS (%)		1%	0.70%	slightly under
Ave Nitrogen Content of Non-Biological VSS, N/COD (%)		---	1.5%	---
Ave Nitrogen Content of VSS, N/VSS (%)		3.1%	3.3%	slightly over
COD of VSS,mg COD/mg VSS		1.42-2.00	1.45	in range
COD of the Total Non-Biodeg. VSS, mg COD/mg VSS		---	1.42	---
COD of the Biodegradable VSS, mg COD/mg VSS		---	1.47	---
Percent Inorganic TSS		---	3.3%	---
COD/BOD5 Ratio, mg COD/mg BOD5		2.0-2.5	2.21	in range
BODU/BOD5 Ratio for Soluble Material		---	1.53	---
Filtrate BOD5/Total BOD5, % of Total BOD5		---	45%	---
Raw Wastewater without Recycles [based on April 2019 Special Sampling]				
Flow	MGD	14.37	14.36	0.00
COD	mg/L	---	577	---
	lb/d	---	69,171	---
BOD_5	mg/L	---	262	---
	lb/d	---	31,337	---
TSS	mg/L	---	251	---
	lb/d	---	30,080	---
VSS	mg/L	---	231	---
	lb/d	---	27,629	---
FSS	mg/L	---	20.5	---
	lb/d	---	2,451	---
TKN	mg/L	---	35.4	---
	lb/d	---	4,244	---
NH_3-N	mg/L	---	23.9	---
	lb/d	---	2,865	---
TP	mg/L	---	5.2	---
	lb/d	---	629	---
Alkalinity	mg/L as $CaCO_3$	---	135	---
	lb/d as CaCO3	---	16,214	---
Primary Influent (Raw Wastewater with Recycles)				
Flow	mgd	16.06	15.97	-0.01
COD	mg/L	534	565	0.06
	lb/d	---	75,369	---
BOD_5	mg/L	232	252	0.08
	lb/d	---	33,538	---

Parameter	Units	Typical/ Reported	Simulated	Comparison/ Relative Diff.
TSS	mg/L	257	234	-0.09
	lb/d	---	31,184	---
VSS	mg/L	---	214	---
	lb/d	---	28,535	---
TKN	mg/L	---	34.0	---
	lb/d	---	4,529	---
NH_3-N	mg/L	18.2	22.9	0.26
	lb/d	---	3,057	---
TP	mg/L	8.1	8.8	0.08
	lb/d	---	1,167	---
Alkalinity	mg/L as $CaCO_3$	146	131	-0.10
	lb/d as CaCO3	---	17,499	---
Primary Treatment				
Primary Clarifiers in Service	---	0.8	1.0	0.29
Surface Overflow Rate	gpd/sf	---	1,986	---
TSS removal	---	---	78.2%	---
PS Blanket Depth	inches	18	18	0.00
PS TSS	mg/L	33,262	33,261	0.00
PS VSS/TSS	---	89.5%	86.6%	-0.03
PS to Blend Tank	gpd	26,269	25,380	-0.03
	lb/d	---	7,044	---
PS to Bioreactors	gpd	2,032	33,643	15.56
	lb/d	---	9,338	---
PS total	gpd	28,301	59,023	1.09
	lb/d	---	16,382	---
Primary Effluent [excludes liquid stream diversion around primary treatment]				
Flow	mgd	---	11.62	---
COD	mg/L	370	323	-0.13
	lb/d	---	31,263	---
BOD_5	mg/L	155	154	0.00
	lb/d	---	14,952	---
TSS	mg/L	51	51	0.00
	lb/d	---	4,959	---
VSS	mg/L	---	47	---
	lb/d	---	4,545	---
TKN	mg/L	---	28.2	---
	lb/d	---	2,737	---
NH_3-N	mg/L	21.1	22.9	0.08
	lb/d	---	2,223	---
TP	mg/L	6.8	6.8	0.01
	lb/d	---	661	---
Alkalinity	mg/L as $CaCO_3$	---	131	---
	lb/d as CaCO3	---	12,724	---
Bioreactors				
Bioreactors in Service	---	2.9	2.9	0.01
Solids Retention Time	d	---	10.5	---
MLSS	mg/L	3,317	3,316	0.00
MLVSS/MLSS	---	78.9%	77.8%	-0.01

Parameter	Units	Typical/ Reported	Simulated	Comparison/ Relative Diff.
Bioreactor Temperature	°C	21.8	21.8	0.00
Bioreactor pH	s.u.	6.4	---	---
Mixed Liquor Recycle Ratio	---	---	2.2	---
Mixed Liquor Destination	---	zone 1	zone 1	---
Diffuser Fouling Factor	---	---	0.8	---
Airflow	cfm	13,128	13,250	0.01
Average Dissolved Oxygen in Aer. Zone	mg/L	---	2.6	---
Ferric Sulfate Solution Feed	gpd	180	153	-0.15
Ferric Sulfate Solution Spec. Grav.	---	---	1.59	---
Iron/Ferric Sulfate Solution	lb/lb	---	0.135	---
Secondary Clarifiers				
Secondary Clarifiers in Service	---	2.2	2	-0.10
Clarifier Sludge Blanket Depth	inches	34	34	0.00
RAS flow	MGD	6.0	6.9	0.15
RAS, WAS TSS	mg/L	10,608	10,659	0.00
WAS	gpd	263,491	263,361	0.00
	lb/d	23,326	23,426	0.00
Plant Effluent				
COD	mg/L	37	35	-0.05
BOD_5	mg/L	2.5	2.7	0.09
TSS	mg/L	2.6	2.6	0.00
NH_3-N	mg/L	0.09	0.07	-0.20
NO_x-N	mg/L	4.35	4.39	0.01
TP	mg/L	0.31	0.13	-0.59
Alkalinity	mg/L as $CaCO_3$	73	103	0.42
Biosolids				
DAF Solids Capture	---	---	99.2%	---
DAF Thickened TSS	mg/L	26,885	26,900	0.00
DAF Recycle TSS	mg/L	137	141	0.02
Blend Tank Level	ft	7.9	7.9	0.00
Dewatering Feed Flow	gpd	152,692	128,902	-0.16
Dewatering Feed TSS	mg/L	26,800	23,736	-0.11
	lb/d	34,149	25,533	-0.25
Dewatering Solids Capture	---	---	97.5%	---
Dewatering Cake Solids	---	16.8%	16.8%	0.00
Dewatering Recycle TSS	mg/L	---	518	---
Dryer Solids Capture	---	---	99.0%	---
Dryer (Pellet) Solids	---	---	94.3%	---
Dryer Recycle TSS	mg/L	---	2,040	---
Pellet production	dry lb/d	---	24,647	---
Pellet production	wet lb/d	25,147	23,714	-0.06
Pellet P/TS (dy basis)	lb/lb	---	2.5%	---
Pellet Fe/TS (dry basis)	lb/lb	---	2.2%	---

Notes:

1. Calibration Period Data is the average of data for 2018
2. Relative Difference = (Simulated - Reported) / Reported
3. Relative Difference outside +/- 0.10 colored red

Attachment 2
Peak Flow Capacity of Primary Clarifiers

Attachment 2 - W.B. Casey WRRF Liquid Stream Capacity Summary

Item	Quantity	Max Month Flow (MGD)	Peak Hour/ Max Month	Peak Hour Flow (MGD)	Criteria
Raw Wastewater Pumping					
Casey raw sewage pumps (9341 gpm each)	4	19.6	2.06	40.4	one out of service at peak flow, specified pumping rate; space for 5th pump
Allocation for plant recycles		2.9	---	---	
Available capacity for raw wastewater		16.70	---	---	
Jackson raw sewage pumps (3999 gpm each)	3	4.70	2.45	11.5	one out of service at peak flow, specified pumping rate; space for 4th pump
Combined capacity		21.40			29.2 mgd with 1 additional pump per pump station
Preliminary Treatment					
Screening					
Front-fed band screens	2	36.0	1.83	66.0	both in service at peak flow, specified capacity
Rotary drum screens	1	19.1	1.83	35.0	both in service at peak flow, specified capacity
Manual bar rack	1	---	---	73.0	2 fps approach velocity at peak flow, 18" freeboard
Rotary drum screen only		19.1	1.83	35.0	front-fed band screens cannot operate in parallel with drum screen, unless grit removal is bypassed
Allocation for plant recycles		2.3			
Available capacity for raw wastewater		16.8			
Grit Removal					
Mechanically-induced vortex grit unit (20' diameter)	1	27.3	1.83	50.0	specified peak flow capacity, which also matches manufacturer literature
Allocation for plant recycles		3.2			
Available capacity for raw wastewater		24.0			
Primary Treatment					
Primary clarifiers (174' x 34' each)	3	28.7	1.83	52.6	2 in service at max month flow, 3 in service at peak flow, 3000 gpd/sf at peak flow
Allocation for plant recycles		3.4			
Available capacity for raw wastewater		25.3			
Primary sludge pumps (100 gpm each)	4	29.3	---	---	1 in service per clarifier in service, continuous operation at max day loads
Secondary Treatment					
Bioreactors	3	---	---	---	3 in service at max month loads, min 30-day average temperature, 1.5 nitrication safety factor
Bioreactor recirculation pumps (16,700 gpm each)	6	---	---	---	1 per bioreactor in service
Bioreactor blowers (8300 scfm each)	3	---	---	---	2 in service at max day loads
Bioreactor diffusers (9" diameter)	8922	---	---	---	swing aerated at max month and max day loads
Secondary clarifiers (160' diameter)	4	---	---	---	3 in svc at max month, 4 in svc at max day, 120 mL/g SVI, 85% of theor. thickening failure
RAS pumps (5600 gpm each)	5	---	---	---	1 per clarifier in service
Overall (all aspects of sec. trt. considered together)		15.4			with primary bypass to maintain pellet quality
WAS pumps (420 gpm each)	2	30.4	---	---	1 in service under all conditions, continuous operation at max day loads
Processes for E.I. Huie Wetlands (17.4 MGD max month permitted)					
Effluent Parshall flume (6' throat)	1	36.5	1.83	66.9	Benefield *et al.* (1984) Treatment Plant Hydraulics for Environmental Engineers
Jackson transfer pumps (4000 gpm each)	8	22.0	1.83	40.3	one out of service at peak flow; specified design point
Processes for Flint River (6.6 MGD max month permitted)					
DensaDeg	1	8.0	---	---	specified maximum monthly average capacity capacity
UV disinfection	1	9.8	1.83	18.0	specified peak flow capacity, 35 mJ/cm2 MS-2 RED, 65% UVT
Effluent Parshall flume (2' throat)	1	11.7	1.83	21.4	Benefield *et al.* (1984) Treatment Plant Hydraulics for Environmental Engineers
Cascade aerator	1	8.7	1.83	16.0	500,000 gpd/ft at peak flow, 6 mg/L DO, 28 C

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Memorandum

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Subject	**Task 5 TM – W.B. Casey WRRF Liquid Stream Process Alternatives Evaluation**
Project Name	W.B. Casey WRRF Capacity Analysis and Plant Expansion Evaluation
Attention	Clayton County Water Authority (CCWA)
From	Scott Levesque/Jacobs Engineering Group Inc. (Jacobs) Kristina Yanosek/Jacobs
Date	April 17, 2020

1. Introduction

The purpose of the Task 5 – Liquid Stream Process Alternatives Evaluation was to select the approach for upgrading the W.B. Casey Water Resource and Recovery Facility (Casey WRRF) from 24 to 32 million gallons per day (MGD). This technical memorandum presents the results of the evaluation.

2. Background

Recent flow projections and the planned decommissioning of the Shoal Creek Water Reclamation Facility (WRF) prompted CCWA to evaluate the timing and approach for expanding the Casey WRRF. Through the capacity evaluation (Task 3 of this project), it was determined that the Casey WRRF would need to be upgraded prior to the transferring flow from the Shoal Creek WRF.

The influent design basis accounts for the combined flows and loads from the Casey WRRF and Shoal Creek WRF. The development of the design basis is described in detail in *Task 1 TM – W.B. Casey WRRF Design Basis*. Wastewater characteristics for this evaluation were refined through special sampling (Task 4 of this project).

Jacobs held two workshops with CCWA to guide this evaluation:

- Task 5 Kick Off held on October 23, 2019 – The purpose of this workshop was to provide an overview of wastewater technologies that could be implemented to upgrade the plant and to select three alternatives for evaluation based on existing conditions and treatment objectives.
- Task 5 Review of Evaluation Results held on December 11, 2019 – The purpose of this workshop was to present the conceptual design details, site plans, cost, and non-monetary considerations of each alternative. Alternatives were discussed, and the group executed a scoring activity to rank alternatives with respect to non-monetary criteria.

3. Technology Screening

Jacobs presented a list of liquid stream alternatives to CCWA at the October 23 , 2019 workshop. Jacobs identified potential treatment alternatives based on the treatment objectives and integration with existing processes and facilities for the plant expansion (Figure 1). It was recommended that existing preliminary, tertiary, and disinfection processes be adopted for the expansion.

Several approaches for "process intensification" were considered, each of which has the potential to allow treatment requirements to be met using fewer bioreactors and smaller footprint:

- Chemically enhanced primary treatment (CEPT)
- Membrane bioreactor (MBR)
- Step feed
- Adsorption/Bio-oxidation (A/B)
- Integrated fixed film activated sludge (IFAS)
- Membrane aerated biofilm reactor (MABR)
- Granular sludge

Other processes that potentially could be implemented in conjunction with one of the above process intensification alternatives include the following:

- Primary sludge fermentation – Primary sludge fermentation could improve performance of an enhanced biological phosphorus removal (EBPR) process used in multiple alternatives.
- Ultra-fine screening – Ultrafine screening would be an element of several of the process intensification approaches.

Continued use of conventional primary clarification followed by the existing three-stage activated sludge process (status quo) was compared to the above-listed process intensification alternatives. For MBR, two sub-options were developed. In the 32 MGD sub-option, an MBR process with immersed membranes would handle all plant flow. In the 8 MGD sub-option, the existing conventional activated sludge (CAS) process with 24-MGD capacity would operate in parallel with an MBR process with 8-MGD capacity. The second sub-option is the least expensive means to incorporate MBR technology into the plant and achieve 32-MGD capacity. This option required operating two different systems, which increases complexity of plant operations; however, it also represented an approach to converting to MBR over time as additional capacity became necessary.

A relative comparison of the alternatives is summarized in Table 1. The Status Quo and the Process Intensification alternatives were considered against key factors to determine which three should be evaluated in more detail. Key considerations included full-scale demonstration, relative capital cost (CAPEX), and relative operating cost (OPEX). Three alternatives that included primary and secondary treatment unit processes were selected for evaluation:

- Status Quo
- CEPT
- IFAS

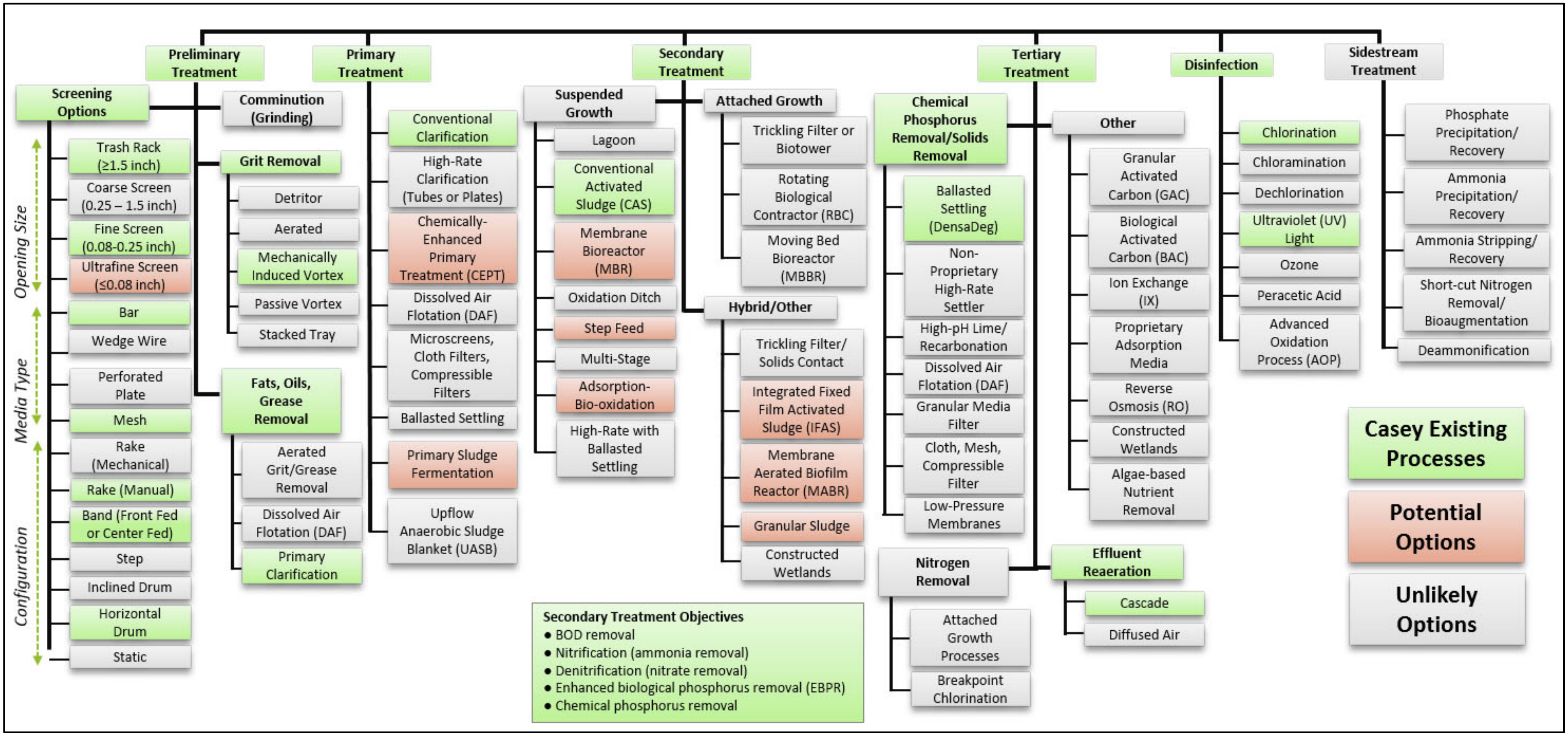

Figure 1. Liquid Stream Treatment Technologies

Table 1. Status Quo and Process Intensification Alternatives Comparison

Process	Demonstrated Full-Scale	Suppliers	Ultra-Fine Screening Required	Relative CAPEX	Relative OPEX	Ability to Stage Implementation
Status Quo	Considerable	N/A	No	$	$	No
CEPT	Considerable	N/A	No	Not determined	Not determined	No
MBR (32 MGD)	Considerable	Several	Yes	$$$$$	$$	Yes
MBR (8 MGD)	Considerable	Several	Yes	$$	$$	Yes
Step Feed	Considerable	N/A	No	$	$	No
A/B	Dozens	N/A	No	Not determined	Not determined	No
IFAS	Considerable	Several	Yes (1)	$$	$	Yes (2)
MABR	1-2	1	Yes	$$	$	Yes
Granular sludge (continuous flow)	Batch only	N/A	No	Not determined	$	No

(1) In general, IFAS requires ultra-fine screening. However, later in this evaluation it was determined through further communication with the manufacturer, that ultra-fine screening was not required for the media being considered for this project (Kruger K3). The manufacturer confirmed that 5-millimeter drum screens followed by primary clarifiers provide adequate protection for the IFAS media and its retention screens.

(2) In general, an IFAS process can stage implementation by initially installing less than the final quantity of fixed film media. For the Casey evaluation, it was determined that the minimum practical fill (25 percent) would be required under design conditions, which means it would not be possible initially to install less media.

4. Technology Evaluation

Jacobs' Pro2D2 whole-plant process simulator was used to develop process sizing and predict effluent characteristics, chemical requirements, aeration requirements, and biosolids production for the Status Quo, CEPT, and IFAS alternatives. Simulations used the influent design basis, effluent design basis, and simulator calibration that had been developed for this project under previous tasks. Solids treatment processes (thickening, digestion, dewatering, and drying) matched those selected in the biosolids management alternatives evaluation. Each of the three alternatives was simulated under the following plant capacity and operating conditions:

- **28-MGD interim plant capacity, maximum month flow and loads, winter temperature.** These simulations were used to assess the potential for staged implementation of facilities needed at 32-MGD plant capacity. This was to identify if any of the alternatives could offer cost savings by deferring some of the capital cost.
- **32-MGD design plant capacity, annual average flow, loads, and temperature.** Results of these simulations became inputs for operation cost calculations, which fed into lifecycle cost calculations.
- **32-MGD design plant capacity, maximum month flow and loads, winter temperature.** These simulations were used to develop process sizing and configuration for 32-MGD plant capacity.
- **40-MGD buildout plant capacity, maximum month flow and loads, winter temperature.** These simulations were used to determine numbers of process units for a tentative future plant buildout capacity. This was to determine if there would be space constraints for any future expansion needs.

Sizing for unit processes determined from simulations was used to produce a preliminary layout for each alternative. Site plans shown in subsequent sections were developed to ensure space was considered for all project elements. Site plans indicate all project elements required for the 32-MGD plant capacity and the 40-MGD theoretical buildout capacity including elements common to all alternatives. For the 32-MGD plant capacity, the following project elements are common to all three alternatives:

- Improvements to raw sewage pumping (not shown)
- Expansion of preliminary treatment
- Construction of primary clarifier No. 4
- Expansion of ultraviolet (UV) disinfection
- Expansion of the cascade aerator
- Expansion of central odor control

For 40-MGD plant capacity, the following project elements are common to all alternatives:

- Improvements to raw sewage pumping (not shown)
- Expansion of preliminary treatment (screening only)
- Construction of primary clarifier No. 5
- Construction of secondary clarifier No. 5
- Expansion of UV disinfection
- Expansion of the cascade
- Expansion of central odor control

4.1 Status Quo

The Status Quo alternative reflects the intent of the original design and footprint that was reserved for this future upgrade. Figure 2 shows the site plan of the liquids treatment side of the Casey plant for the Status Quo alternative. Existing facilities, including those under construction (gray), facilities added for 32-MGD plant capacity (blue), and additional facilities added for 40-MGD plant capacity (orange) are indicated. Space shown for the expansion of primary and secondary treatment facilities for the 32-MGD design capacity was considered in the original design, which allotted footprint for an additional primary clarifier and bioreactor.

The Status Quo alternative requires construction of a fourth bioreactor for 32-MGD plant capacity and a fifth bioreactor for 40-MGD plant capacity. Status quo requires construction of a second DensaDeg train for 32-MGD plant capacity, but no additional DensaDeg train for 40-MGD plant capacity.

Status Quo requires greater nitrified recycle (NRCY) pumping capacity than existing pumps can deliver. Larger pumps would be used in the new bioreactors, and pumps in the existing bioreactors would be replaced.

This alternative has minimal opportunity for staged implementation. Of the facilities required to be constructed for 32-MGD plant capacity, the only facility that could be deferred until 28-MGD capacity is the second DensaDeg train. Deferring a single unit process to a separate construction process is not desired.

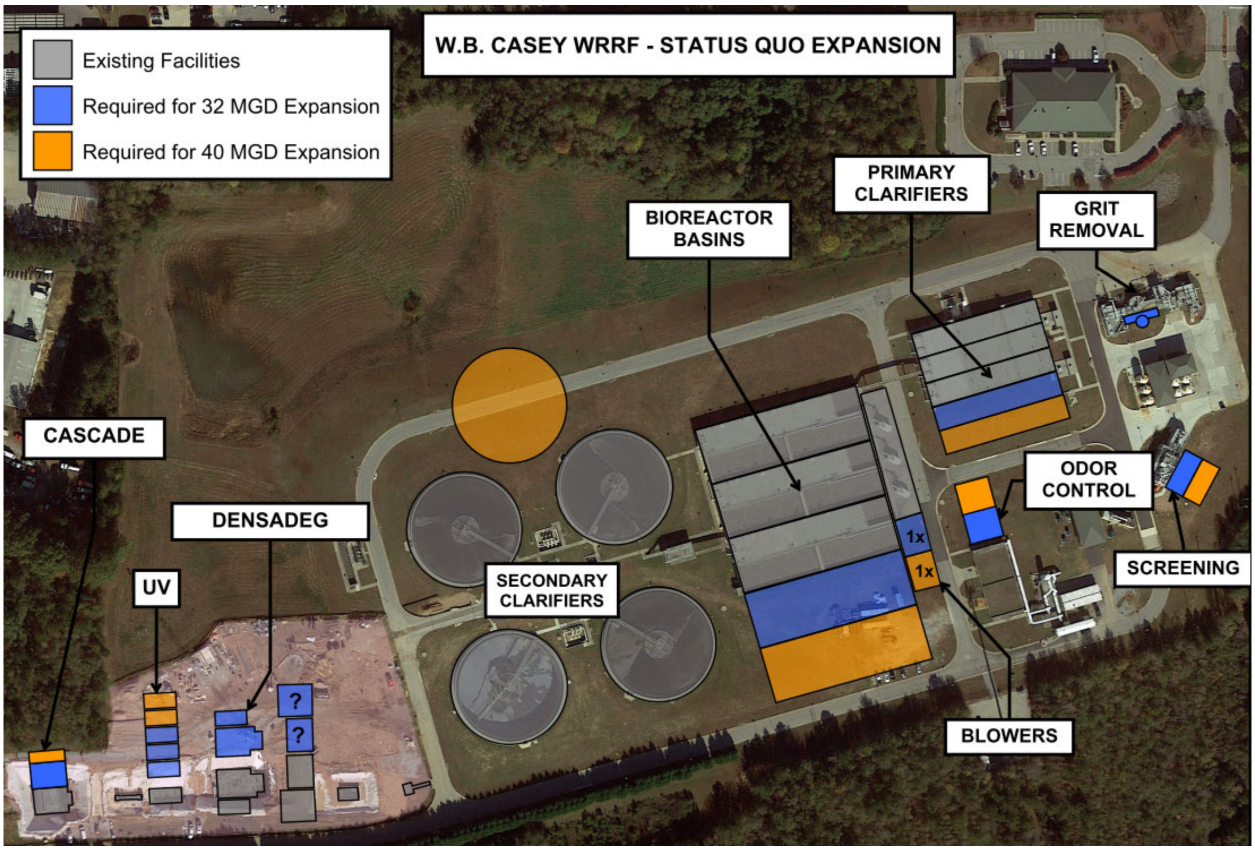

Figure 2. Status Quo Site Plan

4.2 IFAS

Figure 3 shows a site plan of the liquids treatment side of the Casey plant for the IFAS alternative. The most notable difference from Status Quo is that IFAS does not require construction of an additional bioreactor to yield a 32 MGD capacity. The "process intensification" yielded from the use of IFAS media has the benefit of a reduced footprint and the potential for a 40 MGD buildout capacity with only four bioreactors.

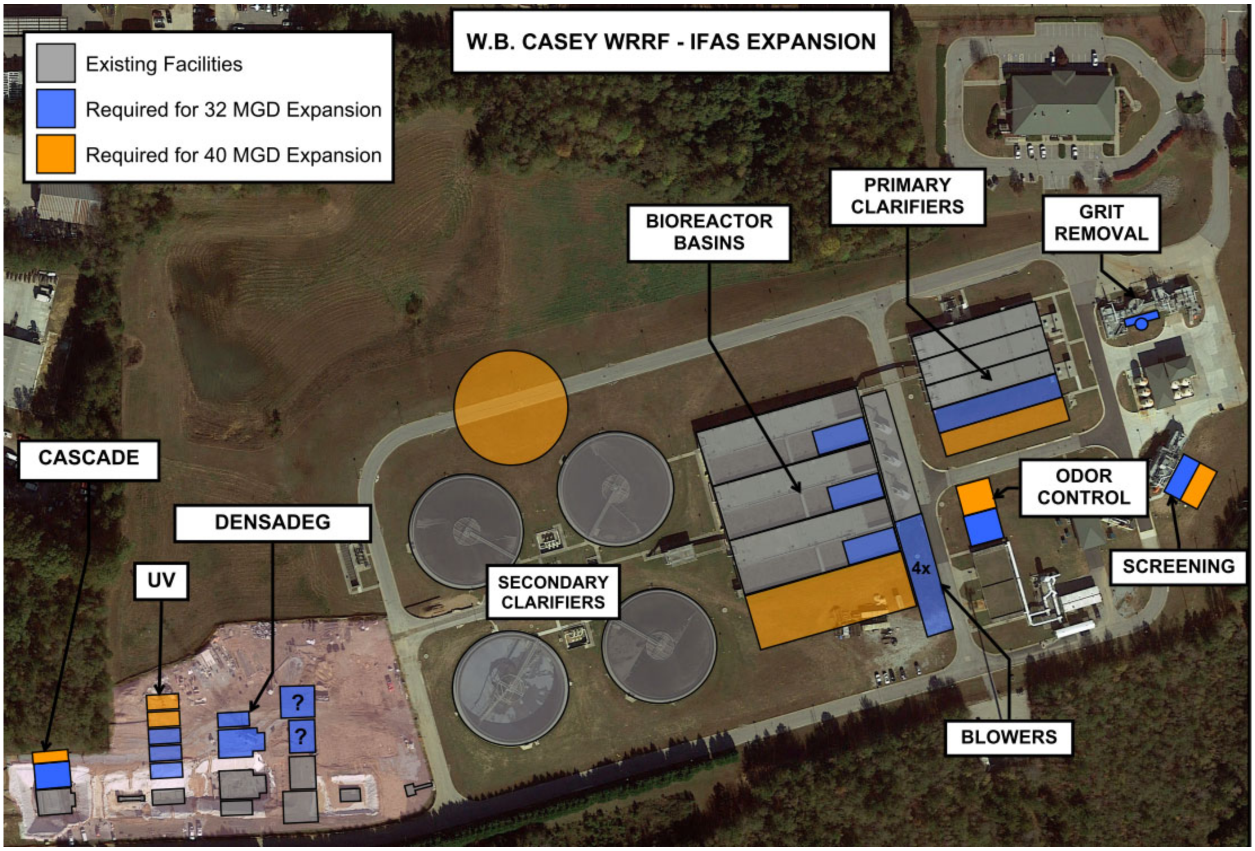

Figure 3. IFAS Site Plan

During the preliminary evaluation of alternatives, it was assumed that IFAS would require construction of an ultra-fine screening facility (2-millimeter [mm] openings) between the primary clarifiers and bioreactors. During subsequent evaluation, it was determined that the IFAS process could use Kruger K3 media, which is 10 mm thick by 25 mm diameter. Kruger confirmed that for this media, the existing 5-mm screening process upstream of primary clarification would offer adequate protection for the media and retention screens.

IFAS requires modification of each existing bioreactor to create a compartment for biomass carrier (shown in blue on Figure 3). These compartments would be aerated using coarse bubble diffusers. Because of velocity constraints in the biomass carrier compartment, it is impractical to pump NRCY from downstream of the compartment to upstream of the compartment. Instead, NRCY would be pumped by new submersible pumps through a submerged pipe, from the downstream end of the first pass to the upstream end of the first pass.

IFAS requires construction of a second DensaDeg train for 32-MGD plant capacity, but no additional DensaDeg train for 40-MGD plant capacity.

Implementation of IFAS would require only the minimum recommended fill fraction of biomass carrier (25 percent) to achieve treatment objectives. The addition of this biomass carrier results in better nitrification than required by permit, representing increased process resiliency with respect to unexpected nitrification inhibition. There also is potential to increase the fill fraction to as high as 67 percent to achieve even lower effluent ammonia if this should be required in the future.

Because initial implementation would require only the minimum fill fraction of biomass carrier, it would not be possible to stage media installation. As with the Status Quo alternative, the IFAS alternative has minimal opportunity for staged implementation. Of the facilities required to be constructed for 32-MGD plant capacity, the only facility that could be deferred until 28-MGD capacity is the second DensaDeg train.

4.3 Chemically Enhanced Primary Treatment

Figure 4 shows a site plan of the liquids treatment side of the Casey plant for the CEPT alternative. Similar to IFAS, the CEPT alternative requires less bioreactor volume that the Status Quo alternative.

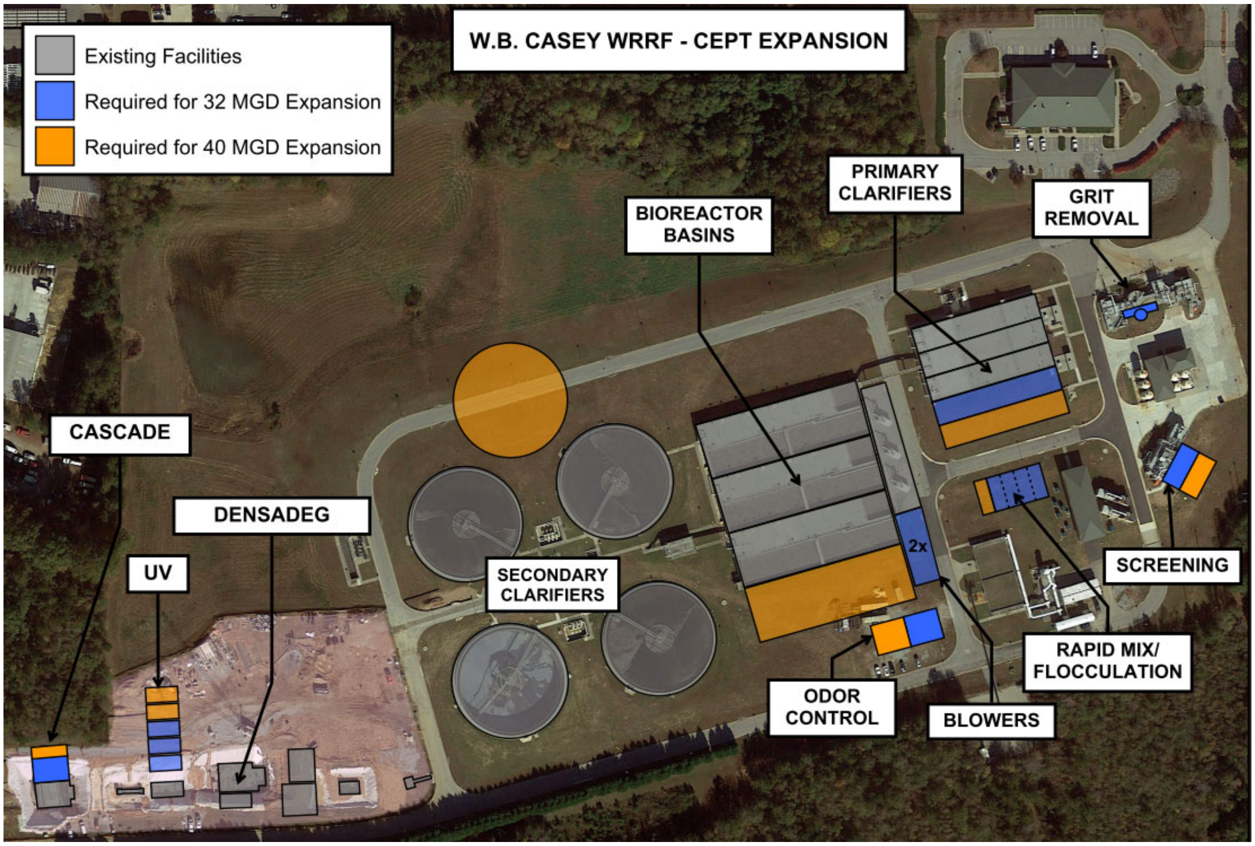

Figure 4. CEPT Site Plan

If this alternative were selected, jar testing should be performed to confirm performance and ferric sulfate and polymer use but this more detailed analysis was beyond the scope of this evaluation. Chemical use costs were based on assumed anticipated requirements. It was also assumed that "formal" mixing facilities would be required. It should be noted that "informal" CEPT capabilities, which consisted of chemical dosing points upstream of primary clarifiers, were an original feature of the Casey WRFF but the lines were removed during the 2015 upgrades.

The assumed CEPT mixing facilities would be located between grit removal and the primary clarifiers. Given limited available hydraulic head between these existing processes, there is a significant design constraint with respect to the configuration of a new mixing facility. To reduce the headloss, there would be one mixing train dedicated to each primary clarifier, rather than a flow split structure. There is insufficient physical space between grit removal and the primary clarifiers, hence it was assumed new mixing facilities would be constructed south of the primary clarifiers. While this configuration likely could be implemented within the headloss constraints, there would be an extensive amount of large piping, such that hydraulics between grit removal and primary clarification would need to be evaluated at a higher level of detail to confirm that mixing facilities can be inserted hydraulically between these processes without resorting to pumping.

Each mixing train has rapid mix tank and two-stage tapered flocculation. Ferric sulfate would be added to rapid mix. Polymer could be fed to first-stage flocculation. Indications are that polymer would not be required until capacity was increased to 40 MGD; however, having the ability to feed polymer at 32-MGD capacity would provide process flexibility.

While the CEPT alternative does not require construction of Bioreactor No. 4 until 40-MGD capacity, air piping and one diffuser grid in each existing bioreactor would need to be replaced for 32-MGD capacity to increase aeration capacity.

CEPT requires greater NRCY pumping capacity than the existing pumps can deliver. Existing pumps would be replaced.

Unlike Status Quo and IFAS, CEPT does not require a second DensaDeg train. It would achieve enough total phosphorus (TP) removal in primary treatment, secondary treatment, and the one DensaDeg train that is currently under construction.

CEPT removes more suspended solids in primary treatment than the other alternatives. Therefore, CEPT requires somewhat larger anaerobic digesters and produces more biogas. Larger digesters increase the cost of this alternative, but increased biogas production is advantageous because it decreases the amount of natural gas that needs to be purchased for biosolids drying. Both factors are considered in the cost analysis.

This alternative has no opportunity for staged implementation.

4.4 Facilities Comparison

Table 2 summarizes primary and secondary treatment facilities required for each alternative. Blower capacity is based on supplying the maximum day airflow with the largest unit out of service. The need to improve air piping in the existing bioreactors (for capacity recovery to 24 MGD) is based on 6,200 standard cubic feet per minute capacity per bioreactor, which was determined recently using pressure drop calculations and blower curves.

Table 2. Summary of Primary and Secondary Treatment Facilities Required for 32-MGD Capacity

Item	Existing 24 MGD Plant	32 MGD Upgrade Alternative		
		Status Quo	IFAS	CEPT
Mixing Facilities Needed (Yes/No)	No	No	No	Yes
Primary Clarifiers (Number)	3	4	4	4
Ultra-Fine Screens Needed (Yes/No)	No	No	Yes	No
Bioreactors (Number)	3	4	3	3
Blowers (Number)	3	4	6	5
Aeration Modifications Needed (Yes/No)	Yes	No	Yes	Yes
Secondary Clarifiers (Number)	4	4	4	4
DensaDeg Trains (Number)	1	2	2	1

4.5 Lifecycle Cost Comparison

Construction and operating costs were estimated for each alternative and then used to calculate lifecycle cost.

4.5.1 Construction Cost

Construction costs were estimated using Jacobs' Conceptual and Parametric Engineering System (CPES), a tool for process design and cost estimating. These cost estimates are Class 4, as defined by the Association for the Advancement of Cost Engineering International (AACEI). Accuracy is -30 to +50 percent. Construction costs are presented in December 2019 dollars.

Differential costs were determined, meaning only facilities that differ among the three alternatives were considered.

Cost estimates were developed for individual facilities (rapid mix, flocculation, bioreactor, DensaDeg, etcetera) using CPES. Typically, a different CPES module is used for each unit process. In these modules, CPES considers the cost for power supply to proposed facilities from non-specific electrical building(s). Markups for demolition, sitework, plant computer system, yard piping, and yard electrical were not added because these costs are expected to be similar for each alternative. There is one exception; yard piping to and from CEPT mixing facilities was considered because it would add a significant differential cost.

After determining a subtotal cost for all facilities in an alternative, sales tax was added. Based on similar projects, it was assumed that half of construction cost represented taxable equipment and materials. A tax rate of 8 percent was used.

After adding sales tax, the following markups were applied consecutively; that is, a new subtotal was determined after applying each markup.

- Contractor overhead 14 percent
- Contractor profit 6 percent
- Mobilization/bonds/insurance 6 percent
- Contingency 20 percent

Percentages for contractor overhead, contractor profit and mobilization/bonds/insurance match those used by Jacobs cost estimators when they estimated cost of the polishing project which is currently under construction. Twenty percent contingency is appropriate for the current level of concept development and the estimating methodology.

Table 3 presents construction cost results for the three alternatives. CEPT has the lowest construction cost. IFAS has the second lowest construction cost, approximately $4.1 million more than CEPT. Status Quo has the highest construction cost, approximately $6.6 million more than CEPT.

To put these cost differences in perspective, the overall plant expansion for the Status Quo alternative including all liquids and solids facilities (not just differential costs) is estimated to have a construction cost of $180 million (-30 to +50 percent).

Table 3. Construction Cost Comparison

Item	Status Quo	IFAS	CEPT
Primary Treatment			
Rapid mix			$640,000
Flocculation			$1,990,000
Yard pipe to/from mixing			$1,180,000
Ferric sulfate storage and feed			$620,000

Table 3. Construction Cost Comparison

Item	Status Quo	IFAS	CEPT
Secondary Treatment			
Bioreactor	$6,650,000	$1,130,000	$1,980,000
Biofilm carrier compartment		$3,380,000	
Blowers	$1,080,000	$1,690,000	$1,530,000
Tertiary Treatment			
DensaDeg process			
Rapid mix	$290,000	$290,000	
Flocculation and high-rate settling	$3,500,000	$3,500,000	
Chemical sludge pumps	$700,000	$700,000	
Ferric sulfate storage and feed	$510,000	$480,000	
Polymer storage and feed	$460,000	$460,000	
Solids Handling			
Anaerobic digesters[1]	$14,520,000	$14,540,000	$15,670,000
Facilities Subtotal	$27,710,000	$26,170,000	$23,610,000
With tax	$28,820,000	$27,220,000	$24,550,000
With contractor overhead	$32,850,000	$31,030,000	$27,990,000
With contractor profit	$34,820,000	$32,890,000	$29,670,000
With mobilization, bonds, insurance	$36,910,000	$34,860,000	$31,450,000
With contingency	$44,290,000	$41,830,000	$37,740,000
Difference to lowest cost	$6,550,000	$4,090,000	$0

[1] Digester cost is considered as digester volume is affected by primary sludge production.

4.5.2 Operation and Maintenance and Lifecycle Costs

Operation and maintenance (O&M) costs were developed using spreadsheet tools. Accuracy is -30 to +50 percent. Costs are presented in December 2019 dollars. Differential costs were determined, meaning only factors that differ among the three alternatives were considered.

The following components of operating cost were considered:

- O&M labor
- Electrical power (for blowers only)
- Equipment maintenance
- Biosolids disposal (credit)
- Chemicals (ferric sulfate and polymer)
- Natural gas (credit resulting from increased biogas production)

Table 4 presents unit costs and other assumptions used to determine lifecycle cost of operation and maintenance.

Table 4. Lifecycle Cost Assumptions

Item	Value	Note
Lifecycle	2022 through 2041 (20 years)	
Discount rate	2 percent per year	Accounts for inflation
Personnel cost (salary and benefits)	$43.64 per hour	Source: 2017 CCWA budget
Electrical power cost	$0.083 per kWhr	Source: CCWA
Pellet revenue	$10 per wet ton	Source: CCWA as February 12, 2019 workshop
Ferric sulfate cost	$1.24 per pound Fe $0.346 per pound $Fe_2(SO_4)_3$	Source: CCWA (revised following December 11 workshop)
Polymer cost	$1.25 per dry pound	Source: CCWA 2017 chemical bids
Natural gas cost	$3.764 per million BTU	Source: Average of 2018 prices provided by CCWA
Polymer usage	12 dry pounds per wet ton	Target for maximum usage
Equipment maintenance	0.5 percent of purchase price per year	

BTU = British thermal units

O&M labor was estimated using a spreadsheet tool published with *The Northeast Guide for Estimating Staff at Publicly and Privately Owned Wastewater Treatment Plants*[1]. This spreadsheet is based on a database of personnel requirements for existing facilities. The relative labor requirements for Status Quo, IFAS and CEPT were 0.97, 1.19, and 3.03 full time equivalent (FTE), respectively.

Table 5 presents results of the operation and maintenance and lifecycle cost analysis. IFAS has the lowest lifecycle cost, followed by CEPT ($0.1 million higher) and Status Quo ($0.9 million higher).

Table 5. Operation and Maintenance and Lifecycle Cost Comparison

Cost Component	Status Quo	IFAS	CEPT
Lifecycle Cost Operations and Maintenance Components			
Operation and Maintenance Labor	$1,410,000	$1,730,000	$2,940,000
Electrical Power	$4,420,000	$5,510,000	$5,060,000
Equipment Maintenance	$440,000	$420,000	$380,000
Pellet Revenue	-$910,000	-$950,000	-$890,000
Chemicals	$8,470,000	$8,650,000	$12,420,000
Natural Gas Reduction (Biogas Credit)	$0	-$10,000	-$380,000
Total Lifecycle Cost of Operation and Maintenance	$13,830,000	$15,350,000	$19,530,000
Capital cost	$44,290,000	$41,830,000	$37,740,000
Total Lifecycle Cost	$58,120,000	$57,180,000	$57,270,000
Difference to Lowest Cost	$940,000	$0	$90,000

[1] New England Interstate Water Pollution Control Commission. 2008. *The Northeast Guide for Estimating Staff at Publicly and Privately Owned Wastewater Treatment Plants.*

4.6 Non-Monetary Criteria Evaluation

Non-monetary criteria were established collaboratively with CCWA staff during the October 23, 2019 kickoff meeting. Criteria developed for solids process alternatives evaluation were used as a starting point to ensure consistency. These criteria were then modified slightly to be more relevant to the liquids process alternatives evaluation. Non-monetary criteria for the liquid stream evaluation are shown in Table 6.

Table 6. Non-Monetary Criteria Definitions

Criteria Name	Performance Measures	Comparative Scoring Criteria
Regulatory Compliance	How reliable are the treatment processes? What effort is required to ensure compliance?	Higher score for less permit risk and higher reliability.
Performance Capability	Does the technology allow for higher performance to meet more stringent regulations?	Higher score for process that can produce lower total phosphorus, total nitrogen, or remove contaminants of emerging concern.
Operations Complexity	Does addition of new process require unique equipment, additional training and/or more operator attention? Is there a reliance on suppliers for proprietary equipment or technical assistance?	Higher score for processes which are easier to operate. Higher score for no increase in staffing.
Worker Health and Safety	Is there anything about the process that requires a greater level of care to protect staff?	Higher score for processes with less risk with respect to worker safety.
Sustainability	Does the process allow for greater energy reduction or resource recovery? Does the process enhance the ability to recovery energy, nutrients, or organic material for beneficial reuse?	Higher score for greener technologies that use less energy and resources and could enhance resource recovery.
Expansion Potential	Does the process enable a phased approach? Does the process have a smaller footprint allowing for more expansion flexibility in the future?	Higher score for technologies that allow for flexibility in future expansion or which may save cost by allowing phased expansion approach.
Community Relations	Does the process have cause for nuisance to the community?	Higher score for technologies with less risk of fugitive odors, less truck traffic, and less noise.

In the Alternatives Evaluation workshop held on December 11, 2019, CCWA personnel ranked the non-monetary evaluation criteria defined in Table 6. Each pair of criteria was compared to determine which was more important to CCWA. This resulted in the scoring and weighting shown in Figure 5.

Criteria		Regulatory Compliance A	Performance Capability B	Operations Complexity C	Worker Health and Safety D	Sustainability E	Expansion Potential F	Community Relations G	Score	Weight
Regulatory Compliance	A		A	A	D	A	A	A	5	0.24
Performance Capability	B			B	D	B	B	B	4	0.19
Operations Complexity	C				D	E	C	C	2	0.10
Worker Health and Safety	D					D	D	D	6	0.29
Sustainability	E						E	E	3	0.14
Expansion Potential	F							G	0	0.00
Community Relations	G								1	0.05

Figure 5. Non-Monetary Evaluation Criteria Weighting

Worker health and safety is the top priority, followed by regulatory compliance, performance capability, sustainability, operations complexity, and community relations. For this evaluation, expansion potential was deemed to have zero weight (that is, not to have value). This is reflective of the fact that all options are expandable within the available footprint.

For each of the three liquid-stream expansion alternatives (Status Quo, IFAS, and CEPT), CCWA personnel assigned a score from 1 to 5 for each non-monetary evaluation criterion. Table 7 presents raw scores and overall weighted scores. Raw scores were not selected for "expansion potential," which had zero weighting. A perfect overall weighted scope would be 5.0. CEPT had the highest overall weighted score, followed by IFAS and then Status Quo. For operations complexity and worker health and safety, the scoring was equal for all alternatives. The rationales for differentiating between the alternatives for the other non-monetary criteria were as follows:

- **Regulatory Compliance**. CEPT was considered to have a greater advantage due to the reliability/predictability of the physical/chemical process in achieving effluent total phosphorus requirements.
- **Performance Capability**. IFAS was considered to have a performance advantage over Status Quo with respect to nitrification. CEPT was considered to have a performance advantage over Status Quo with respect to effluent total phosphorus.
- **Sustainability**. CEPT had a higher score due to the potential to produce more biogas with increased primary sludge production.
- **Community Relations**. CEPT was scored lower due to the increased truck traffic that would result from chemical deliveries and increased odor control challenges resulting from rapid mix and flocculation tankage.

Table 7. Non-Monetary Criteria Alternative Scoring

Parameter	Regulatory Compliance	Performance Capability	Operations Complexity	Worker Health and Safety	Sustainability	Community Relations	Overall Weighted Score
Weight	0.24	0.19	0.10	0.29	0.14	0.05	---
Raw Scores							
Status Quo	3	3	3	3	3	3	---
IFAS	3	4	3	3	3	3	---
CEPT	4	4	3	3	4	2	---
Weighted Scores							
Status Quo	0.71	0.57	0.29	0.86	0.43	0.14	3.00
IFAS	0.71	0.76	0.29	0.86	0.43	0.14	3.19
CEPT	0.95	0.76	0.29	0.86	0.57	0.10	3.52

The non-monetary scoring conducted in the December 11, 2019 workshop resulted in CEPT as the front runner, followed by IFAS, and then Status Quo. While CEPT had the highest (best) non-monetary score, Status Quo had the lowest (best) lifecycle cost. When CCWA personnel voted on the preferred alternative based on preliminary cost and non-monetary score, there was one vote for CEPT, and the others were for Status Quo. The fact that the vote did not match the results of the scoring exercise indicates that the non-monetary criteria and scoring did not fully capture the views of CCWA staff. When faced with the reality of the decision to select a new process configuration, the group questioned the merits of changing the process configuration since they have had good success maintaining the facility and staying in compliance.

Since the December 11, 2019 meeting, the analysis was further refined (final numbers reported herein) to reflect revised ferric sulfate unit cost and removing IFAS ultra-fine screening. These refinements have resulted in closer lifecycle costs among the three alternatives then previously presented.

5. Summary and Conclusions

The following key determinations were made in comparing Status Quo, IFAS, and CEPT alternatives with respect to the conceptual design and cost analysis:

- Footprint is not a differentiator. Any of these alternatives would allow the plant to be expanded to a tentative buildout capacity of 40 MGD maximum monthly average flow.
- Staged implementation is not a differentiator. None of the alternatives offered a significant cost savings by deferring a portion of the capital cost required for upgrade.
- Process intensification yields some construction cost savings. CEPT has the lowest construction cost. IFAS would cost $4.1 million more than CEPT, while Status Quo would cost $6.2 million more than CEPT.
- Lifecycle costs are similar enough that cost should not be a major differentiator in the final alternative selection. IFAS has the lowest lifecycle cost. CEPT would cost $0.1 million more the IFAS, while Status Quo would cost $0.9 million more than IFAS.

Since the onset of this project, updated flow projections and further analysis has led CCWA to defer the design of the Casey WRRF liquid stream unit processes but proceed with design of the biosolids unit processes. While CCWA can reassess or alter the liquid stream process approach in the future, a liquid stream alternative selection is still required to form the basis of design for the biosolids unit processes. Based on this deferment and the analysis described herein, Jacobs recommends the following:

- Eliminate CEPT from further consideration as CEPT would sink cost into chemicals rather than infrastructure and would increase the capacity requirements (and cost) of biosolids unit processes.
- Given current success with Status Quo and no compelling reason to switch to IFAS, assume the Status Quo configuration will remain in place for the foreseeable future and use the mass balance and site plan from the 32 MGD Status Quo alternative for the solids facilities design.

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Memorandum

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SUBJECT	**Task 6 TM, Part 1 – W.B. Casey WRRF Biosolids Alternatives Evaluation**
PROJECT NAME	W.B. Casey WRRF Capacity Analysis and Plant Expansion Evaluation
ATTENTION	Clayton County Water Authority (CCWA)
FROM	Michael Yang/Jacobs/Engineering Group Inc. (Jacobs)
REVIEWED BY:	Todd Williams, Scott Levesque, Kristina Yanosek/Jacobs
DATE	September 27, 2019

1. Introduction

The W.B. Casey Water Resources Recovery Facility (Casey WRRF) currently dries and pelletizes approximately 15 tons of biosolids per day through its pelletizing facility and sells the product to the agricultural industry as a valued fertilizer. The pelletizing facility has been operating for approximately 40 years and has surpassed its plant flow-based operational capacity of 19 million gallons per day (MGD). Additionally, the facility has significantly surpassed its design life. As a result, CCWA has embarked on developing plans for a new biosolids facility and management approach. The purpose of the Casey WRRF Biosolids Alternatives Evaluation is to provide a comprehensive review of biosolids management technologies and to select a management alternative that best meets the goals of CCWA with respect to its future wastewater treatment demands. This memorandum presents results of the Casey WRRF Biosolids Management Alternatives Evaluation.

Jacobs proposed a list of potential biosolids management technologies to CCWA at the first workshop in November 2018. Following a detailed review of current industry trends and discussions of CCWA staff experience, various technologies were eliminated from consideration. Technologies deemed compatible with CCWA biosolids management goals included the following:

- Thermal hydrolysis process (THP) in conjunction with anaerobic digestion
- Anaerobic digestion (mesophilic and thermophilic)
- Rotary drum thermal drying

Six process train alternatives including various combinations of these technologies were selected for further evaluation. Evaluation of these alternatives included a 20-year life cycle cost and non-monetary criteria comparison evaluation.

2. Evaluation of Existing Solids Processes and Facilities

2.1 WAS Thickening

The existing solids processing train produces primary sludge (PS), waste activated sludge (WAS), and primary and secondary scum. Primary scum is concentrated and taken to landfill through a third party. The WAS and secondary scum are pumped separately to dissolved air flotation thickening (DAFT) for thickening to approximately 3 percent solids. Because the existing DAFT facilities have exceeded their useful life, they will be replaced with a rotary drum thickener (RDT) facility, which is currently under construction. The new thickening facility will enable WAS to be thickened to 4 to 6 percent solids. This evaluation assumes RDTs will be used for future WAS thickening for all alternatives considered.

2.2 Sludge Holding Tank

The thickened WAS (TWAS) and PS are currently pumped to a 420,000-gallon sludge holding tank for mixing. The existing sludge holding tank is approximately 60 feet in diameter and 20 feet of effective side water depth, equipped with a pump recirculation system for mixing. Off-gas is captured and treated in a biofilter. An unused smaller tank (former digester) has a capacity of 136,000 gallons. The unused tank is approximately 36 feet in diameter and 18 feet of effective side water depth and is not equipped with mixing or off-gas capture system. The currently used sludge holding tank was built in 1964, and the unused tank was built prior to 1964. Due to the age of both tanks, a structural analysis will be required to evaluate if the structural integrity is adequate for an additional 20 years of service as part of any future solutions. For this study, sludge holding tanks in each alternative are assumed to be new tanks.

2.3 Post Dewatering

The blended sludge from the existing sludging holding tank is dewatered by belt filter presses (BFP) in the existing thermal drying facility (TDF). Two 2.2-meter Andritz presses are dedicated to pelletizing and one 2.2-meter Ashbrook Klammpress can be used to bypass drying and send cake to a trailer for hauling to offsite composting or landfilling by a third party. The Andritz presses and the Ashbrook Klammpress typically produce cake with average of 16 and 19 percent dry solids, respectively.

In 2012, the two Andritz presses were retrofitted with Ashbrook rollers, bearings, and pneumatics. Since the retrofit, multiple replacements of shaft bearings and rollers have been required each year for both Andritz presses due to misalignment between the Andritz press frame and the Ashbrook parts. According to CCWA, the supporting structure for the two Andritz presses has increased in vibration over the years, resulting in frequent roller replacement. Additionally, there are safety concerns with the roller replacement process due to inadequate platform space and hoisting equipment. This has become a major concern for CCWA maintenance staff. For these reasons, this study assumes total replacement of the dewatering units and facility for all evaluated alternatives.

2.4 Thermal Drying

The dewatered sludge cake from the BFPs is mixed with recycled product in a pugmill mixer to bring the solids content up to 70 to 75 percent. The material is then discharged into two Baker-Rullman rotary kiln triple pass dryers that produce pellets with solids content up to 95 percent. Each of the two rotary kiln dryers has an evaporation capacity of 4,578 pounds water per hour (lb/hr). The pellets are pneumatically conveyed through a dual cyclone separator where particles drop and are separated from the air stream. Off-gas is treated with a two-stage wet scrubber system. The first stage is a venturi scrubber using plant water only, which is designed for particulate removal. The second stage is a packed tower chemical system designed for odor control. Caustic (NaOH) and bleach (NaOCl) are used for gaseous pollutant removal. Approximately 1.1 MGD of plant water is used in the scrubber system. The dry solids are lifted using an elevator and are separated into oversize, product, and fine size fractions in a vibrating screen. Product-size pellets (1 to 4 millimeter [mm] diameter) are cooled, coated with Dustrol® for dust control, and sent to product storage. Oversize pellets are crushed in the crusher, combined with fine-size pellets and passed through the recycle bin into the pugmill mixer for blending with incoming dewatered sludge cake. The final product from the pelletizing facility is a Class A biosolids material that CCWA sells to the agricultural industry via a broker for use as fertilizer.

CCWA has had problems maintaining pellet quality because of the fiber in the undigested PS, which results in a ‘fuzzy’ pellet. These lighter pellets produce excess dust and volume, increase transportation costs, and make application more difficult, thus reducing its value as fertilizer. The performance of the TDF deteriorates if there is an excess ratio (mass basis) of PS to TWAS. A bypass was installed to transfer primary sludge from the hoppers of the primary sedimentation tanks to the bioreactor basins (BRBs) to decrease the PS:WAS ratio in the sludge blending tank thereby inadvertently converting PS to TWAS. Although the partial bypass around the primary treatment has enabled control of the PS:WAS ratio and improved pellet quality, it increases the treatment loading in the BRBs.

The TDF has been operating for approximately 40 years and has surpassed its plant-flow-based operational capacity of 19 MGD. In addition, many areas of the facility have been identified as a maintenance and safety concern by CCWA staff. An example is the location of the pugmill directly above the dryer burner. According to CCWA staff, they have witnessed deflagrations occur inside the pugmill causing the covers to swing open, which could have caused injuries to any nearby operators. Another safety concern is the high amount of combustible dust that escapes from conveyors and storage equipment. CCWA was notified by Jacobs that a new standard, National Fire Protection Association (NFPA) 654, requires existing sludge drying facilities to conduct a Dust Hazard Analysis (DHA) every 5 years to show adequate safety measures are implemented to prevent and mitigate fire and dust explosion hazards. Based on a preliminary visit by Andritz in October 2018, the existing facility will likely require a significant upgrade to meet the NFPA 654 standards. CCWA is planning to contract with Andritz to perform a DHA and define the specific upgrades required for compliance with these standards. For these reasons, this study assumes a total replacement of the existing TDF for all alternatives with thermal drying.

3. Proposed Alternatives and Design Criteria

Table 1 summarizes the alternatives proposed for the initial feasibility screening workshop in December 2018. Alternatives 1 and 2 were eliminated due to the need to balance PS:WAS ratio to maintain pellet quality. Alternative 6 was eliminated due to CCWA's preference to remain independent from third parties for its future biosolids management. Alternative 3c (not listed in Table 1) was added to evaluate the relative cost difference of producing Class B cake compared to Class A cake and pellets. At the screening feasibility workshop held on February 14, 2019, six alternatives were selected for cost and benefit evaluation. Table 2 summarizes the selected six alternatives.

3.1 Alternative Evaluation Assumptions

Below are assumptions made in the evaluation for the unit processes included in the six selected alternatives:

- All alternatives include an RDT facility to thicken PS to 5 percent dry solids.
- All alternatives include a sludge screening facility downstream of the RDT facilities (processing PS and WAS) to remove debris not otherwise removed by upstream processes.
- Pre-digestion holding tanks are designed for total of 8-hour hydraulic retention time (HRT); two tanks, each with 4-hour HRT.
- Post-digestion holding tanks are designed for total of 3-day HRT; two tanks, each with 1.5-day HRT.
- No added biogas storage beyond what is available in standard digestion tanks is included for anaerobic digesters. All biogas not used for digester heating, sludge drying, or thermal hydrolysis is assumed to be flared.
- Pre- and post-dewatering facilities are designed for maximum monthly average conditions with one duty and one standby unit.
- For non-THP alternatives, Centrifuge is used for post-dewatering to dewater digested sludge to an average of 23 percent cake.
- For THP alternatives, a BFP is used for post-dewatering to dewater digested sludge to an average of 30 percent cake.
- Existing storage bunkers will be used for pellet storage.
- Operating schedules for all processes is seven days per week, 24 hours per day (24/7) except for post-dewatering and thermal drying, which is 5 days per week, 24 hours per day (24/5).

Table 1. Proposed Biosolids Management Alternatives

Alternative	Advantages	Disadvantages
1 – Expand on Status Quo	• Retain present operational strategy. • Established known product outlets. • Alternative is suitable to receive cake from Northeast WRF.	• Additional dryer capacity will be required. • Existing dryer equipment approaching end of useful life and may need to be replaced altogether. • Requires balance of PS:WAS ratio for pellet quality. However, installation of sludge strain presses prior to dewatering would help mitigate this problem. • Energy intensive due to use of natural gas for pelletizing.
2 – Aerated Holding Tank + Status Quo	• Same as Alternative 1. • Aeration in holding tank possibly reduces the need for PS:WAS ratio balance. Installation of sludge strain presses prior to dewatering could mitigate this problem even further. • Reduces the impact of orthophosphate and volatile fatty acids in the recycle stream (reduces plant metal salt use). • Decreased odor potential in pelletizing facility.	• Additional dryer capacity will be required. • Existing dryer equipment approaching end of useful life and may need to be replaced altogether. • Energy intensive due to use of natural gas for pelletizing. • Slight increase in energy use over Alternative 1 due to aeration of holding tank.
3a – MAD (12d SRT) + TD	• Established known product outlets. • Eliminates the need PS: WAS ratio balance because digestion breaks down fibrous material in PS and digestion makes both PS and WAS more amenable to drying. • Digestion reduces solids loading to dewatering and drying, which will reduce expanded capacity of dryers. • Digestion supports biogas energy recovery. Biogas most likely would be used to support pellet facility. • MAD supports codigestion of FOG without detriment to pellet quality. • Decreased odor potential in pelletizing facility. • Less potential for dust and thermal events compared to status quo.	• Existing dryer equipment approaching end of useful life and may need to be replaced altogether. • May require some cleaning of biogas prior to use in the pelletizer. • Adds operation complexity to the present status quo operation strategy.
3b – MAD PS (12d SRT) + WAS + TD	• Same as Alternative 3a. • Reduced digestion footprint compared to Alternative 3a. • Alternative is suitable to receive cake from Northeast WRF. • Eliminates any potential impact on future UV compared to Alternatives 4a and 4b. • Only one sludge holding/blending tank required. • Sidestream treatment not needed.	• Same as Alternative 3a. • Slightly lower dewatered cake solids vs. Alternative 4 options.

Table 1. Proposed Biosolids Management Alternatives

Alternative	Advantages	Disadvantages
4a – THP (WAS) + PS+ MAD (12d SRT) + TD	• Same as Alternatives 3a and 3b. • Significantly enhances biogas energy recovery and VSR. • Reduced digestion footprint compared to Alternative 3a. • Improved sludge dewatering (higher cake TS resulting in less energy needed for drying). • Alternative is suitable to receive cake from Northeast WRF. • Less potential for dust and thermal events compared to Status quo.	• Same as Alternatives 3a and 3b. • Increases operational complexity. • Sidestream treatment may be required to control nutrient loading to biological plant. • Uncertain impact of THP on pellet formation. Could be problematic. • Likely impact on UV system sizing due to decrease in UV transmittance from recalcitrant compounds formed by THP.
4b – THP (WAS+PS) + MAD (12d SRT)	• Same as Alternative 4a. • Achieve Class A cake without pelletizing facility. • Eliminates thermal drying facility O&M. • Improved sludge dewatering (higher cake TS). • Alternative is suitable to receive cake from Northeast WRF.	• Same as Alternative 4a. • Larger THP process than Alternative 4a. • Dependence on third party for land application. • Less diverse product outlets. • Increase in truck traffic from facility.
5 – TAD (8d SRT)	• Same as Alternatives 3a and 3b minus pelletizing facility advantages. • Enhances biogas energy recovery and VSR more so than mesophilic. • Achieves Class A cake without pelletizing facility. • Excess biogas beyond digester heating needs will allow for potential CNG or Co-Gen use.	• Same as Alternatives 3a and 3b minus pelletizing facility disadvantages. • More complex to operate and maintain than MAD. • Product quality is less than Alternative 4b and status quo. • Requires more energy for digester heating than MAD. • Demonstrate Class A requirement by measuring pathogens, as opposed to use of treatment technique. • Dependence on third party for land application.

Table 1. Proposed Biosolids Management Alternatives

Alternative	Advantages	Disadvantages
6 – Dewatering + Third Party	• Eliminates O&M requirement relative to status quo. • Eliminates need to balance PS/WAS ratio. • Potential synergy with sludge management at Northeast WRF.	• Dependent on third party for solids management. • Odor from unstabilized sludge. • Handling of unstabilized sludge can impact worker health and safety. • Significantly increases truck traffic from facility. • Uncertainty with respect to long term viability. • New dewatering and cake storage facility required.

CNG = compressed natural gas

MAD = mesophilic anaerobic digestion

O&M = operations and maintenance

SRT = sludge retention time

TAD = thermophilic anerobic digestion

TD = thermal drying

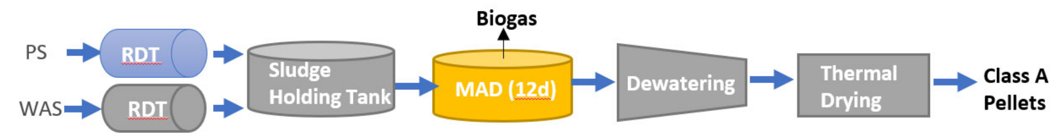
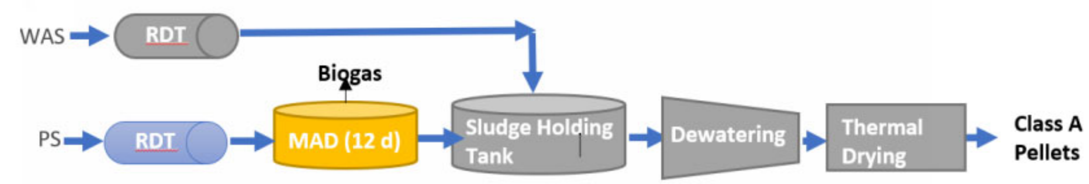
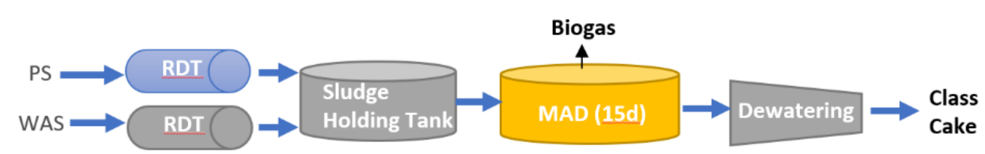
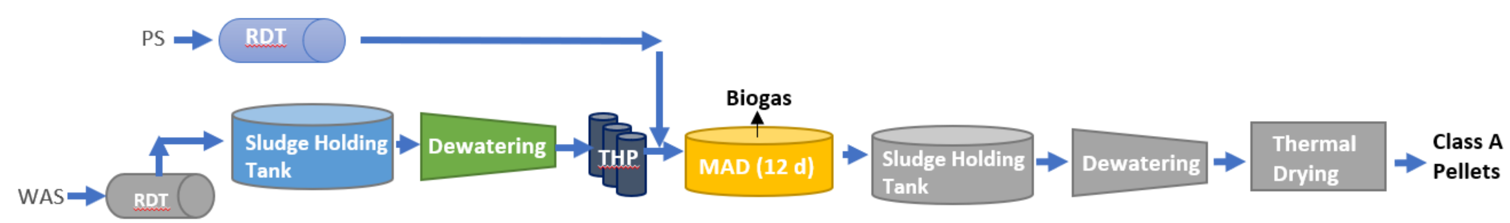
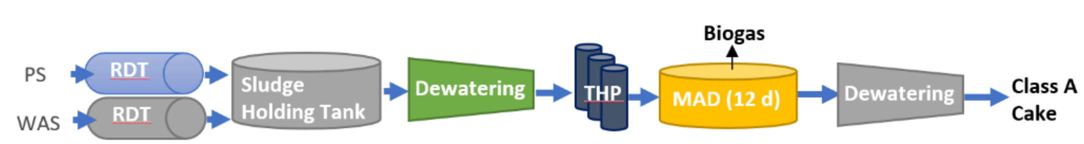
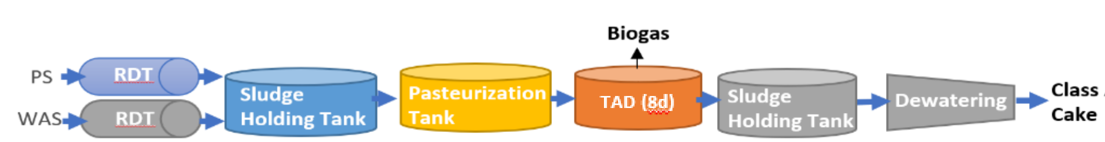
THP = thermal hydrolysis process

TS = total solids

UV = ultraviolet

VSR = volatile solids reduction

Table 2. Biosolids Management Alternatives Considered for Cost and benefit Evaluation for CCWA

Alternative	Process Description	Process Flow Diagram
3a	MAD (12d SRT) + TD	
3b	MAD PS (12d SRT) + WAS + TD	
3c	MAD (15d SRT)	
4a	THP (WAS) + PS+ MAD (12d SRT) + TD	
4b	THP (WAS+PS) + MAD (12d SRT)	
5	TAD (8d SRT)	

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3.2 General Solids Design Criteria

A whole-plant model of Casey WRRF was developed using BioWin, a commercial process simulation software. Model parameters were adjusted (calibrated) to fit simulator predictions to 2017 plant data provided by CCWA. The solids productions were then projected linearly from 2017 to the design year, during which the maximum monthly average plant influent flow is 32 MGD. Table 3 summarizes the design annual average (AA) and maximum monthly average (MMA) solids loads used for this biosolids management study.

Table 3. General Solids Design Criteria

Parameter	Value (Dry lb/d)
Average Annual Load	
Primary solids production	37,600
Thickened secondary solids production	30,500
Total solids production	68,100
Max Monthly Average Load	
Primary solids production	47,300
Thickened secondary solids production	35,100
Total solids production	82,400

lb/d = pounds per day

3.3 Thermal Hydrolysis Process

3.3.1 Process Overview

In the THP, thermal hydrolyses of wastewater solids is achieved by processing solids at about 170 degrees Celsius (°C) at 5 to 6 bars of pressure (320 degrees Fahrenheit [ºF] and 105 pounds per square inch) for 20 to 30 minutes. The process is designed to lyse bacterial cells in WAS and cellulosic material from PS, and to break down extracellular polymer substances (EPS). The overall impact is that the hydrolyzed solids digest more efficiently in anaerobic digesters after THP, resulting in higher volatile solids reduction (VSR) than traditional high-rate mesophilic anaerobic digestion (MAD). The process also allows higher volatile solids loading rates (VSLR) than traditional high rate MAD. Furthermore, the process reduces the viscosity of the solids such that higher solids concentrations can be pumped and mixed in digesters. These factors combine to reduce the required volume of the anaerobic digesters by 50 percent or more over conventional MAD. THP systems can either be batch or continuous. Batch systems have been used for many years with over 70 installations worldwide. Continuous systems are in the early stages of commercial development. The following technology description focuses on the batch system.

The batch THP system with the most successful installations is provided by Cambi AS (Asker, Norway). The process is illustrated schematically on Figure 1. Combined PS and WAS are dewatered to 16.5 percent dry solids or higher and stored in a cake bin. The pre-dewatered solids are pumped to the first stage of the THP system, called a pulper. If the pre-dewatered solids are at a concentration higher than 16.5 percent, dilution water is added ahead of the progressing cavity pulper feed pumps. The pulper acts as a reservoir ahead of the reactors, in which thermal hydrolysis takes place.

Flash steam from downstream of the process is returned to the pulper and mixes and heats the pre-dewatered solids. Air vented from the reactors during filling is also directed to the pulper, which in turn is vented to a process/ foul gas cooler and condenser in the pre-dewatering facility. Non-condensable gases are vented into the hydrolyzed feed to the digesters. Reactor feed pumps operate continuously and feed each reactor or recirculate and mix the pre-dewatered solids. Each reactor is filled separately. During filling, steam, nominally at 175 pounds per square inch gauge (psig), is injected into the feed solids until the reactor is filled to its required level. Steam continues to be added until the reactor contents are approximately 320ºF. The reactor remains at this temperature for 20 to 30 minutes, depending on the requirement for meeting Class A pathogen reduction.

Once the reactor cycle is complete, the hydrolyzed solids are discharged to a flash tank where the pressure is rapidly reduced to 3 psig or less. During flashing, some of the liquid is released as flash steam to the pulper. The hydrolyzed solids end up at about 14 percent dry solids. The hydrolyzed solids are then pumped to the anaerobic digesters. The material is hot, about 220ºF, and must be cooled prior to feeding to the digester. Available cooling options are discussed below. The THP system can be configured with multiple reactors, depending on throughput requirements. Each reactor operates on its own cycle, which takes about 60 to 80 minutes between fills.

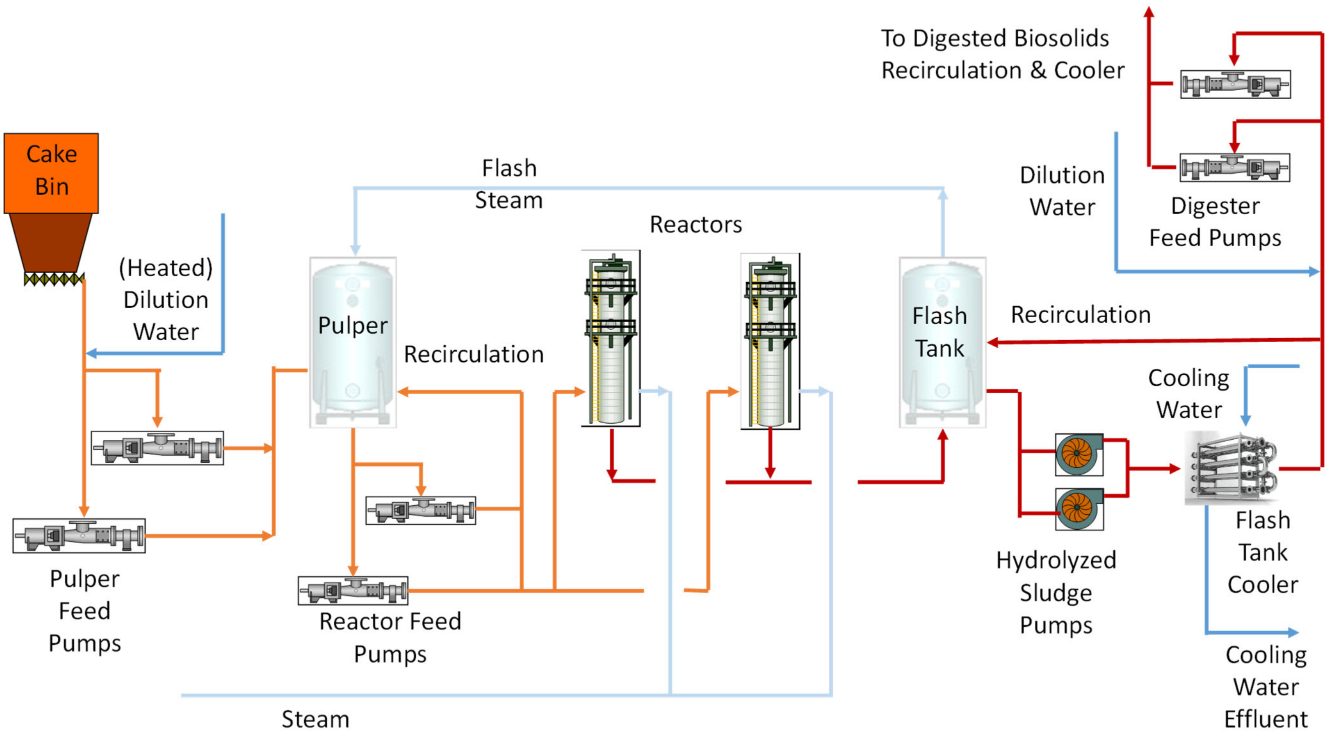

Figure 1. Thermal Hydrolysis Process (THP) Schematic

One option for cooling the hydrolyzed solids is to pump it to a cooling heat exchanger where it is cooled to about 100ºF. If a progressing cavity pump is used, pathogen free dilution water is added to reduce the temperature to about 185ºF to protect the pump stator. The material at this stage is at approximately 11 percent dry solids. At this temperature, the material has a reduced viscosity and pumps relatively easily. Prior to feeding to the cooler, the hydrolyzed solids are mixed with recirculated digester solids at a volumetric ratio of about 3:1 to 4:1 (digester solids to THP solids). This results in combined temperature of about 115ºF entering the cooler at a concentration of 6.5 to 8 percent dry solids. The cooler is a tube-in-tube counter-flow heat exchanger cooled either with a continuous supply of plant effluent water or closed-loop plant effluent cooled by an air-cooled heat exchanger, using adiabatic cooling, for example. The mixture is cooled to about 100ºF before being fed to the digesters.

Two major disadvantages of THP were considered in this study. First, the THP can produce recalcitrant organic compounds, which can decrease plant effluent ultraviolet (UV) transmittance. This was considered in the evaluation by including incremental capital cost of the UV process. Second, the impact of THP on pellet quality is uncertain because of lack of known full scale installations with this configuration, creating a risk factor for this alternative. It would be difficult to mitigate this risk by bench or pilot scale testing of THP, MAD, and drying.

3.3.2 Process Steam

Process steam is used to heat the THP reactor(s). Process steam is generated at 175 psig. The steam is generated from energy recovered from the combined heat and power system (if used) and auxiliary boiler(s). The process steam pressure required at each reactor is approximately 85 psig. Process steam is fed for about 15 to 20 minutes during the sludge feed cycle, beginning shortly after the feed starts. When the reactor is filled and at temperature, steam feed is stopped. Once sludge feed to the first reactor is stopped, feed to the next reactor can be started. Automatic control systems regulate the actual flow of steam to each reactor and length of time to dampen the variation in steam demand by the system.

3.3.3 Unit Process Basis/Design Criteria

The design parameters for THP alternatives are summarized in Table 4. The operating schedule is 24 hours per day and 7 days per week. Centrifuge dewatering is assumed with a dewatered sludge solids content up to 16.5 percent prior feeding to THP. The projected design year's max monthly average dryer solids loading governs the capacity of the THP system. The THP system is design for one duty unit with no spare. The THP system is required to be offline for 3 to 4 weeks per year for maintenance. During this time, sludge will be dewatered via pre-dewatering centrifuge and sent to trailers for third party composting or landfilling.

Table 4. Thermal Hydrolysis Process Design Criteria

Parameter	Units	Alternative	
		4a	4b
		THP (WAS) + MAD PS (12d SRT) + TD	THP (WAS+PS) + MAD (12d SRT)
Sludge type		WAS	WAS / PS
Design year THP solids feed projection (max monthly average)	ppd	31,700	72,200
Design year THP solids feed projection (annual average)	ppd	27,500	59,700
THP solids feed (design)	%	16.5 %	16.5 %
THP solids max month flow (design basis)	gpm	16	36
THP solids average day flow	gpm	14	30
Unit capacity (at design sludge density)	gpm	16	36
Number of units (trains)	#	1	1
Number of spares	#	0	0
Steam demand (design basis)	lb/hr	3,400	7,700
Average max monthly average steam demand	lb/hr	1,650	3,760
Average annual average steam demand	lb/hr	1,470	3,110

gpm = gallons per minute

lb/hr = pounds per hour

ppd = pounds per day

3.4 Anaerobic Digestion

3.4.1 Process Overview

The objective of anaerobic digestion is to stabilize the biodegradable organic matter present in a sludge. It is stabilized by conversion to carbon dioxide (CO_2) and methane (CH_4), both of which are gases that can be easily removed from the sludge. Stabilization occurs in three basic steps:

1. Hydrolysis (disintegration) of particulate and high molecular weight organic compounds (carbohydrates, proteins, and fats) to low molecular weight organic compounds (sugars, amino acids, and long-chain fatty acids).

2. Acid Formation: Fermentation of low molecular weight organic compounds to acetate, formic acid, hydrogen (H_2), and CO_2.

3. Methanogenesis: Conversion of acetate, formic acid, and H_2 to CH_4 and CO_2.

By solubilizing the biodegradable organic matter and converting it to CH_4 and CO_2, the solids concentration of the sludge is reduced. Successful digestion of sludge requires that each of these processes (hydrolysis, acid formation, and methane formation) occurs in the proper order and at the proper rate. The rate and extent of the entire process may be limited by any one of the steps. All three processes are taking place simultaneously. If operated properly, the process is stable and will perform reliably.

The anaerobic digestion process may be designed and operated for temperatures in either the mesophilic (25 to 35°C) or thermophilic (45 to 55°C) range. Although different groups of organisms will be cultured when the digester is operated in the two temperature ranges, the performance of the digester will be similar. Consequently, similar process design criteria may be used for mesophilic and thermophilic digestion. Because of the reduced heating requirements, most digesters are designed for operation in the mesophilic range.

3.4.1.1 Hydrolysis

Most of the readily biodegradable organic matter present in anaerobic digester feed exists as particulate and high molecular weight organic compounds. The role of the hydrolysis of these materials in anaerobic digestion is often neglected. These materials cannot be fermented directly to short-chain volatile fatty acids (acetate and others) but must first be converted to the low molecular weight organic compounds (sugars, amino acids, and long-chain fatty acids). Hydrolysis occurs through the action of extracellular enzymes that are produced by facultative and obligate anaerobic bacteria present in the digester. The rate of hydrolysis is different for various types of materials. Many materials are hydrolyzed quite rapidly, but others are hydrolyzed rather slowly. The rate of hydrolysis of fats is very slow and may control the overall rate of digestion.

3.4.1.2 Acid Formation

Acid formation is the conversion of the low molecular weight organic compounds (sugars, amino acids, and long-chain fatty acids) to acetate, formic acid, CO_2, and H_2O). Other short-chain volatile fatty acids (for example, propionate and butyrate) may be formed first and then converted to the final products.

Acid formation is a rapid reaction. The rapid nature of the reaction and the acidic nature of the reaction products can lead to digester upset if not properly controlled. If sludge is fed to the digester too rapidly, it may be hydrolyzed and converted to volatile acids more rapidly than the acids can be removed by the methane formers. The formation of the acids will reduce the pH of the reactor and reduce biological activity (a good reason for small but frequent digester feedings each day).

3.4.1.3 Methane Formation

Methane formation is the conversion of acetate, formic acid, and H_2 to CH_4 and CO_2. This biotransformation is accomplished by a group of highly specialized bacteria. They are obligate anaerobes (intolerant of oxygen) and are quite sensitive to environmental conditions. The sensitivity of these organisms to environmental conditions contributes to many digester upsets. For example, if sludge is fed to the digester too rapidly and a drop in the reactor pH occurs (as described in Section 3.4.1.2), the methane formers may be inhibited by the low pH, and methane formation will stop. Sludge will be stabilized only if methane formation is occurring.

Successful digestion of sludge requires that each of these processes (hydrolysis, acid formation, and methane formation) occurs in the proper order and at the proper rate. The rate and extent of the entire process may be limited by any one of the steps. All three processes are taking place simultaneously. As described, the interactive nature of the process can lead to process upsets. If operated properly, however, the process is quite stable and will perform reliably.

3.4.2 Thermophilic Digestion

Most anaerobic digesters are operated in the mesophilic (95°F or 35°C) temperature range. They can, however, be operated in the thermophilic (131°F or 55°C) temperature range. Design criteria and system performance for thermophilic anaerobic digestion (TAD) are essentially the same (though somewhat faster) as for mesophilic digestion, except structural design changes are required due to higher stresses and additional insulation may be used to reduce heat loss. A design solids retention time (SRT) of 10 days at the max month sludge loading would be used to size the digester. The volatile solids reduction and gas production would be approximately the same for thermophilic digestion as for mesophilic digestion. Because the temperature is higher, however, the heating costs will be higher for thermophilic digestion.

An alternative to the conventional TAD design is to pre-pasteurize sludge at approximately 70°C for 1 hour to achieve Class A pathogen reduction (inactivation) requirement, prior to digestions at 55°C for 8 days at maximum month sludge loading. This alternative significantly reduces the digester heating and size requirement to achieve thermophilic digestion.

While there are additional costs, TAD may have several advantages over MAD. First, it has been reported that the dewatering characteristics of thermophilically digested sludges are superior to those of mesophilically digested sludge. However, there are few data to evaluate these claims that the additional costs of TAD may be offset by reduced dewatering costs. The second potential advantage of TAD over MAD is greater reduction in the levels of pathogens in the digested sludge. However, to demonstrate that the TAD process meets Class A biosolids requirements, the digested sludge still requires additional testing to demonstrate pathogen reduction. Both MAD and TAD (when operated at or above a 15-day SRT) are considered processes to significantly reduce pathogens (PSRP), which produces Class B sludge. In general, compliance with pathogen requirements (fecal coliform or salmonella) must be demonstrated for all biosolids leaving the production facility.

In summary, thermophilic digestion is more costly than mesophilic digestion. It has been claimed that these increased costs can be offset by decreased dewatering costs and increased reduction of the pathogen levels of these sludges.

3.4.3 Unit Process Basis/Design Criteria

The design parameters for anaerobic digestion for all six alternatives are summarized in Table 5, including a firm design SRT, maximum VSLR, influent feed concentration, and digester operating temperature. All design parameters must be met for sizing the anaerobic digestion system.

Table 6 presents the results of the process design calculations. The design SRTs at the design year at the maximum monthly average digester influent flow rate governs the volume of the digestion process. The biogas production from the anaerobic digestion system is estimated based on a biogas yield of 15 cubic feet of biogas per pound of volatile solids destroyed. The estimated energy yield from the biogas is based on a biogas specific energy of 640 British thermal units per cubic foot (BTU/cf).

Table 5. Anaerobic Digestion Design Parameters

Parameter	Unit	Alternative					
		3a	3b	3c	4a	4b	5
		MAD (12d SRT) + TD	PS MAD (12 d SRT) + TD	MAD (15d SRT)	THP (WAS) + PS MAD (12d SRT) + TD	THP (WAS+PS) + MAD (12d SRT)	TAD (8d SRT)
SRT @ max monthly average loading	days	12	12	15	12	12	8
VSLR @ max monthly average loading	lb VS/cf/day	0.25	0.25	0.25	0.4	0.4	0.25
Influent feed concentration—dry solids	%	5	5	5	11	11	5
System VSR	%	55%	70%	57%	57%	62%	60%
Digester temperature	°F	95	95	95	100	100	130

Table 6. Anaerobic Digestion Process Design Calculations

Parameter	Unit	Alternative					
		3a	3b	3c	4a	4b	5
		MAD (12d SRT) + TD	PS MAD (12 d SRT) + TD	MAD (15d SRT)	THP (WAS) + PS MAD (12d SRT) + TD	THP (WAS+PS) + MAD (12d SRT)	TAD (8d SRT)
TS Mass In	ppd	76,000	42,700	76,000	74,400	72,200	76,000
VS Mass In	ppd	60,700	34,100	60,700	59,400	57,700	60,700
Flow	MGD	0.18	0.10	0.18	0.10	0.10	0.18
Digester Volume Each	MG	1.1	0.6	1.4	0.6	0.6	1.5
Pasteurization Tank Volume Each	Gal	NA	NA	NA	NA	NA	7,600
Number of Digesters	#	3	3	3	3	3	2
Number of Pasteurization Tanks	#	NA	NA	NA	NA	NA	4
Digester Total Volume	MG	3.3	1.8	4.1	1.8	1.7	2.9
Digester Diameter	ft	75	55	80	55	55	80
Digester Sidewater Depth	ft	33	35	36	33	32	39
MCRT	Days	18	18	22.5	18	18	16
VSLR	lb VS/cf/d	0.14	0.14	0.11	0.25	0.25	0.16
Digested Solids Concentration	%	4.6	4.4	4.5	8.5	8.5	4.5

Table 6. Anaerobic Digestion Process Design Calculations

Parameter	Unit	Alternative					
		3a	3b	3c	4a	4b	5
		MAD (12d SRT) + TD	PS MAD (12 d SRT) + TD	MAD (15d SRT)	THP (WAS) + PS MAD (12d SRT) + TD	THP (WAS+PS) + MAD (12d SRT)	TAD (8d SRT)
Estimated biogas production	cf/d	501,000	372,000	519,000	508,000	537,000	547,000
Estimated biogas energy production	MMBtu/d	320	238	332	325	343	349

Gal = gallons

cf = cubic feet

MG = million gallons

MMBtu/d = million British thermal units per day

ppd = pounds per day

3.5 Rotary Drum Thermal Drying

3.5.1 Process Overview

Rotary drum drying technology is based on evaporation of water by direct contact of wet material with a stream of hot air. The major components of the more prevalent rotary drum dryer systems include the wet cake bin, recycle bin, mixer, furnace, drying drum, air/solids separator, main fan, saturator, product screen, crusher, cooler, and dried sludge storage silos. A schematic for a rotary drum drying system is shown in Figure 2. For Casey WRRF, the existing pellet storage bunker is assumed to be reused for future pellet storage, thus no additional dried sludge storage silo is required.

Dewatered sludge cake entering the drying system passes through a wet cake bin and is then mixed with recycled dry product in the mixer to create uniform spherical granules with approximately 60 to 70 percent dry solids. The hot air or gas required for the process is usually produced in a gas-fired furnace; however, the use of other types of fuel are also feasible. The furnace produces a stream of hot air/exhaust at temperatures between 800 to 1,000°F (425 to 535°C).

The evaporation process takes place in a horizontally-mounted, slowly rotating drying drum. The dried material is conveyed through the drum where the hot air stream comes into direct contact with wet biosolids, heats the material, and evaporates the water contained in the biosolids. Dried pellets and the moisture-laden air stream leave the drying drum at temperatures between 185 and 220°F (85 to 105°C).

Both dried solids and hot air pass together through the air/solids separator, where solid particles drop and are separated from the air stream. Dry solids are typically separated into oversize, product, and fine size fractions on vibrating screens. Product-size pellets (1 to 4 mm diameter pellets are typically most desirable) are cooled and then pneumatically conveyed to silos for storage and loading onto trucks or railroad cars. Oversize pellets are crushed in the crusher, combined with fine-size pellets, and passed through the recycle bin into the mixer for mixing with incoming dewatered sludge cake.

The hot, moisture-laden air is drawn by the main fan into the saturator, where air is cooled and water vapor is condensed by a counter-current flow of hot process air and cold cooling water. Most of the cooled air is recycled back to the drying drum, while approximately 10 to 30 percent of the flow is treated in the air emission control system and discharged to the atmosphere.

The rotary drum drying system is generally capable of producing uniform round pellets with approximate size of 1 to 4 mm. The hardness and characteristics of pellets produced by rotary drum dryers are typically better and more marketable than those produced by other drying technologies.

Rotary drum dryers are one of the most common types of dryers found in the U.S. Because of the high temperature heating medium, this technology generally provides higher evaporation capacity for a given size machine than other technologies. This technology is the most frequently applied in large installations due to the high capacity available.

Rotary drum dryers are relatively complex systems and require more operator oversight than other drying technologies. Maintenance activities can be demanding because of the large quantity and nature of parts within the system. The time required for startup is generally several hours. Drum dryer systems are typically operated continuously to minimize re-heating after each shutdown/startup. An operating cycle of 24 hours per day for 4 to 5 consecutive days is common for drum drying facilities.

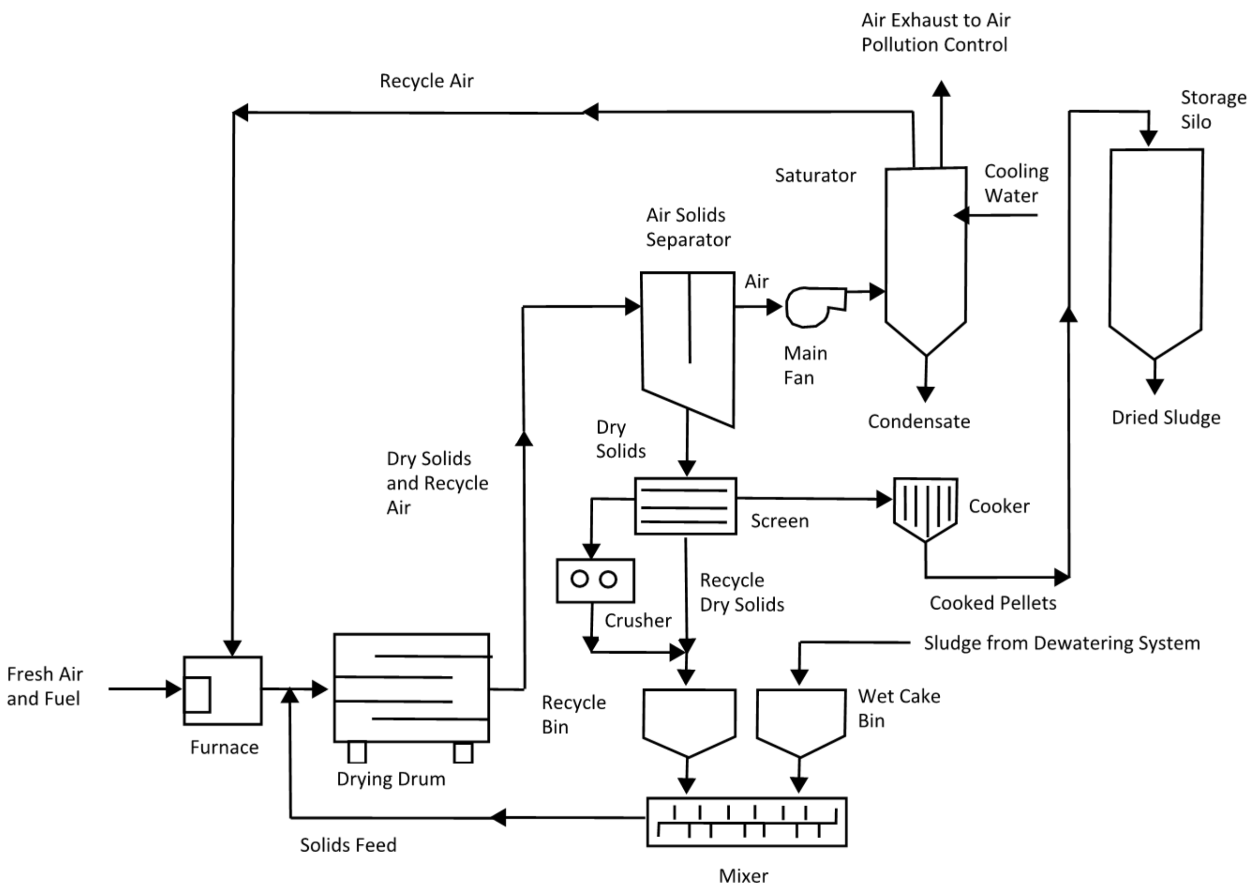

Figure 2. Rotary Drum Drying System Process Flow Diagram

3.5.2 Unit Process Basis/Design Criteria

The design parameters for rotary drum dryer alternatives are summarized in Table 7. The operating schedule for dryers is 24 hours per day and 5 days per week. The target product solids concentration is 95 percent dry solids pellets. The projected design year's max monthly average dryer solids loading governs the required evaporation capacity of the dryer system. The dryer system is design for one duty unit with no spare. Under design conditions, if the dryer must be taken offline for more than a day, dewatered cake would be sent to the trailer for third party composting or hauling to a landfill.

Table 7. Rotary Drum Dryer Process Design Criteria

Criteria	Units	Alternative		
		3a	3b	4a
		MAD (12d SRT) + TD	**PS** MAD (12 d SRT) + TD	THP (WAS) + **PS** MAD (12d SRT) + TD
Design solids loading (maximum month)	dry lb/hr	2,360	2,840	2,150
Dryer solids feed	%	23	23	30
Product solids concentration	%	95	95	95
Design water evaporation capacity	lb H2O/hour	7,790	9,360	4,900
Operation schedule	hours per day/days per week	24/5	24/5	24/5
Unit capacity required	lb H20/hr	8,800	11,000	5,500
Number of units (trains)	#	1	1	1
Unit heat energy required	MMBtu/hr	11.29	13.56	7.10

MMBtu/hr = million British thermal units per hour

4. Life Cycle Cost Evaluation

For each alternative, capital and operating cost estimates were developed. These cost estimates are Class IV (+50%/-30%), as defined by the Association for the Advancement of Cost Engineering (AACE) International. The life cycle duration evaluated was 20 years, beginning in 2022 and ending in 2042.

The life cycle cost evaluation assumed linear increase in annual average influent flows between 2022 (16.9 MGD) and 2042 (20.5 MGD). These values include all flows from the Shoal Creek collection basin and steadily increasing flows from the College Park collection basin. Corresponding annual average solids loads (PS and TWAS) to proposed solids processes are 46,800 and 55,400 dry pounds per day.

Economic factors used to perform the life cycle cost evaluation are presented in Table 8.

Table 8. Basis for Operation and Maintenance Cost Analysis

Parameter	Value	Source/Notes
Personnel cost	$44/hour	Northeast WRF Tertiary Polishing Evaluation
Landfilling/Hauling cost	$70/wet ton	Northeast WRF Tertiary Polishing Evaluation
Land application cost	$45/wet ton	CCWA
Polymer cost	$1.25/dry lb	NEWRF Tertiary Polishing Evaluation
Electrical cost	$0.083/kilowatt-hour	NEWRF Tertiary Polishing Evaluation
Natural gas cost	$3.74/MMBtu	CCWA

Table 8. Basis for Operation and Maintenance Cost Analysis

Parameter	Value	Source/Notes
Pellet revenue	$10/ton	CCWA
Annual equipment maintenance cost	0.5% of facility capital cost	Typical value
Discount rate	2%/year	CCWA Facility Evaluation Summary Report (CH2M, 2017); return on investment relative to inflation

CH2M HILL Engineers, Inc. (CH2M). 2017. *Clayton County Water Authority Facility Evaluation Summary Report*.

4.1 Capital Costs

Jacobs utilized its proprietary Conceptual and Parametric Engineering System (CPES®) tool to develop capital costs for the construction of each alternative. CPES allows development of project-specific capital costs for wastewater treatment processes and facilities. The tool was designed specifically to improve the accuracy of conceptual-level cost estimates which are often performed during alternatives analysis and during preliminary engineering.

CPES contains modules for various water treatment processes, each located on a separate worksheet. Input cells for each process allow the user to specify basic design criteria for the particular unit process. CPES uses the inputs to perform interim process calculations and generate a quantity takeoff for each unit process. The quantity takeoff provides the basis for the capital cost estimate. Wherever possible, each unit process module is based on one or more constructed Jacobs projects. Contract documents for each of the model unit processes were used to develop parametric equations used to adjust the quantity takeoff for the model facility based on project-specific information supplied by the user. Vendors provided budget quotes for the equipment listed in their scope of supply, which were added to the CPES modules to improve the accuracy of each capital cost estimate. Economic factors were added to account for markups and additional project costs such as sitework, plant computer system, yard electrical, yard piping and demolition. Table 9 summarizes the economic factors used for calculating the capital costs. Table 10 summarizes the estimated capital cost for each unit process for each alternative.

Table 9. Capital Cost Assumptions

Parameter	Value
Markups	
Contractor Overhead	12%
Contractor Profit	10%
Contractor Mobilization/Bonds/Insurance	3%
Contingency	30%
Additional Project Costs	
Overall Sitework	6%
Plant Computer System	6%
Yard Electrical	9%
Yard Piping	8%
Demolition	0%

Table 10. Capital Cost Summary

Unit Process	Alternative					
	3a	3b	3c	4a	4b	5
	MAD (12d SRT) + TD	PS MAD (12 d SRT) + TD	MAD (15d SRT)	THP (WAS) + PS MAD (12d SRT) + TD	THP (WAS+PS) + MAD (12d SRT)	TAD (8d SRT)
PS Thickening	$2,330,000	$2,330,000	$2,330,000	$2,330,000	$2,330,000	$2,330,000
Sludge Screening	$3,380,000	$3,380,000	$3,380,000	$3,380,000	$3,380,000	$3,380,000
Pre-digestion Sludge Holding	$770,000	-	$770,000	$570,000	$770,000	$770,000
Pre-dewatering	-	-	-	$3,540,000	$3,790,000	-
THP	-	-	-	$6,290,000	$9,290,000	-
MAD	$17,130,000	$13,080,000	$19,380,000	$12,440,000	$12,550,000	-
TAD	-	-	-	-	-	$14,570,000
Post-digestion Sludge Holding	$930,000	$1,030,000	$930,000	$1,000,000	$1,000,000	$930,000
Post-dewatering	$3,710,000	$3,930,000	$3,710,000	$3,560,000	$3,560,000	$3,710,000
Thermal Drying	$11,060,000	$11,800,000	-	$8,660,000	-	-
UV[1]	-	-	-	$620,000	$2,000,000	-
Total (Before Markups)	$39,300,000	$35,500,000	$30,500,000	$42,400,000	$38,700,000	$29,500,000
Total (With Markups)	$83,700,000	$75,700,000	$64,900,000	$90,200,000	$82,300,000	$62,800,000

[1] Incremental cost relative to baseline facility.

4.2 Life Cycle Cost Summary

Table 11 presents the results from the cost evaluation.

Table 11. Lifecycle Cost Comparison

Cost Component	Alternative					
	3a	3b	3c	4a	4b	5
	MAD (12d SRT) + TD	PS MAD (12 d SRT) + TD	MAD (15d SRT)	THP (WAS) + PS MAD (12d SRT) + TD	THP (WAS+PS) + MAD (12d SRT)	TAD (8d SRT)
Equipment Maintenance	$12,400,000	$11,200,000	$9,600,000	$13,300,000	$12,200,000	$9,300,000
Electrical Power	$11,300,000	$11,900,000	$9,200,000	$10,600,000	$8,840,000	$9,140,000
Natural Gas	$1,400,000	$500,000	#VALUE!	#VALUE!	#VALUE!	$1,300,000
Polymer	$6,800,000	$6,200,000	$6,800,000	$8,000,000	$8,300,000	$6,700,000
Residuals Management [1]	$(1,060,000)	$(1,200,000)	$23,000,000	$2,800,000	$23,120,000	$22,600,000
Operations Labor	$30,900,000	$30,900,000	$20,600,000	$41,200,000	$30,900,000	$20,600,000
Total O&M Cost	$61,700,000	$59,500,000	$69,200,000	$75,900,000	$83,400,000	$59,200,000
Capital Cost	$83,700,000	$75,700,000	$64,900,000	$90,200,000	$82,300,000	$62,800,000
Total Lifecycle Cost	$145,400,000	$135,100,000	$134,100,000	$166,100,000	$165,700,000	$128,900,000

[1] ( ) indicates revenue gain from pellets.

5. Non-Monetary Evaluation

In a February 2019 workshop, CCWA and Jacobs selected non-monetary criteria, for which Jacobs quantified relative importance using a forced-weighting process. The selected non-monetary criteria, performance measures, and resulting weights are summarized in the Table 12.

Table 12. Descriptions of Non-Monetary Criteria

Evaluation Criteria	Performance Measures	Relative Weight
Regulatory compliance risk	Risk of plant effluent permit or air permit being exceeded. Are standard being met as set by federal, state and local government?	24%
Diversity of disposal options	Are there multiple use options of the end product?	19%
Neighborhood impacts	To what degree can odor be controlled? What is the vehicle and noise impact?	14%
Worker health and safety	What is the relative level of worker health and safety protection required?	29%
Operations complexity	Addition of new process requiring unique equipment, additional training and/or operator certification, reliance on suppliers for technical assistance, more chemicals, etcetera.	5%
Sustainability/Long term viability	Ability to recover heat, energy, nutrients, or organic material for beneficial use. Ability of alternative to be sustained and provide effective solution over time.	10%

The six alternatives were evaluated based on the non-monetary criteria noted in Table 12. Resulting from considerable discussion at the April 2019 workshop, each criterion of each alternative was assigned a raw score ranging from 1 to 5. The raw scores were then multiplied by their corresponding relative weight to calculate the criteria score for each alternative.

Results of the non-monetary evaluation are shown in Figure 3. The three highest scoring alternatives were 3a, 3b, and 5 which were all tied with a score of 73. Diversity of disposal options was a differentiator for alternatives 3a and 3b due to the marketability of Class A pellets produced from thermal drying. (However, alternative 4a was given a slightly lower score for this criterion due to the uncertain impacts of THP on pellet quality). Alternative 5 scored highest due to higher scores for both worker health and safety and regulatory compliance risk. For worker health and safety, scores were docked for alternatives with potentially hazardous equipment. For regulatory compliance risk, scores were docked for alternatives requiring air permits and for alternatives with THP due to the potential impact on effluent quality from reduced UVT.

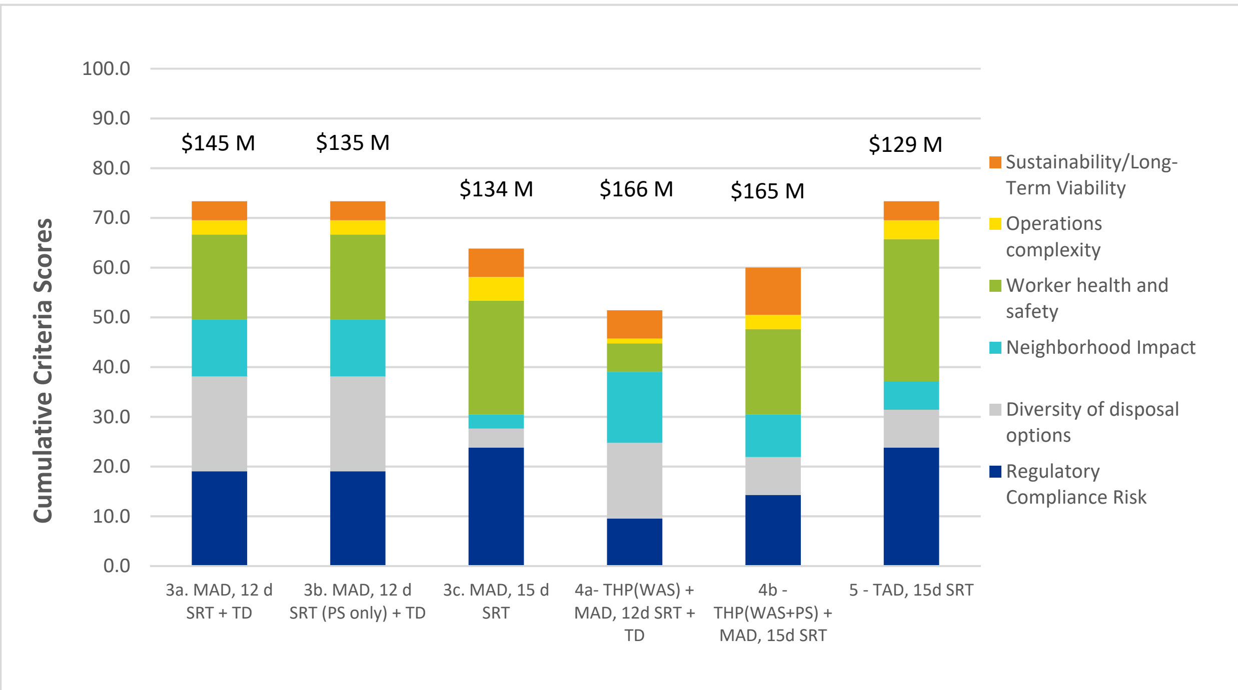

Figure 3. Non-Monetary Scoring Results

6. Results

After consideration of cost and non-monetary criteria, alternative 3b was selected using the following step-wise logic:

- All alternatives resulting in a cake (3c, 4b, and 5) were eliminated. While not necessarily reflected in the non-monetary scoring (alternative 5 had one of the highest scores), CCWA staff maintained that they had a strong preference for thermal drying and continued production of pellets due to the positive historical experience in marketing pellets and the high value placed on resource recovery.
- Alternatives including THP (4a and 4b) were eliminated due to both the highest lifecycle cost and the lowest cumulative criteria scores.
- Of the remaining two alternatives (3a and 3b), alternative 3b was selected due to the lower lifecycle cost.

SUBJECT	**Task 6, Part 2 TM– W.B. Casey Biosolids Regionalization Analysis**
PROJECT NAME	W.B. Casey WRRF Capacity Analysis and Plant Expansion Evaluation
ATTENTION	Clayton County Water Authority (CCWA)
FROM	Kristina Yanosek/Jacobs Engineering Group Inc. (Jacobs)
REVIEWED BY	Todd Williams, Scott Levesque/Jacobs
DATE	June 5, 2020

1. Introduction

This analysis follows the Task 6 W.B. Casey biosolids alternatives evaluation that was completed in April 2019. During the biosolids alternatives evaluation, the possibility of processing biosolids from the Northeast Water Reclamation Facility (WRF) at the W.B. Casey Water Resources Recovery Facility (Casey) was considered as a potential means of reducing operational costs. Since the relative life cycle cost comparison would not be impacted by the inclusion of the additional biosolids quantity, this "regionalization" alternative was not factored into the initial evaluation.

The W.B. Casey biosolids alternatives evaluation concluded in the selection of alternative "3b" which included anaerobic digestion of primary sludge (PS), combined dewatering of digested PS and waste activated sludge (WAS), and thermal drying. The details of this analysis are summarized as in *Task 6 TM, Part 1 – W.B. Casey Biosolids Alternatives Evaluation*. The selected alternative described in that memo was used as the "baseline" alternative for comparing regionalization to continued separate management of the W.B. Casey and Northeast biosolids.

The purpose of this follow-on evaluation was to compare both the life cycle costs and non-economic factors of the baseline to regionalization. The selected path forward will be reflected in the planning and design of the new solids processing facilities at the Casey WRRF.

2. Background

Class A biosolids are produced at Casey through a drying/pelletizing process. The existing pelletizing facility, which has been in operation since 1980, is at capacity and has reached the end of its useful life. The W.B. Casey biosolids alternatives evaluation was prompted by the need for a new facility. The process selected in the biosolids alternatives evaluation will allow CCWA to continue to produce Class A biosolids and avoid high disposal costs. Currently, CCWA sells pellets from Casey for $10 per wet ton.

At the Northeast WRF, unstabilized dewatered WAS is disposed by a third party (ERTH Products), which transports the biosolids to a composting facility for stabilization and production of Class A biosolids. Currently, CCWA pays $79 per dry ton for Northeast biosolids disposal. CCWA has long been committed to resource recovery and has prioritized beneficial reuse through composting over a less costly disposal contract for landfilling. As landfills continue to limit acceptance of biosolids, the cost of all third party biosolids disposal options has increased in response to market pressure.

In the regionalization alternative, CCWA would transport unclassified Northeast biosolids to Casey for further processing rather than rely on a third party for disposal of unclassified biosolids. As a result, CCWA would increase the value of the Northeast biosolids, increase the production of marketable Class A biosolids, and eliminate the high disposal cost imposed by third party handling. This would require new and/or expanded infrastructure. Northeast biosolids would be transferred to Casey either through pumping liquid waste activated sludge (WAS) through the collection system or by trucking dewatered cake.

CCWA had previously considered transporting Northeast biosolids to Casey to save disposal costs and decrease reliance on third-party processing for production of Class A biosolids. This was evaluated by Brown and Caldwell (B&C) as described in *Evaluation of Combining WRF Biosolids for Pelletizing, TM no. 1 Alternatives Evaluation and (SEWT) Model Summary (2014).* In this evaluation, several regionalization alternatives were compared. It was recommended that CCWA pump WAS from both Shoal Creek and Northeast WRFs to W.B. Casey through the existing collection system. The liquid stream would enter W.B. Casey at the headworks where it would be mixed and processed with influent raw sewage. This evaluation did not consider the impacts on the W.B. Casey secondary treatment process (both bioreactor capacity and cost for increased aeration). In addition to exclusion of this cost factor, there have been other process changes and planning efforts in the past seven years that negate these previous results.

For this updated regionalization analysis, only Northeast biosolids are considered as CCWA plans to decommission Shoal Creek within the planning horizon. In establishing the evaluation criteria for a regionalization alternative, both pumping liquid WAS through the collection system and trucking dewatered WAS cake were initially considered. However, CCWA staff indicated they were no longer interested in the pumped alternative due to suspected unfavorable collection system conditions, capacity issues, and operational concerns, all of which rendered this alternative undesirable. Therefore, only dewatered cake transfer (via trucking) was considered in this analysis to represent the regionalization alternative.

3. Alternatives and Design Criteria

3.1 Development of Alternatives

The baseline alternative (3b) was compared to regionalization in which Northeast dewatered cake would be trucked to W.B. Casey and added to the process upstream of thermal drying. The analysis was done in two steps. First, the cake receiving station and thermal drying facility was sized for a Northeast WRF design maximum capacity of 8 MGD, for consistency with the planned capacity of the Northeast WRF facility. (At the time of this evaluation, CCWA was pursuing a new wasteload allocation (WLA) for an interim flow limit. The 8 MGD flow was selected as the likely interim flow limit). In this regionalization alternative (designated as 3b-1), excess capacity could be used to accept non-CCWA cake throughout the life cycle. It also required a larger thermal drying facility.

Results from the 3b and 3b-1 alternatives (presented in a workshop held on April 29, 2020) indicated an unfavorable life cycle cost for 3b-1. After further discussion of other possible approaches, CCWA requested that an additional alternative be considered in which 1) the thermal drying facility is not enlarged to accommodate Northeast biosolids and 2) the cake receiving station size has one rather than two cake receiving hoppers. This alternative (designated as 3b-2) would not include acceptance of non-CCWA cake. Furthermore, transfer of Northeast cake would occur only as long as the W.B. Casey thermal drying facility had excess capacity. In other words, the capacity would not match the design capacity of the Northeast WRF, and another approach would eventually be required for managing Northeast biosolids.

Assumptions, design criteria, and results for all three alternatives 3b, 3b-1, and 3b-2 are presented herein. Simplified process flow diagrams depicting the variations between the alternatives are shown in Figure 1. The following unit processes upstream of dewatered cake addition are common to all alternatives and therefore were not included in the comparative cost analysis:

- Separate PS and WAS thickening
- Thickened sludge screening (not depicted in Figure 1)
- Pre-digestion sludge holding (not depicted in Figure 1)
- Anaerobic digestion of PS only
- Post-digestion sludge holding

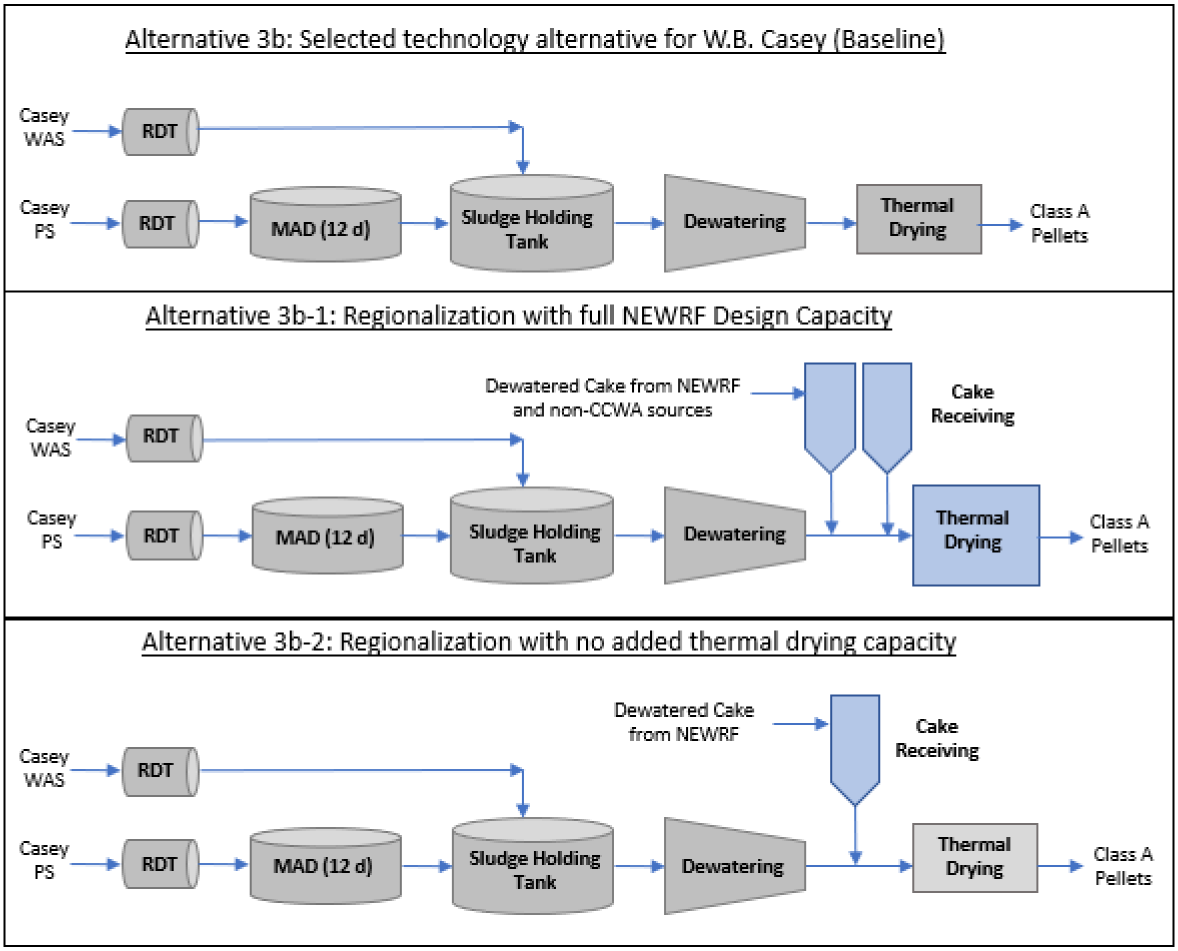

Figure 1. Alternatives Considered for Regionalization Analysis

3.2 Process Simulation

Process simulations were completed to develop mass balances for the baseline and regionalization alternatives. The design maximum month average (MMA) flow for W.B. Casey and Northeast were 32 MGD and 8 MGD, respectively. Since the original alternatives analysis completed in April 2019, more accurate influent characterization for W.B. Casey had been obtained to complete the capacity analysis, and the model had been updated accordingly resulting in a different mass balance than previously used for alternative 3b. Additionally, updated flow projections had been made since the original biosolids alternatives evaluation. The new flow projections for 2022 and 2041 (beginning and end of life cycle) were used to establish annual average (AA) biosolids productions for these evaluation years. The average biosolids production was used for the life cycle cost evaluation, and the design maximum month conditions were used to size facilities.

3.3 Biosolids Design Criteria

Table 1 summarizes the design basis for each alternative based on AA biosolids for the beginning and end of the life cycle, the design MMA biosolids, and the associated evaporation rate required for thermal dryer sizing. For Alternative 3b-1 the cake receiving station and dryer were sized for the design MMA combined solids quantities from both Casey and Northeast. For Alternative 3b-2, the design evaporation capacity was not increased to accommodate Northeast but there is still enough excess capacity to process Northeast biosolids on an average basis at the end of the lifecycle in 2041. However, in 2030, the smaller dryer will not have sufficient capacity at

MMA conditions and some of the Northeast biosolids would have to be hauled elsewhere for disposal. At the end of the lifecycle in 2041, approximately 85 percent of the Northeast biosolids would be processed at Casey.

Table 1. Design Criteria – Biosolids Quantities for Unit Process Sizing and Lifecycle Cost Analysis

Parameter	Units	2022 AA	2041 AA	Design MMA[a]
Biosolids Production Quantities				
Casey Solids Production	DT/d	15.9	22.6	31.2
	WT/d	63.7	90.2	125
Northeast Solids Production	DT/d	3.0	3.6	11.0
	WT/d	11.6	14.0	42.3
Sizing Criteria for Alternative 3b, Baseline (W.B. Casey biosolids only)				
Dewatered Cake to Thermal Dryer	DT/d	15.9	22.6	31.2
	WT/d	63.7	90.2	125
Evaporation Rate	lb water/hr	5,453	7,739	10,745
Sizing Criteria for Alternative 3b-1, Regionalization (W.B. Casey + Northeast biosolids + non-CCWA biosolids)				
Dewatered Cake to Thermal Dryer	DT/d	18.9	26.2	42.2
	WT/d	75.3	104.2	167
Evaporation Rate	lb water/hr	6,589	9,107	14,860
Sizing Criteria for Alternative 3b-2, Regionalization (W.B. Casey + Northeast biosolids)				
Dewatered Cake to Thermal Dryer	DT/d	18.9	26.2	31.2
	WT/d	75.3	104.2	125
Evaporation Rate	lb water/hr	6,589	9,107	10,745

WT/d = wet ton per day, DT/d = dry ton per day, lb water/d = pounds water per day

a) Represents winter conditions to reflect highest potential solids production.

4. Life Cycle Cost Evaluation

For each alternative, capital and operating cost estimates were developed. These cost estimates are Class IV (+50%/-30%), as defined by the Association for the Advancement of Cost Engineering International (AACEI). The life cycle duration evaluated was 20 years, beginning in 2022 and ending in 2041.

4.1 Capital Cost

Jacobs utilized its proprietary Conceptual and Parametric Engineering System (CPES®) tool to develop capital costs for the construction of each alternative. CPES allows development of project-specific capital costs for wastewater treatment processes and facilities. The tool was designed to improve the accuracy of conceptual-level cost estimates that are often performed during alternatives analysis and during preliminary engineering. Some cost elements for the cake receiving station were based on a schedule of values for a recent Jacobs construction project. Vendor quotes were used for the thermal drying equipment and truck and trailers. Economic factors were added to account for contractor markups and additional project costs such as sitework, plant computer system, yard electrical, yard piping, and demolition. Table 2 summarizes the economic factors used for calculating the capital costs.

Table 2. Capital Cost Assumptions

Parameter	Value
Markups	
Contractor Overhead	12%
Contractor Profit	10%
Contractor Mobilization/Bonds/Insurance	3%
Contingency	30%
Additional Project Costs	
Overall Sitework	6%
Plant Computer System	6%
Yard Electrical	9%
Yard Piping	8%
Demolition	0%

Design criteria for the differential capital cost components for each alternative are summarized in Table 3. Capital costs are summarized in Table 4. The capital cost estimate of the initial regionalization alternative (3b-1) is $13.2 million greater than the baseline alternative. The refined regionalization alternative with less dryer capacity and reduced cake receiving facility (3b-2) is $6.0 million greater than the baseline alternative.

Table 3. Design Criteria for Differential Capital Cost Components for Baseline and Regionalization Alternatives

Unit Process	Baseline	Regionalization	
	3b	3b-1	3b-2
Truck and Trailer	—	Diesel Truck (Qty 1) with Tilt Trailers (Qty 2)	
Cake Receiving Facility	—	Process Equipment and Building (76’ x 60’)	Process Equipment and Building (76’ x 40’)
Dryer and Ancillary Equipment	DDS-50 (Capacity 11,023 lb water/hr)	DDS-70 (Capacity 15,435 lb water/hr)	DDS-50 (Capacity 11,023 lb water/hr)
Pelletizing Facility Building	110’ x 75’ x 60’ tall	125’ x 90’ x 60’ tall	110’ x 75’ x 60’ tall

Table 4. Differential Capital Costs for Baseline and Regionalization Alternatives

Unit Process	Baseline	Regionalization	
	3b	3b-1	3b-2
Diesel Truck	—	$125,000	$125,000
Trailers (tilt)	—	$100,000	$100,000
Cake Receiving Station	—	$8,242,000	$5,746,000
Drying Facility	$34,712,000	$39,397,000	$34,712,000
Total	**$34,712,000**	**$47,864,000**	**$40,682,270**
Differential (Relative to 3b)		**+ $13,152,027**	**+ $5,971,000**

4.2 Operating Costs

The life cycle cost evaluation assumed increase in annual average process quantities between 2022 and 2041 proportional to projected raw wastewater flow. Only differential operating costs among the three alternatives were considered, as summarized in Table 5. Unit costs and assumptions used to calculate operating costs are summarized in Table 6.

Table 5. Differential Cost Components used in Operating Cost Comparison

Parameter	Baseline	Regionalization		Notes
	3b	3b-1	3b-2	
Cake receiving station electrical		X	X	Screw conveyors and cake pumps
Cake receiving station polymer		X	X	Pipe lubrication for transferring cake from receiving silo to wet cake bin
Cake receiving station equipment maintenance		X	X	Defined as a percent of the facility capital cost.
Trucking costs		X	X	Fuel, maintenance, labor to transfer cake from Northeast to W.B. Casey.
Drying facility maintenance cost		X		As percent of CAPEX, higher for 3b-1, equal for 3b and 3b-2
Natural gas		X	X	Additional natural gas required Northeast and other external biosolids
Pellet revenue		X	X	Additional revenue from pelletizing Northeast (3b-1 and 3b-2) and other external biosolids (3b-1 only).
Unclassified cake disposal	X		X	Cost of disposing Northeast cake. Due to lower facility capacity for 3b-2, a portion of the Northeast cake is disposed of as unclassified cake.

Table 6. Unit Costs and Assumptions for Operation and Maintenance Cost Analysis

Parameter	Value	Unit	Source/Notes
Discount Rate	2%	/yr	Accounts for inflation
Personnel	$47.69	/hr	2017 CCWA budget escalated to 2020
Electrical Energy	$0.077	/kWhr	Current (2020) from CCWA
Natural Gas	$3.28	/MMBtu	Current (2020) from CCWA
Equipment Maintenance	0.5%	/yr	As percent of facility capital cost
Polymer/cake volume ratio	0.006	--	Based on installation/operational experience
Polymer cost	$1.25	/lb	Same as for NEWRF Technology Evaluation
Truck capacity per load	26.25	WT	Historical average for NEWRF
Distance from NEWRF to Casey WRRF (round trip)	22	Miles	
Time per load (transit and offload)	1.2	hr	
Drying facility operating schedule	120	hr/wk	5 days, 24 hours
Non-CCWA cake total solids concentration	20%		Midpoint of typical range
Pellet Revenue	$10	/WT	Current contract rate
Market Rate for Unclassified Cake Disposal by Third Party (start of life cycle)	$79 / $100	/WT	Current rate is $79/WT. Group consensus at kickoff was to use $100/WT for a conservative rate. Life cycle cost was determined for both values.
Escalation rate (above inflation) for unclassified cake disposal	2%	/yr	Consistent with Northeast Technology Evaluation
Revenue for Non-CCWA Cake Received at Casey as percent of Market Rate	90%	--	Assume CCWA would establish rate at 90% of market rate to ensure customers.
Utilization of Spare Capacity for Non-CCWA Cake	50%		Applied to alternative 3b-1 only.

Operating costs for each cost component are summarized in Table 7 for each of the three alternatives. At the kick off meeting for this work, it was agreed that a unit cost of $100 per wet ton would be used for the unstabilized cake disposal cost. This cost is based on current higher rates for unstabilized cake disposal in the metro Atlanta area. Following the initial analysis presented at the results meeting held on April 29, 2020, Jacobs indicated that the life cycle cost comparison was highly sensitive to this disposal cost and that a change in the market would have a significant impact on the cost benefit of regionalization. Given this sensitivity of the results to this unit cost, operational and life cycle costs are also presented for the lower unstabilized cake disposal unit cost of $79 per wet ton.

Table 7. Life Cycle Operational Cost Comparison

Cost Component	Baseline	Regionalization	
	3b	3b-1	3b-2
Truck Operation	$0	$44,000	$42,000

Table 7. Life Cycle Operational Cost Comparison

Cost Component	Baseline	Regionalization	
	3b	3b-1	3b-2
Truck Driving Labor (Cake Transport)	$0	$166,000	$158,000
Revenue from non-CCWA Cake Receiving	$0	-$7,365,000[a] -$9,322,000[b]	$0
Pellet Revenue	$0	-$385,000	-$376,000
Power for Cake Receiving Station	$0	$122,000	$54,000
Polymer for Cake Pumping	$0	$2,483,000	$1,091,000
Cake Receiving Equipment Maintenance	$0	$417,000	$290,000
Drying Facility Equipment Maintenance	$1,307,000	$1,483,000	$1,307,000
Natural Gas	$0	$982,000	$928,000
Unstabilized Cake Disposal[a]	$7,058,000[a] $8,935,000[b]	$0	$365,000[b] $462,000[c]
TOTAL	**$8,365,000[a] $10,242,000[b]**	**-$2,053,000[a] $-4,010,000[b]**	**$3,859,000[a] $3,956,000[b]**

[a]It is estimated that 100 percent of cake from NEWRF can be processed at Casey through 2029 after which there will not be sufficient capacity for all NEWRF cake in all months. Approximately 85 percent of the cake from NEWRF can be processed at Casey at the end of the 20-year lifecycle.

[b]Based on unstabilized cake disposal cost of $79/WT in year 1.

[b]Based on unstabilized cake disposal cost of $100/WT in year 1.

4.3 Life Cycle Cost Summary

Total life cycle costs at unstabilized cake disposal rates of $79 and $100 are summarized in Tables 8 and 9, respectively. At the current unstabilized cake disposal cost of $79/WT, regionalization is not financially advantageous. At a higher unstabilized cake disposal cost of $100/WT, alternative 3b-1 shows a slight cost advantage over the baseline, and alternative 3b-2 is close but still more costly than the baseline. Overall, the costs are similar enough to render either option reasonable.

Table 8. Life Cycle Cost Comparison for Baseline and Regionalization Alternatives Assuming Unit Cost of Unstabilized Cake Disposal is $79/WT in Year 1.

Cost Component	Baseline	Regionalization	
	3b	3b-1	3b-2
Capital Cost	$34,712,000	$47,864,000	$40,682,270
Operational Cost	$8,365,000	-$2,053,000	$3,859,000
Total	**$43,077,000**	**$45,811,000**	**$44,541,000**

Table 9. Lifecycle Cost Comparison for Baseline and Regionalization Alternatives Assuming Unit Cost of Unstabilized Cake Disposal is $100/WT in Year 1.

Cost Component	Baseline	Regionalization	
	3b	3b-1	3b-2
Capital Cost	$34,712,000	$47,864,000	$40,682,270
Operational Cost	$10,242,000	-$4,010,000	$3,956,000
Total	**$44,954,000**	**$43,854,000**	**$44,638,000**

5. Non-Monetary Evaluation

Non-monetary criteria were established in February 2019 for the initial biosolids alternatives evaluation. After collectively developing the criteria, CCWA weighted them with respect to importance in the alternative selection process. These same non-monetary criteria and weighting, summarized in Table 10, were applied to this follow-on regionalization analysis. Performance measures and scoring criteria descriptions were modified slightly to reflect better the specific concerns related to biosolids cake receiving.

Table 10. Non-Monetary Criteria and Weighting used to Score Alternatives

Evaluation Criteria	Performance Measures	Scoring Criteria	Weighting
Regulatory Compliance	Risk of plant effluent permit or air permit being exceeded. Are standards being met as set by federal, state and local governments?	Higher score for less permit impact/risk.	24%
Diversity of Disposal Options	Multiple use options for the end product.	Higher score for process that has multiple potential uses/outlets.	19%
Neighborhood Impact	Potential for fugitive odors. Vehicle and noise impact.	Higher score for processes with less odor risk, less vehicle traffic and less potential for noise/visual impacts.	14%
Worker Health and Safety	The relative level of worker health and safety protection required.	Higher score for processes with less requirement for PPE.	29%
Operations Complexity	Addition of new process requiring unique equipment, additional training and/or operator certification, reliance on suppliers for technical assistance, more chemicals.	Higher score for processes that are known or have been operated without new training requirements or specialized staff. Higher score for no increase in staffing.	5%
Energy Reduction, Resource Recovery, Sustainability	Ability to recover heat, energy, nutrients or organic material for beneficial use.	Higher score for alternatives that recover these resources.	10%

Using the original scores for the Baseline (3b) alternative assigned in April 2019, the regionalization alternative (3b-1) was assigned relative scores.

Since alternative 3b-2 was not yet developed during the workshop, a separate score for this alternative was not developed in a group setting. Alternatives 3b-1 and 3b-2 are similar with respect to most criteria except for “Operations Complexity.” CCWA scored regionalization (3b-1) lower for Operations Complexity primarily due the contracting, marketing, and coordination required to accept non-CCWA biosolids. For alternative 3b-2, this concern would not apply as only Northeast cake would be handled at the cake receiving station. Given that there is still additional equipment and some inter-organizational coordination required, this criterion was given a score of 2.5.

Similarly, "Neighborhood Impact" would be slightly better for alternative 3b-2 than alternative 3b-1 due to reduced truck traffic. For alternative 3b-2, this criterion was given a scope of 3.5.

In addition to complexity, major disadvantages of regionalization included the greater potential for fugitive odors and a slight increase in safety risk to CCWA staff hauling cake from Northeast. The major non-monetary advantage to regionalization recognized by staff was the improved flexibility of management options by producing more Class A biosolids and reducing dependency on landfills or third parties for further processing of unclassified solids.

Scores are summarized in Table 11. These scores were then multiplied by their corresponding relative weight to calculate the non-monetary score for each alternative. Results of the non-monetary evaluation are shown in Figure 2 which indicates close scores with both the Baseline (3-b) Regionalization (3b-2) alternatives having a score of 73 and the Regionalization (3b-1) alternative having a slightly lower score of 71.

Table 11. Non-Monetary Scoring for Baseline and Regionalization Alternatives.

Evaluation Criteria	Baseline	Regionalization	
	3b	3b-1	3b-2
Regulatory Compliance	4	4	4
Diversity of Disposal Options	5	7	7
Neighborhood Impact	4	3	3.5
Worker Health and Safety	3	2	2
Operations Complexity	3	2	2.5
Energy Reduction, Resource Recovery, Sustainability	2	2	2

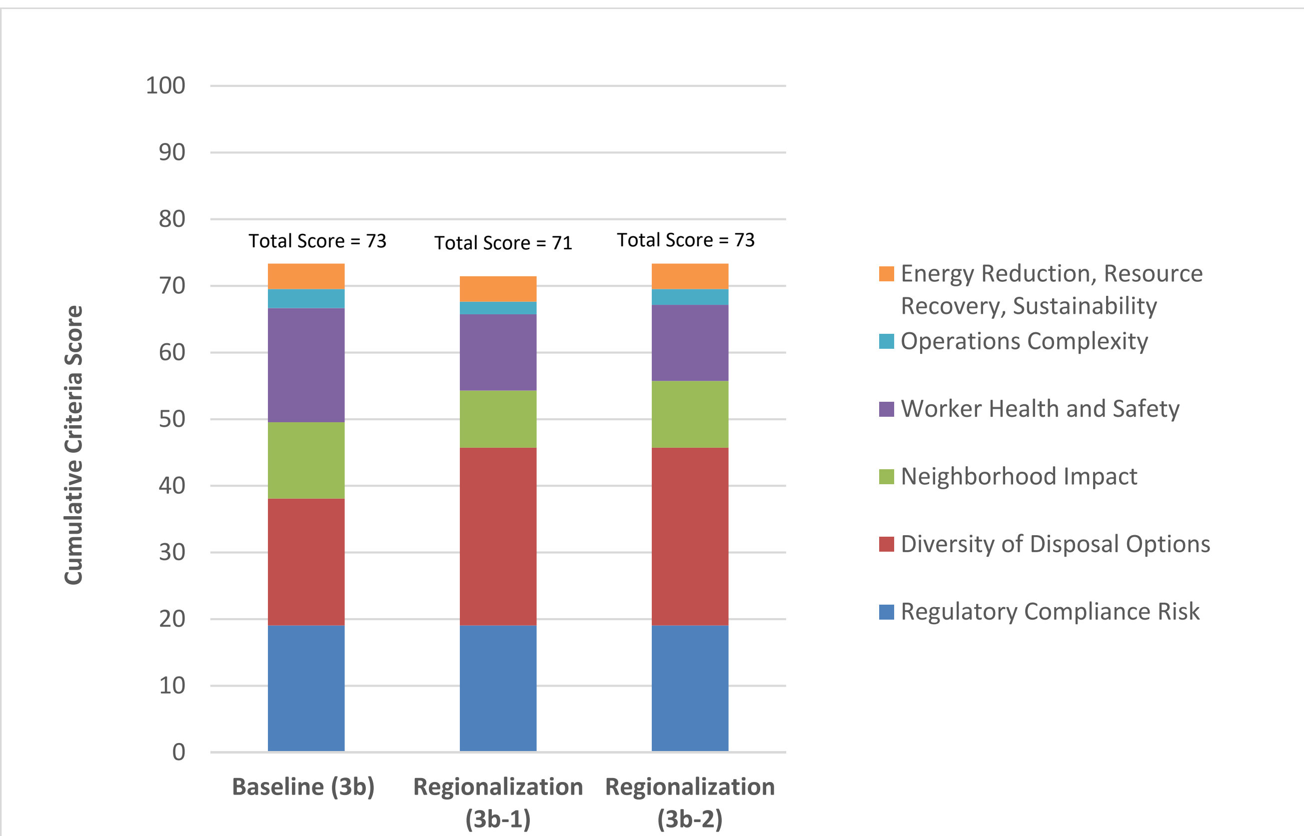

Figure 2. Non-Monetary Scores for Baseline and Regionalization Alternatives.

6. Recommendation

Based on the cost analysis, regionalization may reduce CCWA operational costs if the cost of managing unstabilized cake solids continues to rise. However, at the current rate of $79/WT and based on the initial capital cost estimate of the cake receiving station, regionalization (3b-1) does not have a cost advantage. Eliminating the additional drying capacity and reducing the size of the cake receiving station (3b-2) did not reduce the capital cost sufficiently to justify regionalization on a cost basis. Furthermore, non-monetary scoring did not show a strong inclination towards regionalization.

Given that capital cost was based only on conceptual design information, it is possible the capital cost could be lower after further definition of the design. Therefore, it is recommended that CCWA include the cake receiving station with one silo for the preliminary engineering design for the new W.B. Casey biosolids facilities. As the construction cost becomes more refined and market conditions stabilize, CCWA may elect to proceed with or defer construction of the cake receiving station.