FIRST AMENDMENT TO AGREEMENT FOR PROFESSIONAL SERVICES
(Design Professional)

THIS FIRST AMENDMENT TO AGREEMENT is made and entered into this 1ST day of NOVEMBER, 2021, by and between the City of Merced, a California Charter Municipal Corporation ("City"), and Stantec Consulting Services, Inc., a New York Corporation ("Consultant").

WHEREAS, City is undertaking a project to design upgrades at its Wastewater Treatment Facility ("Project"); and

WHEREAS, City and Consultant have previously entered into an Agreement for Professional Services ("Agreement") dated June 15, 2020; and

WHEREAS, City and Consultant desire to amend said Agreement to provide for additional services in connection with said project.

NOW, THEREFORE, the parties hereto, in consideration of the mutual covenants hereinafter recited, agree as follows:

1. Section 22, "ADDITIONAL WORK," is hereby added to the Agreement to read as follows:

> "22. ADDITIONAL WORK. Consultant shall perform the additional work outlined in the proposal from Consultant to City dated July 26, 2021, attached hereto as Exhibit 1."

2. Section 23, "ADDITIONAL COMPENSATION," is hereby added to the Agreement to read as follows:

> "23. ADDITIONAL COMPENSATION. The City shall pay to Consultant the not to exceed additional sum of One Million Six Hundred Seventy-Three Thousand Eight Hundred Dollars ($1,673,800.00) for the additional work described in Exhibit 1 and in accordance with the rates set forth on Exhibit 1, attached hereto."

ATTACHMENT 2

3. Except as herein amended, the Agreement dated June 15, 2020 shall remain in full force and effect.

IN WITNESS WHEREOF, the parties have caused this First Amendment to Agreement to be executed on the date first above written.

CITY OF MERCED
A California Charter Municipal Corporation

BY: Stephanie Dietz
City Manager

ATTEST:
STEPHANIE R. DIETZ, CITY CLERK

BY: _____
Assistant/Deputy City Clerk

CITY of MERCED, CALIFORNIA INCORPORATED APRIL 1, A.D. 1889

APPROVED AS TO FORM:

BY: Kimberly C Madgey 9/9/21
City Attorney Date

301254 PO# 138377
ACCOUNT DATA:

BY: _____
Verified by Finance Officer V-16324
Funds available. mg 9/29/21
551-1157-637-65-00 118015 FE 9/29/21
$1,126,148.00
553-1108-637-65-00 118015
$547,052.00

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CONSULTANT
STANTEC CONSULTING SERVICES, INC., A New York Corporation

BY: Steven L. Beck
(Signature)

Steven L. Beck
(Typed Name)

Its: Senior Principal
(Title)

BY: _____
(Signature)

_____
(Typed Name)

Its: _____
(Title)

Taxpayer I.D. No. 68-0309852

ADDRESS: 3875 Atherton Road
Rocklin, CA 95765

TELEPHONE: (916) 773-8100
FAX: (916) 773-8448
E-MAIL: steven.beck@stantec.com

Stantec Consulting Services Inc.
3875 Atherton Road, Rocklin CA 95765-3716

July 26, 2021
File: 184031329

Attention: Ken Elwin, Director of Public Works
City of Merced
1776 Grogan Avenue
Merced, CA 95341

Dear Mr. Elwin,

Reference: City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project

Stantec Consulting Services Inc. (Stantec) is submitting this proposal to provide design services for the City of Merced Wastewater treatment Facility (WWTF) Phase VI Improvements Project identified in the Merced WWTF Phase VI Preliminary Design Report. The WWTF Improvements Project (Project) will improve treatment reliability, enhance biogas utilization, and reduce energy costs. The Project can be designed to accommodate two separate competitively bid packages (ensuring projects are shovel ready, depending on funding sources).

The Project includes the following components:

Influent Flow Meter

Design new influent flow meter to replace existing Parshall flume flow indicating transmitter and reprogram the plant SCADA system to record influent flows more accurately.

Influent Pump Station

Repair exposed concrete where coatings have failed and recoat concrete surfaces with high solids epoxy system.

Headworks

Replace the two perforated plate screens and washer/compactors with two new screens and washer/compactors.

Install baffles in the vortex grit basins.

Secondary Treatment

Replace Reactor Basins No. 1 and 2

Convert Reactor Basin No. 3 to a Modified Ludzack-Ettinger (MLE) process with swing zone and new fine bubble diffusers.

Replace existing aeration blowers with new technology gas turbine blowers to optimize biogas utilization.

UV Disinfection System

Recoat UV concrete channels.

EXHIBIT 1

Sludge Thickening

Upgrade DAFT with latest technology microbubble air floatation system and replace retention tank.

Solids Dewatering

Add parallel sludge cake conveyors

Solids Drying

Add supplemental heating system to five of the seven existing active solar dryers.

Septage Receiving Station

The existing septage receiving station will be modified to accommodate gravity flow from the septage trucks and the existing packaged septage receiving station will be replaced with higher capacity septage receiving equipment.

Hybrid Digestion Pilot Testing

Ammonia nitrogen in the centrate from the sludge dewatering process that is returned to the headworks is adversely impacting the downstream secondary treatment process. Several alternatives were investigated to migrate this including construction of larger anoxic basins, sidestream treatment, and hybrid digestion. One of the alternatives investigated is a new hybrid digestion process called ExCalibAer by Thermal Process Systems, Inc. (TPS) that can remove a portion of the nitrogen and is reported to have other benefits including enhanced sludge dewatering and reduced struvite formation. Pitot testing is recommended to verify the effectiveness of this process. Stantec will assist TPS with the testing protocol, monitoring the pilot test, and prepare technical report summarizing the pilot testing results.

Attachment A includes a summary table of the preliminary estimate of the total project cost.

Our proposed scope of work is as follows:

TASK 510: DETAILED DESIGN

Stantec will prepare design drawings and specifications and prepare final bid documents.

SUBTASK 510.001: DESIGN COORDINATION AND MEETINGS

Stantec's project manager will coordinate the design work and provide project administrative services during the design phase including monitoring and control of budget for each major task of work and providing quality assurance and quality control activities. Stantec will conduct a project kick-off meeting with the City to review the project scope, deliverables, and schedule. Stantec will use Microsoft Teams to conduct monthly progress meetings during detailed design. Additionally, Stantec's project manager is always available for impromptu meetings, calls, and emails to receive direction and comments from the City and to keep the project team informed.

SUBTASK 510.002: QUALITY CONTROL AND CONSTRUCTABILITY REVIEWS

Stantec will complete quality control reviews and constructability reviews of the drawings, specifications, and other bidding documents between the 60 and 90 percent progress submittals. Documents will be reviewed for correctness, completeness, and coordination with other documents and between disciplines. The QA/QC process will involve senior engineers and construction managers. The final QA/QC by senior staff will be completed between the 90 percent and final submittal.

SUBTASK 510.001: GEOTECHNICAL REPORT UPDATE

Stantec's sub-consultant BSK will prepare a geotechnical report amendment. The existing geotechnical engineering reports (including field exploration, laboratory analyses, and engineering evaluations) from the Phase V Solids Handling Project will be updated to incorporate the latest codes and geotechnical design recommendations including design parameters for structural foundations, dewatering, and general site excavation and backfill.

SUBTASK 510.002: PREPARE TECHNICAL DRAWINGS AND SPECIFICATIONS

Stantec will prepare design drawings and specifications. A preliminary drawing list used to estimate the work effort is provided in Attachment B. Stantec will prepare technical specifications in 5-digit CSI format using Microsoft Word. Stantec will prepare EJCDC front-end specifications for the bid documents using Microsoft Word. Stantec will prepare all drawings using AutoCAD and final construction drawings will be stamped and signed by the design engineer.

SUBTASK 510.003: DESIGN SUBMITTAL PACKAGES

Stantec will provide City staff with a design submittal packages of the drawings and specifications at 60 percent and 90 percent complete including an estimate of the probable construction costs. After receiving City review comments on the 90 percent submittal package, Stantec will incorporate these comments and prepare a 100 percent complete submittal package for City approval.

SUBTASK 510.004: PREPARE FINAL BID DOCUMENTS

After City approval of the drawings and specifications, Stantec will prepare Final Bid Documents that include City approved front-end specifications. The front-end documents will include a bid schedule with the pre-negotiated TPS cost for furnishing and installing the ASD heating equipment (see Attachment C).

Task 510 - Deliverables

- Kick-off meeting agenda and notes (PDF file)
- Design progress meetings agendas and meeting notes (budget limit of 6, PDF file)
- Design schedule updates (budget limit of 6, PDF file)
- Monthly invoices and project updates (PDF file)
- Amended Geotechnical Report (electronic PDF file)
- 60 Percent Complete Submittal Package (electronic PDF files)
- 90 Percent Complete Submittal Package and Cost Estimate (electronic PDF files)
- 100 Percent Complete Submittal Package (electronic PDF files)
- Final Bid Documents (5 hard copies and electronic PDF files)

TASK 520: HYBRID DIGESTIION PILOT TEST

Thermal Process Systems (TPS) offered to provide its Ex-CalibAer sludge digestion pilot for five (5) months to test its digestion process at the City of Merced WWTF. Stantec will provide engineering support services to oversee the data collection and ensure that the data is being recorded and reported per the agreed testing protocol. At the completion of the pilot testing, Stantec will provide a technical report on the procedures and the findings of the pilot testing. The scope of work includes three subtasks:

SUBTASK 520.001: TESTING PROTOCOL FOR PILOT TEST

Stantec will assist TPS to develop objectives of the pilot and testing protocol including the testing parameters, methods, and frequency of sampling. Stantec will also coordinate with Thermal Process Systems on pilot set-up, feed sources, and data interpretation and calculations.

SUBTASK 520.002: OVERSEE PILOT OPERATION

Stantec will conduct weekly site visits by a Stantec engineer to oversee the pilot operation and coordinate with TPS and City to ensure quality data. This scope includes twenty (20) site visits during the 5 months operation of the pilot.

SUBTASK 520.003: PILOT TESTING TECHNICAL REPORT

Stantec will analyze the pilot data and write an engineering technical report to summarize the data and performance of the pilot test.

Task 520 - Deliverables

- Weekly Site Visit Reports (budget limit of 20)
- Technical Report (5 hard copies and PDF file)

Reference: **City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project**

BUDGET

The estimated time and expense budget for the above scope of services is **$1,673,800**. This budget includes an annual escalation of labor and expenses at 4 percent starting on January 1, 2022. A breakdown by task of the Stantec's labor costs, sub-consultant costs, and other direct costs is provided in Attachment B. We understand the proposed scope of work will be an amendment to our existing Agreement for the Phase VI Project Preliminary Design dated June 15, 2020.

Regards,

Stantec Consulting Services Inc.

Steven L. Beck, P.E.
Senior Principal
Phone: (916) 826-3665

Stantec Consulting Services Inc.

Beth Cohen, P.E.
Senior Engineer
Phone: (916) 541-2384

Attachment A –Phase VI Improvements Project Cost Estimate
Attachment B –Stantec Design Budget Breakdown
Attachment C – Project Schedule
Attachment D –TPS ADS Supplemental Heating System Proposal
Attachment E –TPD Supplemental Heating System Process Guarantee
Attachment F –TPD ExCalibAer Pilot Testing Proposal

Reference: **City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project**

ATTACHMENT A – MERCED WWTF PHASE VI IMPROVEMENTS PROJECT COST ESTIMATE

Phase VI Improvements Project Cost Item	Estimated Cost ($)
Influent Pump Station and Headworks	
New Influent Flow Meter	40,000
Concrete Repair and Recoating	100,000
Mechanical Screens and Washer/Compactors	650,000
Grit Basin Baffles	140,000
Secondary Treatment	
Replace Reactor Basins No. 1 and 2	7,800,000
Modify Reactor Basin No. 3	1,200,000
Replace existing blowers with new Gas Turbine Aeration Blowers	2,200,000
UV Disinfection	
Recoat Channels	140,000
Sludge Handling, Thickening, Digestion, and Storage	
DAFT Improvements	90,000
Solids Dewatering and Drying	
Supplemental Heating System for Existing Active Solar Dryers	2,940,000
Parallel Sludge Cake Conveyance System Conveyor	700,000
Septage Receiving	
Septage Receiving Station Modifications and Equipment Replacement	800,000
Subtotal 1	**16,800,000**
General Conditions, Site Work, Site Piping and Electrical (35%)	5,880,000
Subtotal 2	**22,680,000**
Contingencies (20%)	4,536,000
Subtotal 3 (Construction Cost)	**27,216,000**
Engineering and Construction Management	3,898,000
Total Project Cost	**31,114,000**

Notes: Assumes midpoint of construction ENRCCI = 12,000.

Reference: **City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project**

ATTACHMENT B – STANTEC DESIGN BUDGET BREAKDOWN

FEE ESTIMATE - City of Merced WWTF Phase VI Improvements Project

Name	Beck, Steven	Hauser, Jeff	Cohen, Seth	Monson, Conan	Botrous, Akram	Huang, Long	Estes, Darrin	Barlow, Andy	Maddux, Mike
Role	Project Manager	QA/QC	Project Technical Lead	Construction Manager	Senior Process Engineer	Senior Electrical Engineer	Mechanical Engineer	Senior Designer	Senior Designer
Project Billing Rate	$252.00	$252.00	$243.00	$243.00	$251.00	$243.00	$217.00	$192.00	$192.00
Total Units (T&M)	396	80	465	60	460	902	400	1104	344
Fee (T&M)	$99,792.00	$20,160.00	$112,506.00	$14,580.00	$115,460.00	$219,186.00	$86,800.00	$211,968.00	$66,048.00
Escalation (T&M)	$1,746.86	$555.22	$2,005.13	$401.55	$2,385.89	$3,698.21	$1,428.65	$3,752.70	$1,262.18
Total Fee (T&M)	$101,538.86	$20,715.22	$114,510.13	$14,981.55	$117,855.89	$222,884.21	$88,228.65	$215,720.70	$67,310.18

Name	Morales, Heather	Valukhin, Alex	Huang, Chris	McCartland, Kelly	Diaz, Loretta				
Role	Electrical Designer	Civil Engineer	Electrical Engineer	Civil Engineer	Admin Assistant	ODCs	HERWIT Engineering	BSK	Consultant
Project Billing Rate	$173.00	$183.00	$170.00	$170.00	$108.00	$1.00	$1.10	$1.10	$1.10
Total Units (T&M)	814	299	1114	160	142	9256.13	102540	15000	117000
Fee (T&M)	$140,822.00	$54,717.00	$189,380.00	$27,200.00	$15,336.00	$9,256.13	$112,794.00	$16,500.00	$128,700.00
Escalation (T&M)	$2,616.83	$1,067.38	$3,273.53	$220.75	$318.34	$0.00	$0.00	$0.00	$0.00
Total Fee (T&M)	$151,581.83	$55,784.38	$192,653.53	$27,420.75	$15,654.34	$9,256.13	$112,794.00	$16,500.00	$128,700.00

Project Summary	Labour	Expense	Subs	Total
Fixed Fee	$0.00	$0.00	$0.00	$0.00
Time & Material	$1,406,549.87	$9,256.13	$257,994.00	$1,673,800.00
Total	$1,406,549.87	$9,256.13	$257,994.00	$1,673,800.00

WBS Code	Task Code	Task Name	Start Date	End Date
1	**510.000**	**Detailed Design**	**13-Sep-21 (Mon)**	**18-Mar-22 (Fri)**
1.1	510.001	Design Coordination and Meetings	13-Sep-21 (Mon)	18-Mar-22 (Fri)
1.2	510.002	Quality Control and Constructability Reviews	13-Dec-21 (Mon)	11-Feb-22 (Fri)
1.3	510.003	Geotechnical Report Update	13-Sep-21 (Mon)	11-Nov-21 (Thu)
1.4	510.004	Prepare Drawings and Specifications	13-Sep-21 (Mon)	18-Mar-22 (Fri)
1.5	510.005	Design Submittal Packages	13-Dec-21 (Mon)	11-Feb-22 (Fri)
1.6	510.006	Prepare Final Bid Documents	14-Feb-22 (Mon)	18-Mar-22 (Fri)
2	**520.000**	**Hybrid Digestion Pilot Study**	**13-Sep-21 (Mon)**	**28-Feb-22 (Mon)**
2.1	520.001	Prepare Testing Protocol	13-Sep-21 (Mon)	28-Jan-22 (Fri)
2.2	520.002	Oversee Pilot Operation	13-Sep-21 (Mon)	28-Jan-22 (Fri)
2.3	520.003	Prepare Technical Report	31-Jan-22 (Mon)	28-Feb-22 (Mon)

Units

WBS Code	Beck, Steven	Hauser, Jeff	Cohen, Seth	Monson, Conan	Botrous, Akram	Huang, Long	Estes, Darrin	Barlow, Andy	Maddux, Mike
1									
1.1	208		104						
1.2		80		60					
1.3	4								
1.4	152		319		400	878	400	1008	280
1.5	12		24			16		72	48
1.6	8		16			8		24	16
2									
2.1	4				20				
2.2									
2.3	8				40				

WBS Code	Morales, Heather	Valukhin, Alex	Huang, Chris	McCartland, Kelly	Diaz, Loretta	ODCs	HERWIT Engineering	BSK	Consultant
1									
1.1					24	2500			
1.2						200			
1.3								15000	
1.4	750	235	1050		74	500	102540		117000
1.5	48	48	48		24	500			
1.6	16	16	16		8	1500			
2									
2.1					4				
2.2				160		4056.13			
2.3					8				

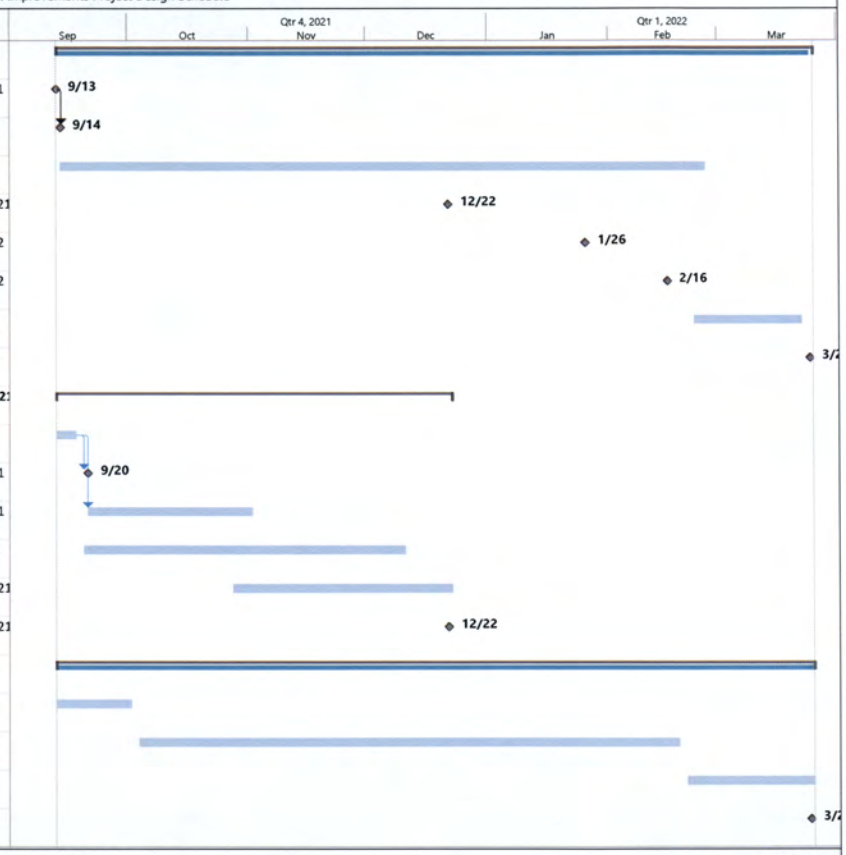
WBS Code	Task Type	Hours	Labour	Expense	Subs	Total
1	**Time & Material**	**6494**	**$1,359,173.89**	**$5,200.00**	**$257,994.00**	**$1,622,373.89**
1.1	Time & Material	336	$81,602.26	$2,500.00	$0.00	$84,102.26
1.2	Time & Material	140	$35,698.77	$200.00	$0.00	$35,898.77
1.3	Time & Material	4	$1,008.00	$0.00	$16,500.00	$17,508.00
1.4	Time & Material	5546	$1,149,036.65	$500.00	$241,494.00	$1,391,030.65
1.5	Time & Material	340	$85,889.40	$500.00	$0.00	$86,389.40
1.6	Time & Material	128	$35,940.82	$1,500.00	$0.00	$37,440.82
2	**Time & Material**	**244**	**$47,369.98**	**$4,056.13**	**$0.00**	**$51,426.11**
2.1	Time & Material	28	$6,512.43	$0.00	$0.00	$6,512.43
2.2	Time & Material	160	$27,420.75	$4,056.13	$0.00	$31,476.88
2.3	Time & Material	56	$13,436.80	$0.00	$0.00	$13,436.80

Reference: **City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project**

ATTACHMENT C – PROJECT SCHEDULE

Attachment C
City of Merced WWTF
Phase VI Improvements Project Design Schedule

ID	Task Name	Duration	Start	Finish
1	**Detailed Design**	**7 mons**	**Mon 9/13/21**	**Fri 3/25/22**
2	Notice to Proceed	0 days	Mon 9/13/21	Mon 9/13/21
3	Project Kickoff Meeting	0 days	Tue 9/14/21	Tue 9/14/21
4	Prepare Drawings and Specifications	119 days	Tue 9/14/21	Fri 2/25/22
5	50% Design Submittal	0 days	Wed 12/22/21	Wed 12/22/21
6	90% Design Submittal	0 days	Wed 1/26/22	Wed 1/26/22
7	100% Design Submittal	0 days	Wed 2/16/22	Wed 2/16/22
8	Prepare Bid Documents	20 days	Wed 2/23/22	Tue 3/22/22
9	Submit Final Bid Document	0 days	Fri 3/25/22	Fri 3/25/22
10	**SRF Funding Support**	**73 days**	**Mon 9/13/21**	**Wed 12/22/2**
11	Prepare CWSRF General Application	5 days	Mon 9/13/21	Fri 9/17/21
12	CWSRF Staff Kickoff Meeting	0 days	Mon 9/20/21	Mon 9/20/21
13	Prepare CWSRF Technical Package	30 days	Tue 9/21/21	Mon 11/1/21
14	Prepare CWSRF Environmental Package	3 mons	Mon 9/20/21	Fri 12/10/21
15	Prepare CWSRF Financial Security Package	2 mons	Thu 10/28/21	Wed 12/22/21
16	Submit CWSRF Application & Packages	0 days	Wed 12/22/21	Wed 12/22/21
17	**Hybrid Digestion Pilot Test**	**7 mons**	**Mon 9/13/21**	**Fri 3/25/22**
18	Prepare Testing Protocol	15 days	Mon 9/13/21	Fri 10/1/21
19	Oversee Pilot Operations	5 mons	Mon 10/4/21	Fri 2/18/22
20	Prepare Technical Report	25 days	Mon 2/21/22	Fri 3/25/22
21	Submit Technical Report	0 days	Fri 3/25/22	Fri 3/25/22



Mon 7/26/21

Reference: **City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project**

ATTACHMENT D – TPS ADS SUPPLEMENTAL HEATING SYSTEM PROPOSAL

THERMO-SYSTEM
INDUSTRIE- & TROCKNUNGSTECHNIK GMBH

627 110 East 110th Avenue
Crown Point, IN 46307

Preliminary Budget Proposal

To:	Mr. Steven Beck, P.E.	**Date:**	June 18, 2021
Company:	STANTEC	**From:**	Alexander Kraemer
Tel.:	(916) 826-3635	**Tel.:**	+1 (219) 663-1034
cc:	Mr. G. Harris, P.E. HERWIT Engineering Rep: Mr. B. Leidecker, P.E. CHC Water		
Subject:	Thermal Process Systems, Inc. [TPS] Thermo-System® [ThS] Active Solar Dryer™ [ASD] System Cost Estimate for SolarPlus™ Upgrades at Merced, CA WWTP		

The Active Solar Dryer™ installation in Merced, California is the largest biosolids solar dryer in North America, designed to process 2,719 dry tons per year of biosolids from an anaerobic digestion process.

Thank you for the opportunity to work with you and your team of subject matter experts on this project. TPS with its partner Thermo-System GmbH is pleased to offer the following proposal to supply materials and services to upgrade five (5) of the City's seven (7) existing ASD chambers to a SolarPlus™ drying system using digester gas and/or natural gas. The conditions for the utilization of digester gas is supplemental.

If this proposal is accepted, TPS will complete the project in accordance with the terms and conditions to be agreed on. A process warranty is included in the proposal.

MERCED

This preliminary Cost Estimate is divided into the following sections:

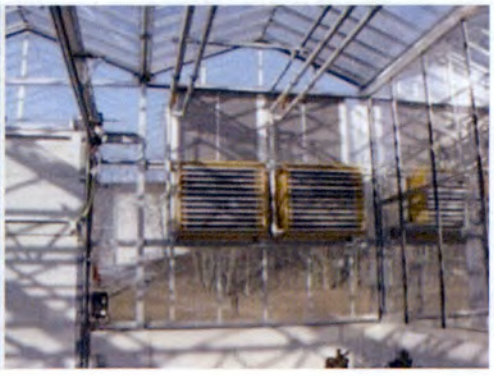
I. Brief Description of the Thermo-System® Supplemental Heating System Upgrade
   1. Supplemental Heating System
II. Equipment and Services Provided by Thermal Process Systems, Inc.
III. Services Supplied by Others
IV. Cost Estimate and Terms

Thank you for again for this opportunity. We look forward to working with you on this turn-key project upgrade. Should you have any questions or need clarifications, please feel free to contact me at +1 (561) 846-0334. Thanks.

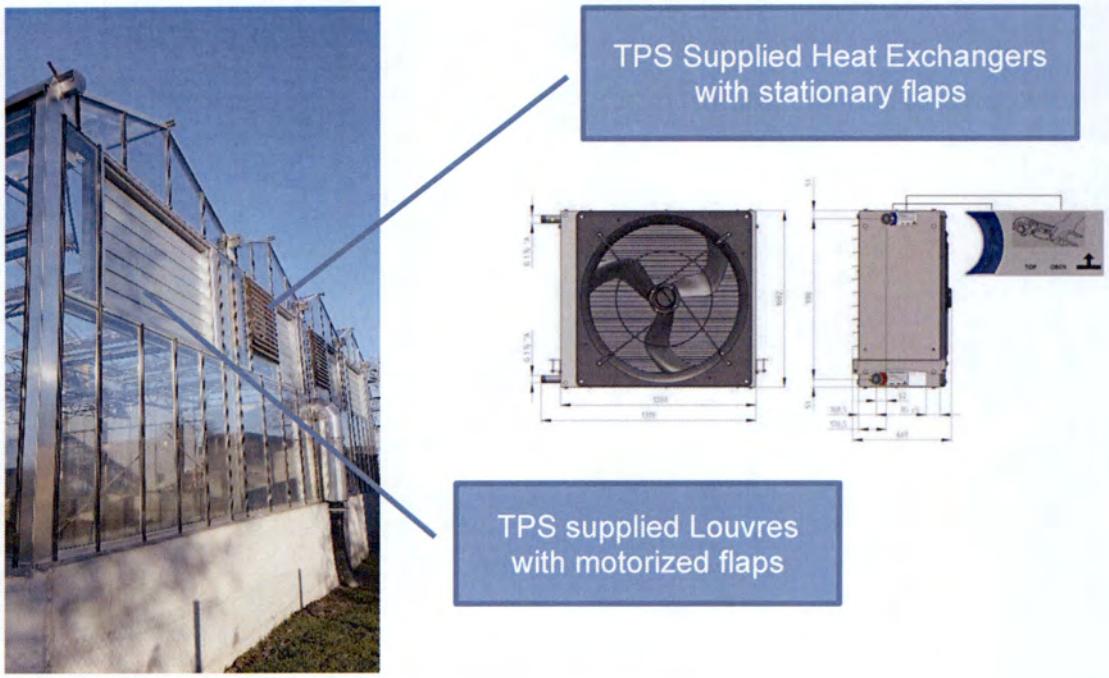
Sincerely,
Thermal Process Systems, Inc.
Alexander Kraemer
Product Manager
akraemer@thermalprocess.com

PART 1 - BRIEF DESCRIPTION OF THE THS SUPPLEMENTAL HEATING SYSTEM

A. In order to increase the biosolids loading rate to the existing ASD, a drying chamber would need to be equipped with a TPS/ThS approved supplemental heating system. The heating system in the solar dryer would consist of a boiler connected to an array of closed loop water-to-air radiators installed in the trusses of the greenhouse as well as the air inlet. Although it is assumed that water will be used, other heat transfer fluids, like water glycol may be used. The water-to-glycol mixture typically contains 38 to 45 percent water.

B. To avoid heat losses with the current design scheme at Merced, each of the five (5) ASD chambers shall require an enclosed gable. The SolarPlus™ drying chambers shall be equipped with two gable integrated air flaps (louvers) and two heat exchangers with stationary flaps to allow fresh air to be heated, before it enters the SolarPlus™ drying chamber. The louver flaps are driven by 3 phase electric motors. At the opposite end of the chamber, the existing installed exhaust fans are to blow saturated air out of the ASD chamber.



PART 2 - EQUIPMENT AND SERVICES SUPPLIED BY TPS

TPS will furnish and install all materials and equipment for the SolarPlus™ system upgrade as described above:

A. Boiler(s)
   a. Boiler(s) plus flue gas kits.
   b. Air Permit Authority to Construct.

B. Boiler Loop Piping/Pump Package
   a. Primary piping loops with pump, air seperator, make-up water and mixing valve.
   b. Secondary pump for each boiler.

C. Water Treatment Package
   a. Chemical bypass feeder with valves.

D. Hot Water Zone Valve/Pump Assy
   a. Zone valve assemblies with flow regulators and pumps.

E. Hot Water Piping
   a. Sch 10 steel piping and hangers connecting from primary boiler loops to zones.

F. Unit Heaters (HEx)
   a. Hot water hydronic unit heaters: 50pc (10 per SolarPlus™ drying chamber).

G. Unit Heater Piping Hookups
   a. Piping hook ups including hoses, valves and flow regulators from and to ASD only.

H. System drawings
   a. Installation notes.
   b. Diagram for internal electrical cabinet wiring.
   c. Boiler package piping details, and zone valve piping details.
   d. Overhead hydronic piping diagram.
   e. Stamped engineering drawings are not included, by others.

I. Sensors & Controls for Boiler Loop Piping/Pump Package
   a. Temperature sensors, control software, electrical cabinets, pump motor starters, and unit heater relays are included.

J. System Installation
   a. Installation of equipment, i.e. Unit Heaters, piping, boiler piping as part of this proposal.
   b. Louvers, polycarbonate sheets, framing and brackets at the air inlet side of each of the five ASD chamber(s).
   c. All cable trays, electrical, plumbing and landing from boiler to ASD.

d. Air exchange system programming modifications to include exhaust fans, ceiling fans, air inlet flaps, and motors with the heating system upgrade.

e. Final installation inspection, start-up supervision and operator training is provided. Extended training and/or plant operation supervision is also available for an additional fee.

PART 3 - SERVICES PROVIDED BY OTHERS

A. Stamped Engineered Drawings (including civil, electrical, mechanical, structural) for all facilities outside of Active Solar Dryer chambers.

B. Dumpsters, trash removal, restroom requirements, and temporary power & water.

C. Gas and water lines to Boiler Loop Piping/Pump Package is by others.

D. Civil, electrical, mechanical, structural, plumbing of any kind and gas line connections prior to Boiler Loop Piping/Pump Package are by others.

E. Anchor bolts for Boiler/Pump Package is by others.

PART 4 - COST ESTIMATE AND TERM

A. The budget price for the equipment and services supplied is as follows. All pricing is FOB Factory, Freight Allowed. **$2,670,860.00**USD

B. Terms are 30% with order, 60% net 30, 10% upon startup.

C. Stamped Engineering Drawings will be submitted to City for approval within 4 weeks of written Notice to Proceed.

D. Equipment installed and tested within 22 weeks of Stamped Engineering Drawings approved by the City.

Reference: **City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project**

ATTACHMENT E – TDS ADS SUPPLEMENTAL HEATING SYSTEM PROCESS WARRANTY

Thermal Process Systems, Inc
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THERMAL PROCESS SYSTEMS
THERMSOLAER

PERFORMANCE GUARANTEE
Thermal Process Systems, Inc. Project: Merced, CA – Heater Upgrade

This Performance Guarantee ("Performance Guarantee" or "Guarantee") is furnished and delivered by Thermal Process Systems, Inc. ("TPS") to the Buyer (the Buyer shall be the owner of the Equipment during the Guarantee Period) of the Equipment sold pursuant to the above-titled Project and identified as Thermal Process Systems Project No. 700193_HEx ("Equipment"). TPS has also furnished a Mechanical Warranty on the Equipment pursuant to TPS's Standard Terms and Conditions. The terms and conditions of this Performance Guarantee are separate and distinct from the Mechanical Warranty and are set forth below:

Guarantee Period. TPS guarantees the performance of the Equipment for **two (2)** years from the day that the Equipment is started up (or otherwise put into use) at the Project jobsite. An adjustment made per this Guarantee will not void the Guarantee, nor does it imply an extension of the Guarantee Period. Equipment serviced and/or parts replaced during the Guarantee Period carry the un-expired portion of the original Guarantee only.

Performance Parameters. Thermal Process Systems will maintain the Effluent Performance Quality defined below only:

1. When the Equipment is operated per Thermal Process Systems's instructions, manuals or other materials (i.e., O&M Manuals or other materials illustrating Equipment operation, installation, maintenance, etc.);
2. When the terms and conditions of this Guarantee are met;
3. When the Maximum Influent Values defined herein are not exceeded (as shown in the Basis of Design); and
4. When the Feed Biosolids Characteristics (i.e., constituents, elements, etc. found in the Feed Biosolids) do not change, or are not modified, in any way from those Feed Biosolids Characteristics known by Thermal Process Systems at the time this Guarantee is developed.

BASIS OF DESIGN:

Application:	Anaerobically Digested Biosolids
Dry Solids Per Day:	14,941 lbs/d (average), not to exceed max. of 18,724 dry lbs/d
Dry Solids Content in Feed:	minimum 22% cake dryness from centrifuges
Cake Dryness after ThermSolAer:	75% dried solids

EFFLUENT PERFORMANCE QUALITY:
Thermal Process Systems will guarantee that the seven Active Solar Dryer™ with the TPS heater system upgrade will process all of the above-mentioned biosolids (Basis of Design) to a minimum cake dryness of 75% dry solids content during the winter months, when operated per the Thermal Process Systems O&M and by Thermal Process Systems operation recommendations. During the five (5) following months of the year: November, December, January, February, and March the City agrees to utilize either natural gas, biogas, or the combination of; to provide the heaters with the necessary heating power to process biosolids quantity and quality indicated above: "BASIS OF DESIGN".

Mandatory Data. In the event that Buyer asserts that the Equipment is failing to meet the Effluent Performance Quality, the minimum data to be collected and reported by the Buyer to Thermal Process Systems in writing in a coherent and timely manner is as follows:

- A representative sample of the biosolids is to be taken from one solar dryer and sent to an independent laboratory for analysis. The Buyer and Thermal Process Systems will agree upon a suitable laboratory to perform the analysis.
- Thermal Process Systems will provide a sampling plan to ensure that a representative sample is taken.
- The Buyer is to provide the amount, dry solids content, and biosolids level at the time the biosolids in question was loaded into the solar dryer chamber.

NOTE: Failure to provide this minimum level of data will suspend the Cure Period until such time as all data reporting is brought up to date completely or the Effluent Performance Quality guaranteed herein is maintained. There shall be no liability borne by Thermal Process Systems during the time Thermal Process Systems must wait to receive this most important data from Buyer.

Guarantee Requirements. In the event Buyer believes that the Equipment is failing to meet the Effluent Performance Quality:

Buyer shall:
1. Notify Thermal Process Systems in writing of the suspected problem and provide all facts, data and information necessary to verify the problem;
2. Provide other information (i.e., plant operation data, feed biosolids characteristics, chemical usage, etc.) that may be required by Thermal Process Systems to identify the cause of the suspected problem; and
3. Provide immediate access to the site with necessary utilities and manpower as required to assist Thermal Process Systems in determining the cause of the suspected problem.

Thermal Process Systems shall:
1. Review all facts, data and information provided by the Buyer to determine the cause of the problem.
2. Recommend and perform any additional test work that may be required to determine the cause of the problem.
3. If, after review of existing data or performance of additional recommended test work, the results indicate that the Equipment is meeting the guaranteed Effluent Performance Quality, then the cost of reviewing the data and performing any additional test work, including engineering time, travel expenses and test costs, shall be borne by Buyer.
4. If, after review of existing data or performance of additional recommended test work, the results indicate the Equipment is not meeting the guaranteed Effluent Performance Quality due to a factor outside the Thermal Process Systems's control, then Buyer and Thermal Process Systems will work together to resolve the situation by a cooperative, good faith effort. However, no liability shall be borne by Thermal Process Systems.
5. If, after review of existing data or performance of additional recommended test work, the results indicate that Thermal Process Systems's Equipment is not meeting the guaranteed Effluent Performance Quality, and subject to all conditions of this Guarantee being met, charges incurred by Thermal Process Systems in correcting the Equipment, including Thermal Process Systems's engineering time and travel expenses, any recommended test work, modifications to existing equipment or addition of new equipment, shall be borne by Thermal Process Systems.

Mitigation Requirements: If it is determined that the Equipment is not meeting the guaranteed Effluent Performance Quality, in no event shall any work be done, or services or material be purchased, or expense otherwise incurred by the Buyer for the account of Thermal Process Systems until after full and complete particulars have been submitted and approved in writing by Thermal Process Systems. Thermal Process Systems must be given the opportunity to discuss and research alternative methods to lower the costs involved in such corrective work. Returned items will not be accepted unless Thermal Process Systems has previously agreed to such return in writing and supplied written return-shipping instructions to Buyer.

Maximum Liability: In the event Thermal Process Systems expends any funds pursuant to this Guarantee during the Cure Period, Thermal Process Systems's total aggregate liability under this Guarantee shall be no greater than 25% of the Purchase Order value between Thermal Process Systems and Buyer.

Cure Period: Thermal Process Systems shall have thirty (30) days from the date of receipt of Notice (as outlined above) to submit a written plan outlining the actions necessary to cure any alleged problems with the Equipment. Thermal Process Systems shall have an additional thirty (30) days beyond the initial thirty (30) days (sixty (60) days total from the date of receipt of Notice) to cure any alleged problems with the Equipment. However, if Thermal Process Systems deems that the alleged problems are not curable within sixty (60) days, then Thermal Process Systems shall work in conjunction with the project engineer in developing an action plan to cure such problems within a reasonable time.

Guarantee Nullification. This Performance Guarantee will be null and void, if:

(A) The Equipment is used for purposes other than those for which it was originally designed or intended;
(B) The Equipment is not used in accordance with generally approved practices;
(C) The Equipment is not stored in accordance with Thermal Process Systems's specific instructions. (It is Buyer's responsibility to request storage instructions from Thermal Process Systems)

(D) A Disaster, Force Majeure and/or an Act of God occurs, whether natural or manmade, such as (but not limited to) fire, flood, wind, earthquake, cave-in, lightning, war, or vandalism;
(E) There are any unauthorized repairs, alterations or modifications of the Equipment not approved in writing by Thermal Process Systems; validation
(F) Any abuses, neglect, or misuse of the Equipment, including without limitation, the operation of Equipment after a defect is discovered; valid
(G) The Equipment is operated by persons not properly trained for that purpose;
(H) The Equipment is repaired or in any way changed from the original condition as provided by Thermal Process Systems;
(I) The Equipment is improperly installed, maintained, lubricated and/or exposed to elements that are detrimental to the materials of construction;
(J) Negligence, neglect, accident or other conditions beyond the control of Thermal Process Systems occur;
(K) The Influent Biosolids Characteristics change; and/or
(L) Decomposition of the Equipment by chemical action occurs.

Terms and Conditions

LIMITATION OF LIABILITY: Unless expressly agreed to in writing by Thermal Process Systems, all damages not direct and actual in nature, including without limitation, consequential, incidental, exemplary and punitive damages, shall be expressly prohibited damages are not covered by this Guarantee. Such prohibited damages include, but are not limited to, lost rent or revenue; rental payments; costs (increased or not) of administration or supervision; costs or delays suffered by others unable to commence work or provide services as previously scheduled for which a party to this contract may be liable; increased costs of borrowing funds devoted to the Project (including interest); delays in selling all or part of the project upon completion; termination of agreements to lease or buy all or part of the project, whether or not suffered before completion of services or work; forfeited bonds, deposits, or other monetary costs or penalties due to delay or halting of the Project; interest for any reason assessed to Buyer; increased taxes (federal, state, local, or international) due to delay or recharacterization of the project; lost tax credits or deductions due to delay or halting; impairment of security; attorney and/or other legal fees for any reason assessed to Buyer, loss of use of the Equipment or any associated Equipment, costs of substitute facilities or services, down time costs, claims of customers of Buyer for such other damages; or any other indirect loss arising from the conduct of the parties.

DISPUTE RESOLUTION: Any issue, claim or dispute ("Action") that may arise out of or in connection with this Project and which Buyer and Thermal Process Systems are not able to resolve by good faith negotiations, shall be submitted to mediation. Both parties shall choose a mediator and said mediator will decide the forum most convenient for both parties. Both parties agree to reasonably attempt to resolve all Actions via this medium. If mediation shall fail, the Action shall be submitted to binding arbitration administered by the American Arbitration Association under its Construction Industry Arbitration Rules and Mediation Procedures (Including Procedures for Large, Complex Construction Disputes), and judgment on the award rendered by the arbitrator(s) may be entered in a court having jurisdiction thereof. The parties agree to use mediation then arbitration to resolve such Action in lieu of litigation. In the event that an Action is brought, the prevailing party shall be entitled to be reimbursed for, and/or have judgment entered with respect to, all of its costs and expenses, including reasonable attorney's fees' and legal expenses.

GOVERNING LAW & VENUE: The rights and obligations of Buyer and Thermal Process Systems shall be governed by and interpreted in accordance with the substantive laws of the state of Florida including the uniform commercial code of Florida, excluding conflicts of law and choice of law principles. Venue for all disputes related to this Project shall be held in Crown Point, Indiana unless otherwise agreed to in writing by Thermal Process Systems.

MISCELLANEOUS: This Guarantee does not cover onsite labor, freight or any failure of normal wearing parts unless said failure has resulted from defective materials and/or workmanship, which is governed by Thermal Process Systems's Mechanical Warranty. The parties agree that the foregoing constitutes the entire Guarantee by Thermal Process Systems and that there are no other guarantees, terms or conditions, expressed or implied, unless otherwise agreed to in writing. This document may not be modified or superseded other than by an instrument in writing signed by both Buyer and Thermal Process Systems. This document shall be binding upon and inure to the benefit of Buyer and Thermal Process Systems and their assignees. The invalidity or non-enforceability of any particular provision of this document shall not affect the other provisions hereof, and this document shall be construed in all respects as if such invalid or unenforceable provisions were omitted.

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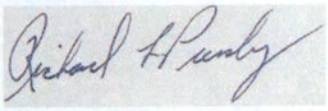
THERMAL PROCESS SYSTEMS
THERMSOLAER

THIS GUARANTEE IS EXCLUSIVE AND IN LIEU OF ALL OTHER GUARANTEES AND WARRANTIES OF QUALITY, WRITTEN, ORAL OR IMPLIED; ALL OTHER WARRANTIES, UNLESS PROVIDED BY THERMAL PROCESS SYSTEMS IN WRITING, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED.

Signature



Mr. R. L. Pressley
President – Thermal Process Systems, Inc.

Reference: **City of Merced WWTF Design Proposal for WWTF Phase VI Improvements Project**

ATTACHMENT F – TDS HYBRID DIGESTION PILOT TEST PROPOSAL

Thermal Process Systems, Inc.

June 9th, 2021

Mr. Steven Beck, P.E.
Senior Principal

STANTEC
3875 Atherton Road
Rocklin CA 95765-3716

M: +1 (916) 826-3665
E: Steven.Beck@Stantec.com

Thermal Process Systems, Inc. (TPS) is pleased to offer the following pilot demonstration proposal for the ExCalibAer™ process.

We look forward to working with you on this project. Please feel free to contact us with questions and/or comments.

Sincerely,

Alexander Kraemer

Alexander K. Kraemer
Product Manager

Thermal Process Systems, Inc

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E: akraemer@thermalprocess.com

Thermal Process Systems, Inc.

Thermal Process Systems, Inc. is pleased to offer the following proposal and preliminary scope of supply for the solids handling and processing for your digestion project. The following proposal explains the fundamental theory behind Thermal Process Systems' ExCalibAer™ process that combines multistage anaerobic digestion with aerobic digestion.

Anaerobic digestion is the biological process of breaking down compounds without the presence of oxygen and is commonly used in wastewater treatment plants. The use of anaerobic digestion in a plant is favorable as it is capable of processing large amounts of high-strength waste and produces a methane-rich biogas that can be utilized as a fuel supplement. Many anaerobic digestion processes today operate as a single unit. Effectively controlling a single-stage anaerobic digester can be difficult, as there are multiple biological processes occurring together. The main stages of anaerobic digestion are hydrolysis (solubilizing solid material), acidogenesis (formation of volatile fatty acids), and methanogenesis (conversion of acids to methane).

Issues may arise in single-stage units because these processes occur at different rates; the first two occurring rapidly, while the conversion of volatile fatty acids (VFAs) to methane is a much slower process. Performing the entire anaerobic digestion process in a single vessel is problematic because it is difficult to understand the current state of the reactor at any given time. The pH of an anaerobic digester is commonly used as an indication to the health of the digester. However, a significant fluctuation in the pH may occur long after the digester enters a stressed state due to its alkalinity buffer. This makes it problematic to identify and correct any problems posed to the system. The ExCalibAer™ system separates the stages of anaerobic digestion to achieve a reliable and more efficient approach to the anaerobic treatment of biosolids.

The ExCalibAer™ process utilizes three different digestion environments; each tailored to accommodate a different bacterial culture. Fresh feed material is fed into the smaller Feed De-Nit (FDT) anaerobic digester, where the more rapid processes of hydrolysis and acidogenesis take place. This volatile fatty acid (VFA)-rich material is then transferred to the larger methanogen anaerobic digester (MR), where the VFAs undergo methanogenesis to produce a methane-rich biogas. The anaerobically digested biosolids are transferred to a final mesophilic aerobic digester (SGR). This final unit plays an important role in removing ammonia through nitrification and conditioning the biosolids before dewatering. There are several other benefits that this Sweet Gas Reactor (SGR) offers, which will be discussed later. What separates ExCalibAer™ from other anaerobic digestion processes is the *process control capabilities* achieved with recycling material from the SGR back to the Feed De-Nit Tank (FDT). This recycle through the process offsets fluctuations in the feed coming into the Feed De-Nit Tank (FDT), maintaining a more consistent feed and stable operation of the anaerobic process. Recycling material from the SGR can control the anaerobic digester's VFA to alkalinity ratio (VFA/ALK), ammonia, pH, and H_2S production.

ExCalibAer™ consistently achieves improved volatile solids (VS) destruction and biogas production with lower hydraulic retention times (HRTs), increasing the capacity of an anaerobic digestion process. The process control mechanisms used, significantly reduce many of the concerns that come with classical anaerobic digestion. The biosolids being dewatered out of the SGR are considered odor-free to the operator of a WWTP, while others outside our profession would describe the low-odorous smell of the biosolids as musty and earthy. The biosolids

out of the SGR generally achieves higher cake solids with little to no coagulants and a stark reduction to the polymer demand. The combination of improved VS destruction and dewaterability of the biosolids results in significantly less material that needs to be either hauled from the facility, or further treated onsite.

The purpose of the Feed De-Nit is two-fold. Traditionally it is used to separate the fundamental stages of anaerobic digestion, which is commonly a single-stage process, into an acid-production phase and a gas-production phase. Hydrolysis and the formation of VFAs take place in this first process tank with an HRT under 2 days. The short HRT accommodates the more rapid anaerobic digestion steps, while preventing the slower formation of methane. A critical aspect for the successful operation of an anaerobic digestion process is a consistent feed into the digesters. Material entering a facility may vary widely in its composition, so the ExCalibAer™ process accommodates this by recycling material from the SGR. The recycle stream effectively dilutes the feed material, allowing stable operation, while preventing the anaerobic digester from becoming VFA overloaded. Creation of the VFAs and other organic compounds is accompanied by a small amount of gas production that may include, but is not limited to hydrogen (H_2), ammonia (NH_3), and carbon dioxide (CO_2).

The second major function is to provide a reducing environment for de-nitrification. SGR recycle is retuned to this tank with a high concentration of oxygen-rich nitrates. Bacteria use the oxygen in the nitrates, releasing N_2 gas, while using that oxygen to oxidize the sulfides to sulfates. This process changes the predominant electron receptor inhibiting the generation of H_2S-producing sulfur reducing bacteria.

Parameters continuously monitored in the tank include the temperature, pH and oxidation-reduction potential (ORP). These will be monitored by a temperature/pH/ORP probe. The acid tank is maintained at a temperature of 99°F with a higher mixing intensity than the methanogen reactor to effectively promote hydrolysis of the feed material. Heat may be supplemented to the Feed De-Nit through the biogas produced in the methanogen reactor and directly via the SGR recycle.

The methanogen reactor completes the anaerobic digestion process with the VFAs formed in the Feed De-Nit Tank (FDT) being converted to a methane-rich biogas. This digester is the critical stage of the process, where the overall effectiveness is demonstrated through high VS destruction and gas production. The formation of methane is much slower than the processes occurring in the acid tank. Therefore, a larger tank with a longer HRT (15 days) is used to allow the methanogen culture sufficient time to properly digest the biosolids. VFAs introduced to the methanogen reactor are met by methanogenic bacteria that convert the material into a biogas mixture. Methane is the primary constituent of this biogas, although some other gases, including CO_2, H_2S, nitrogen (N_2), may also be produced.

The methanogenic bacteria in the methanogen reactor (MR) are the most sensitive culture throughout the process, therefore requiring the most attention to their environment. The digester is to be operated at 95°F with as little variance in this value as possible. The temperature, along with pH and ORP, will be monitored with a probe, identical to the Feed De-Nit Tank (FDT).

Material that has proceeded through the full anaerobic digestion has had a significant portion of its VS destroyed at this point. However, there is still a large presence of nitrogen in the form of ammonia (NH_3) and ammonium (NH_4^+) that must be treated. Unlike the preceding digesters, the SGR is an aerobic digester, where the biosolids undergo rapid nitrification as a final solids conditioning step. Nitrification involves converting ammonia to nitrate (NO_3^-). Some digestion processes alternate between nitrification and denitrification in the same tank. The ExCalibAer™ process utilizes the anaerobic environment of the Feed De-Nit digester (FDT) to reduce nitrates in

the recycled SGR material to nitrogen gas, as the bonded oxygen molecules are used to oxidize sulfur compounds. The nitrate source of oxygen inhibits the activity of sulfate-reducing bacteria, significantly reducing the formation of H_2S in the biogas.

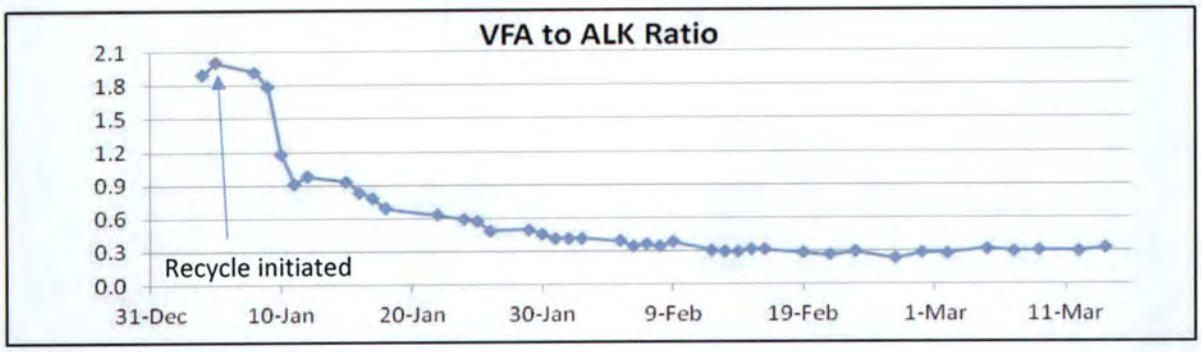
Oxygen demand is based upon the amount of soluble chemical oxygen demand (COD) available to the microbial community as a food substrate. The process is designed to be self-regulating and therefore is adaptable to several feed cycle protocols, providing the instantaneous uptake demand does not exceed the maximum capability of the aeration equipment. Secondary signals are received from temperature probes mounted near the ORP probe and from our proprietary foam control monitoring system. Liquid and airflows are controlled independently to sustain optimum reactor performance. This portion of the control process is patented with the U.S. Patent Office number 6,203,701.

The calculated oxygen requirement in the SGR is based upon 100% ammonia oxidation and 8% VS destruction rate (mass balance) for secondary solids. The actual destruction may vary. The aeration system is designed with positive displacement blowers for the air delivery system. Positive displacement blowers have been selected because of their ability to operate with variable backpressure created by changing liquid depths and reactor temperature. The displacement of airflow is a direct correlation to blower rpm. The blower selected for this application will operate at ≈90% of maximum rpm at the design airflow. This design point offers a high degree of flexibility to turn the blower rpm up or down. Therefore, the system has the inherent capability of increasing O_2 delivery during unexpected high COD feed concentrations. An unusually high uptake or demand is detected by a low ORP reading and is met by increasing pump and blower speeds above the anticipated requirement. It also has the capability to decrease pump and blower speeds for energy and temperature conservation during periods of low solids feeding, unattended weekends, or inactivity.

A hydraulic foam control system is also included as part of our package. The foam layer is the upper reactor's insulation blanket. Foam suppression nozzles connected to a side stream off the jet pump supply the energy source. The pump is designed to operate at sufficient volume and pressure to recycle reactor contents, which primary function is breaking down the foam. The foam bubbles are ruptured by the mixing intensity of the nozzle and return SplashCone™ unit. The system is operated, when required and controlled by the foam level radar transmitter in the top of the reactor.

In the SGR a single probe is used for monitoring temperature, pH, and ORP conditions in the tank. This reactor operates at a temperature of 95°F and pH in the range of 6.0 – 6.6 for optimal performance of the mesophilic bacteria. ORP is used to monitor the nitrification and regulates the amount of air entering the tank.

A commonly used indication of poor anaerobic digester health is the pH being severely depressed. However, a low pH does not give a full picture of what is occurring in the digester. Research suggests that the ratio of VFAs (expressed as mg/L acetic acid) to alkalinity (expressed as mg/L calcium carbonate), VFA/ALK, is a better indication as it takes into account the buffering capacity of the material. A ratio value below 0.3 denotes a healthy anaerobic digester. Plug-flow operation of the ExCalibAer™ system without a recycle resulted in the anaerobic digester or Methanogen Reactor (MR) becoming severely VFA overloaded, reaching a VFA/ALK value above two. Once this was determined shortly after beginning testing, the recycle from the SGR to the Feed De-Nit Tank (FDT) was initiated. The figure below shows the rapid decline of the VFA/ALK value with continued use of the SGR recycle before leveling off to a steady state value of 0.30.

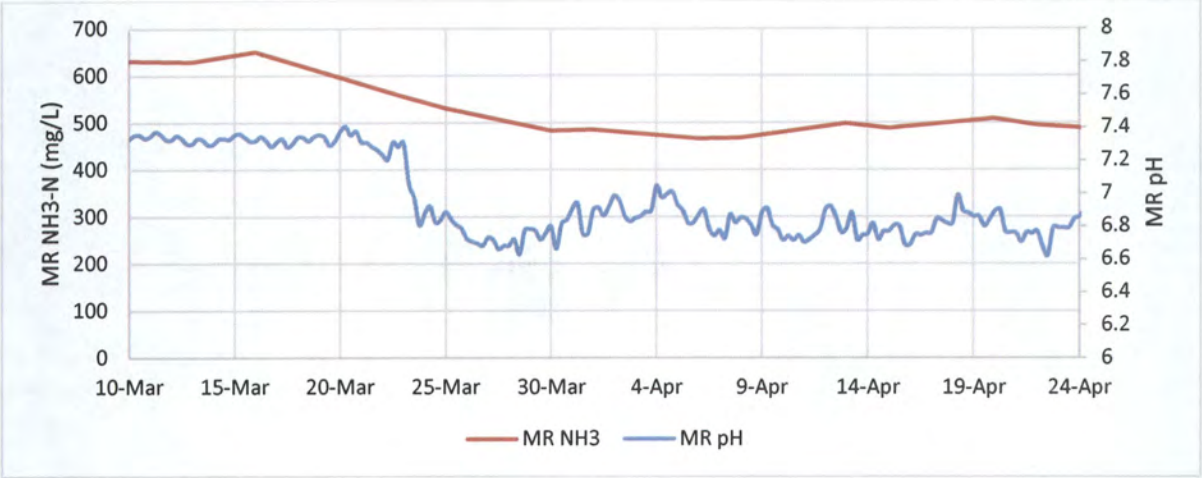


Operation of the ExCalibAer™ process with the SGR recycle results in a system with consistent VS destruction across the digesters and an elimination of upsets or foaming events. When operating at steady state, the methanogen reactor (MR) demonstrated 55% VS destruction, while the SGR achieved a further 10% VS destruction of the incoming anaerobic material. Overall, the ExCalibAer™ system achieves 60% VS destruction.

Another aspect of the ExCalibAer™ process being observed was the capability of the system to control the pH of the Anaerobic Digester (alternatively, Methanogen Reactor, MR) in a range that would decrease or eliminate the potential for struvite formation. This is achieved by decreasing the ammonia in the MR through the recycle, therefore lowering the pH of the digester. The table below shows measurements of the components for struvite (Mg, NH_3-N, PO_4-P, specific conductance) that were taken early in the pilot demonstration to determine a target pH for the MR.

Input Data							Results				
Total Mg (mg/L)	Total NH3-N (mg/L)	Total Ortho-P (mg/L)	pH	Temp (Celcius)	Specific Conductance (umhos/cm)	Flow (m3/day)	Struvite (kg/day)	Total Mg (mg/L)	Total NH3-N (mg/L)	Total Ortho-P (mg/L)	Log of Saturation Index
85	1000	200	7.3	35	4960	1000	714	14	959	110	0.94
85	900	200	7.2	35	4960	1000	653	20	863	118	0.77
85	800	200	7.1	35	4960	1000	566	29	768	129	0.59
85	700	200	7	35	4960	1000	438	42	675	145	0.41
85	600	200	6.9	35	4960	1000	253	60	586	168	0.21
85	500	200	6.8	35	4960	1000	0	85	500	200	-0.01

As operation stabilized, the recycle rate was increased to 200% to better distribute heat across the system. This also produced a result observed in each pilot demonstrations. The higher recycle rate began to effectively decrease the ammonia in the MR before stabilizing. It can be observed below that this effect was accompanied by a decrease in the MR pH, which similarly stabilized.



As the ammonia was decreasing in the MR, the pH reached the value determined to eliminate potential struvite formation. It was observed that as the pH in the MR decreased, the soluble phosphorus began to increase before leveling off, seen below. These results reinforce the struvite formation calculations previously shown.

The ExCalibAer™ process improves the digestion portion of a WWTP in a way that enables positive effects to ripple through an entire facility. Effective nitrogen removal significantly lowers the amount of nitrogen being returned to the headworks from dewatering. The ability to maintain phosphorus solubility through the digestion process offers an ideal scenario for recovering phosphorus in the centrate. While there are several methods of

reclaiming phosphorus from digestate, the same chemistry can be applied on the centrate where there are fewer competing compounds that lower the removal efficiency. Centrate produced by dewatering material from the SGR has minimal biological activity and alkalinity remaining. The result is a reduction of the chemical demand for phosphorus precipitation and the required pH adjustments. This can be especially effective for facilities utilizing biological nutrient removal (BNR) processes. BNR facilities that do not have a phosphorus removal stage have a tendency to cycle up in their phosphorus levels as a result of perpetually recycling the nutrient through the process. This buildup of phosphorus can lead to the BNR process no longer being able to keep up as well as critical struvite issues throughout the plant.

The ability to reliably remove a high percentage of the phosphorus from the centrate daily enables a facility to maintain more steady-state values throughout the entire facility. A facility that has already experienced the phosphorus cycling up will take some time to remove the excess before bringing the system into steady-state operation.

An additional benefit of increasing the recycle is a direct benefit to the biogas being produced. Operation with a recycle sufficient to provide an 8:5 mole ratio nitrate to sulfide reduces H_2S in the biogas to significantly lower levels. At the same time, the biogas maintained textbook biogas production rates.

Description: Digest Offgas AD-Pilot
Received: 04/17/2020
Sample No.: 200420006

	Result	Units	Method
Atmospherics, H2 and Inerts			
Nitrogen	12.36	Mol %	GC-TCD
Oxygen	4.08	Mol %	GC-TCD
Methane	62.52	Mol %	GC-TCD
Carbon dioxide	21.04	Mol %	GC-TCD
Sulfurs			
Hydrogen sulfide	334	ppb v	GC-ICP-MS

The reduction of H_2S in the biogas produced is attributed to biological mechanisms exhibited in literature. Previous research has shown the ability of nitrates to inhibit the activity of sulfate-reducing bacteria (SRBs) that are responsible for the reduction of sulfur compounds to H_2S. Previous work and case studies have used synthetic nitrate sources (typically calcium nitrate) that were shown to be effective at preventing the formation of H_2S. However, the amount of these nitrate sources required were typically not economically feasible. The natural biological processes carried out in the SGR provide a drastically cheaper nitrate source. This effect was also observed, when the recycle was first initiated, but this phase has demonstrated the ability of the nitrates being recycled from the SGR to completely halt the processes carried out by SRBs. In some anaerobic digestion systems, iron is supplemented as ferric sulfate or ferric chloride to reduce the H_2S produced. With the SGR's natural prevention of H_2S in the biogas, the ExCalibAer™ automated process optimization can significantly reduce iron supplementation.

The SGR is a critical step as it provides proper solids conditioning to improve the dewatering capabilities of the biosolids leaving the ExCalibAer™ process. Biosolids produced by this digestion process does not require any coagulants and require significantly less polymer, when dewatering to produce a cake with a higher solids content. Lab centrifuge testing results obtained from a Decanter Centrifuge Manufacturer are shown in the table below. Well-digested biosolids release a portion of the entrained water within the cell structure in the reactor. Therefore, digested material can release a higher percentage of free water during dewatering. Anaerobic digestion is susceptible to the formation of extracellular polymeric substances (EPS), a biofilm primarily composed of proteins and carbohydrates. EPS has a high stored water content, binding up to 5 grams H_2O/gram EPS. The SGR is very effective at breaking down proteins and carbohydrates. This releases the water stored in EPS and allows it to drain out of the biosolids during dewatering, significantly improving dewatering results.

While dewatering operations are site-specific, the work of Dr. Julia Kopp demonstrates that the amount of phosphorus and the volatile solids fraction remaining in biosolids are two of the most critical factors in the resulting dewatered cake solids. Additional VS destruction achieved in the SGR reduces the volatile solids fraction further than anaerobic digestion alone, while the aforementioned phosphorus recovery from the centrate reduces the phosphorus remaining in the digestate prior to dewatering. These effects combine to offer significant improvements to the dewatering of biosolids processed by the ExCalibAer™ system. Pilot experience indicates the cake solids would increase by up to 20% (e.g., from 20%TS to 24%TS), significantly reducing the amount of material to be hauled or dried following dewatering.

Sample	Total Solids (%)	Coagulant (mL Ferric Sulfate)	Flocculant (mL Polymer)	Cake Solids (%)	Coagulant (active lb/dry ton)	Flocculant (active lb/dry ton)
Pilot SGR	2.31	0	9	32.2	0	18

ExCalibAer™ Process Optimization Benefits:

- Automated Control Process resulting in less operator attention
- Class 'B' as a liquid or solid material
- Low odor biosolids
- Continued re-seeding of aeration basin with nitrifiers (after dewatering)
- Ability to handle septage and grease
- Can be integrated into almost any design scheme with existing tankage
- Substantial sludge volume reduction
- Lower HRTs increase throughput capacity
- Nutrient (N and P) removal from return stream
- Potential for more effective P recovery
- Reduction of H_2S in biogas
- Reduction of struvite in anaerobic digester
- No coagulant requirement for dewatering
- Reduction of polymer for dewatering
- Increased cake solids from mechanical dewatering process

Thermal Process Systems provides process and design engineering and design support to the design engineer. Technical instructions for the **ExCalibAer™** pilot unit, start-up, as well as operation and maintenance are also included. Thermal Process Systems' personnel will be there every step of the way to ensure smooth operation of the **ExCalibAer™** pilot process, from initial setup and information sessions, access to design data, assistance in sampling, startup, operation, and trouble shooting.

Proposed Site location of Trailer Unit:

Proposed design daily loading of 3.5 dry lbs/day of sludge material loaded on a 5-day work week.

ExCalibAer Pilot Package

Sludge Type	
Primary/WAS	8 gal/day
Feed-Denitrification Tank	1
Methanogen Reactors	1
Sweet Gas Reactors	1
%TS Average	~5.0%
%TS Range	4 - 6%
%VS	80%

Acid Phase Digester Sizing
One stainless steel tank – 14" Ø x 4'

One (1) Acid Phase Digester complete with:
1) One (1) 1 HP, top-mounted explosion-proof motor complete with shaft mixer assembly.
2) One (1) ORP/pH probe and analyzer with temperature readout.
3) One (1) Vacuum gauge sensor.

4) One (1) Liquid level sensor with local readout.
5) One (1) Heat belt
6) One (1) Sample tap

Anaerobic Digester Sizing
One stainless steel tank – 30" Ø x 4'

One (1) Anaerobic Digester complete with:
1) One (1) 1/3 HP, variable speed mixing pump.
2) One (1) ORP/pH probe and analyzer with temperature readout.
3) One (1) Vacuum gauge sensor.
4) One (1) Liquid level sensor with local readout.
5) One (1) Heat belt
6) One (1) Sample tap

Sweet Gas Reactor Sizing
One stainless steel tank – 20" Ø x 6'

One (1) Sweet Gas Reactor complete with:
1) One (1) 1 HP top-mounted explosion proof motor complete with shaft mixer assembly.
2) One (1) 0.12 HP vacuum pump with airflow assembly.
3) One (1) ORP/pH probe and analyzer with temperature readout.
4) One (1) Liquid level sensor with local readout.
5) One (1) Heat belt
6) One (1) Sample tap

Transfer Equipment
1) One (1) 0.2 HP positive displacement transfer pump.
2) One (1) 0.1 HP positive displacement transfer pump.
3) One (1) 0.5" Magnetic flow meter and transmitter for feed and intra-process control and monitoring.
4) Eight (8) 1" Actuated valves.
5) One (1) stainless steel sink with garbage disposal
6) One (1) feed holding tank
7) All necessary PVC piping and connections

Included Spare Parts
1) One (1) ORP/pH Probe.
2) One (1) vacuum pump
3) Transfer pump tubing

Electrical Package MCC/VFDs
1) One (1) Pre-wired PLC cabinet with control equipment and power quick connects

TPS System Supply

TPS will provide the equipment for the process demonstration, deliver it to the job site. TPS will also provide a process engineer or product manager to start-up the system and operate as time permits, but from time to time may require some assistance from the plant staff.

Project Oversight

A TPS trained Water Quality Control employee from the City of Merced will conduct the following:

- Routine day-to-day operation of the pilot unit (Monday-Friday)
- Collection of samples
- Testing of samples (defined below)

A TPS employee will conduct:

- Remote Supervision
- Periodic check-ups during site visits
- Summary of pilot results at the end of the demonstration

Testing Requirements (for all digesters)

Liquid Testing (Minimum 3x per week)

- Total Solids
- Volatile Solids
- Soluble Chemical Oxygen Demand (sCOD)
- Volatile Fatty Acids (VFAs)
- Alkalinity
- Ammonia
- Total Nitrogen
- Ortho-phosphate
- Total Phosphorus

Once per month

- Magnesium
- Calcium
- Sulfides
- Sulfates

As required

- Sludge dewaterability – jar testing
- Sludge dewaterability – by manufacturing

Gas Testing (minimum 3x per week)

- Carbon Dioxide
- Ammonia
- Hydrogen Sulfide

- Oxygen
- Nitrogen Oxides

As required

- GC bag testing

Work and material not included

1) The Facility shall supply the necessary space for the pilot unit.
2) The Facility shall supply a thickened feed material.
3) The Facility shall supply space for laboratory equipment and testing.
4) The Facility shall supply all necessary electrical connections and utilities. The Electrical Requirements are as follows:
   The TPS Control Panel requires a 100-amp 240 VAC four wire service electrical connection with neutral and ground. Neutral to be sized for 100% load.
   - VFDs 240VAC – 20A
   - Pumps and Blowers 120VAC – 20A
   - Heat Belts 120VAC – 20A
   - Air Conditioner 120 VAC – 15A
   - Valves and Automation120VAC – 15A

Liability Limitation

Thermal Process Systems, Inc. and its employees and owners shall not be held liable for any unforeseen, unanticipated, and unsuspected injuries, damages, and losses that result from improper actions by plant staff or faulty utilities.

TPS is willing to sign a waiver for its employees.

Delivery to Job Site

6 – 8 Weeks

Respectfully Submitted,

Alexander Kraemer

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TPS looks forward to working with the City of Merced and STANTEC on this process demonstration. If you have any questions regarding this proposal, please do not hesitate to contact us.

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