

The Northeast Residuals & Biosolids Conference

# Lab-Scale Thermophilic Startup Influencing Full-Scale Startup



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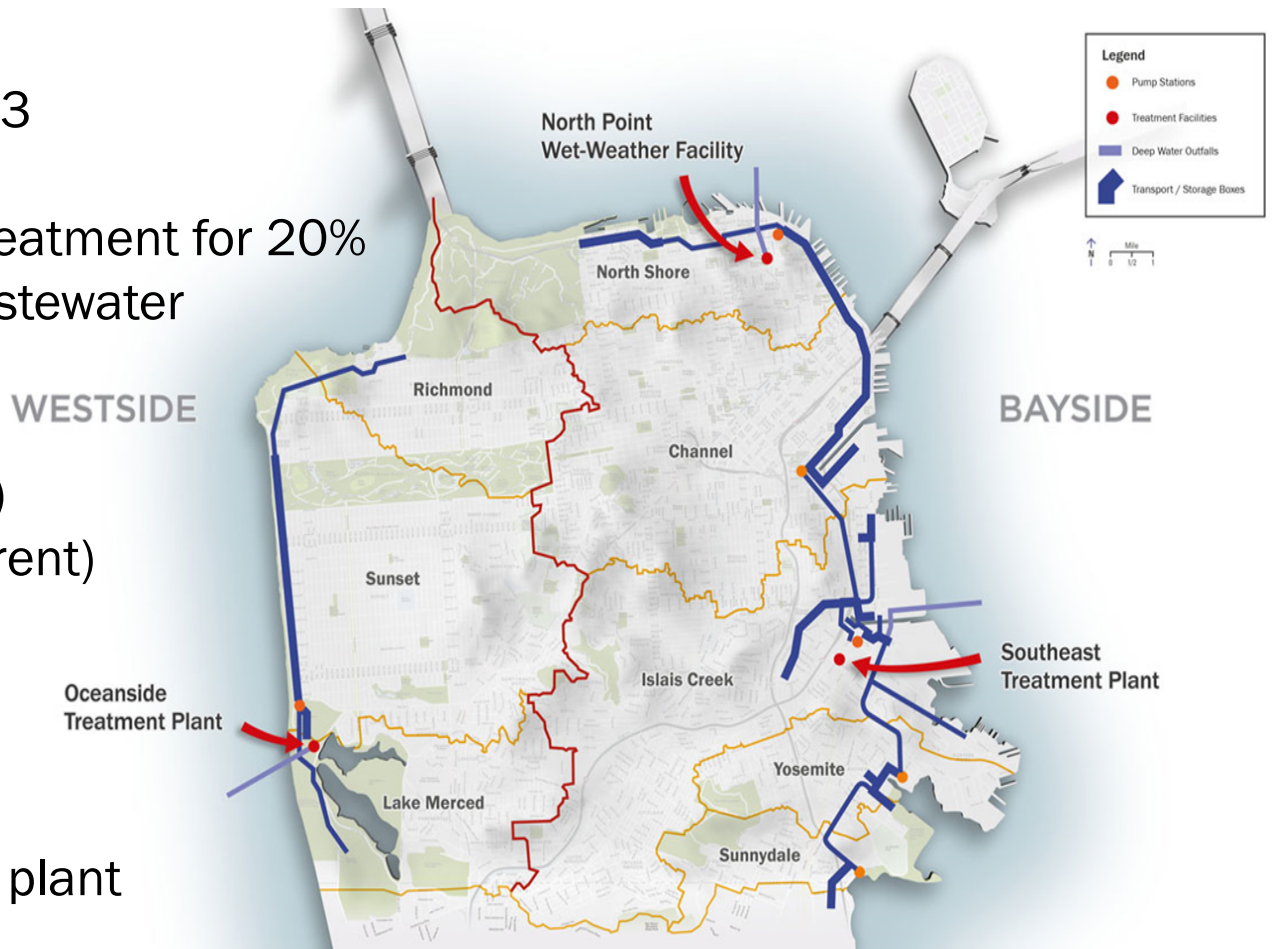
San Francisco  
**Water Power Sewer**  
Services of the San Francisco Public Utilities Commission

# Presentation Outline

- Background
  - Oceanside Plant
  - Digester Upgrades
- Objectives and Results of Lab-Scale Studies
- Full-Scale Implementation
- Conclusions

# Oceanside Plant Overview

- Commissioned in 1993
- Provides secondary treatment for 20% of San Francisco's wastewater
- Dry weather flow:  
21 MGD (design)  
12-14 MGD (current)
- Wet weather flow:  
65 MGD
- High rate pure oxygen plant



# Oceanside Plant – Existing Operation

- Egg Shaped Digesters
  - 4 @ 750,000 gal each
- Flow Through Mode of Operation
- Achieve Class B Biosolids
  - 15 Days  
@ 95 Deg F (35 Degrees C)
- Current Biosolids End Uses
  - Wet Season – Landfill Beneficial Use (ADC)
  - Dry Season – Land Application in nearby Solano and Sonoma Counties

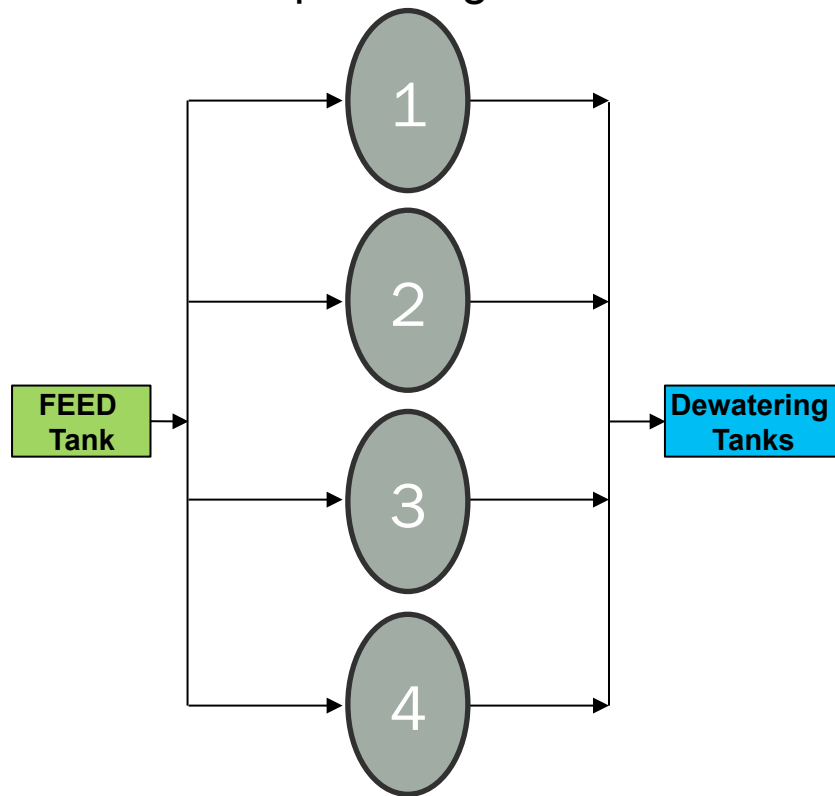


# Temperature Phased Anaerobic Digestion

- Driver to Class A – County ordinance requirement in order to continue to land apply
- Temperature Phased Anaerobic Digestion (TPAD) Process
  - Three thermophilic digesters operate in batch mode
  - One mesophilic digester receives all thermophilic sludge
- Achieve Class A through time and temp
  - 24 hours
    - @ 131 Deg F (55 Deg C)

# TPAD Conversion

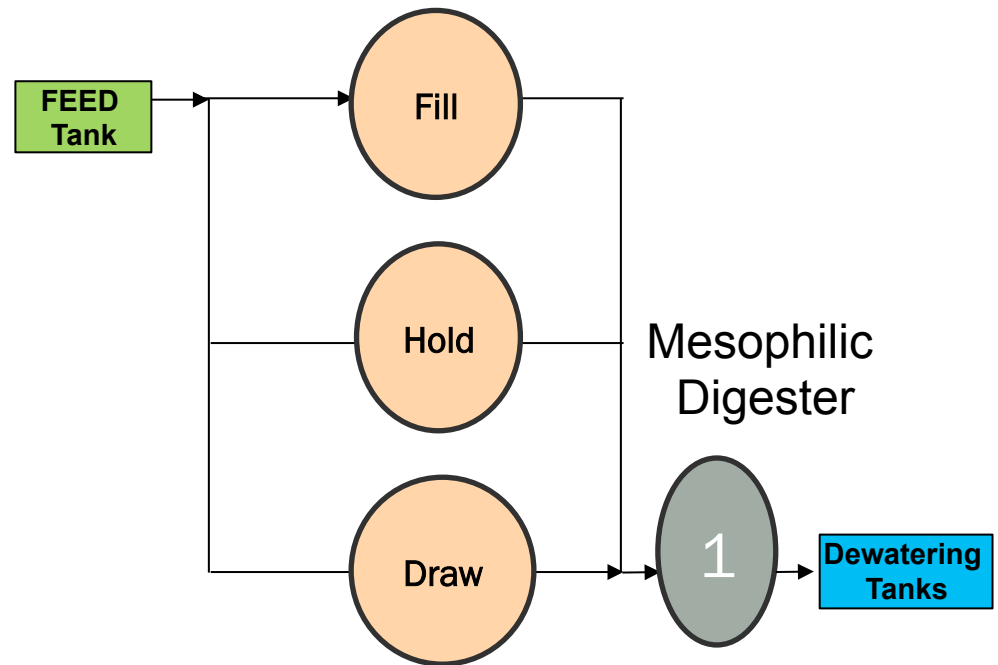
## Mesophilic Digesters



- **Previous Operation**

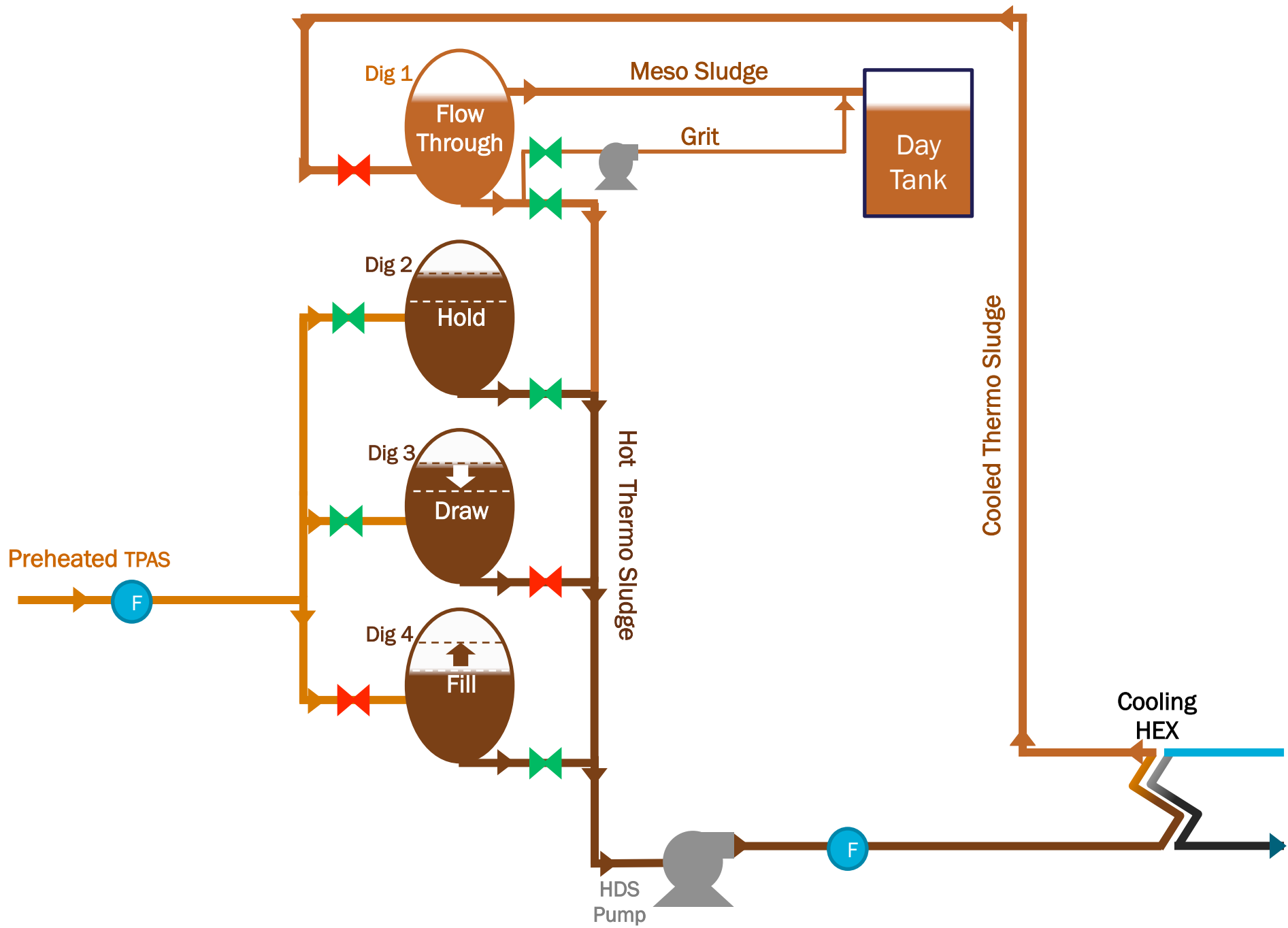
- 4 Mesophilic digesters operating in parallel
- Daily feed evenly split to online digesters so each digester receives ~30,000 gal feed

## Thermophilic Digesters



- **Future Operation – TPAD**

- 3 Thermophilic Digesters alternate in Fill-Hold-Draw Mode where Fill digester receives 130,000 gal feed
- 1 Mesophilic Digester receives transferred thermophilic sludge





# Digester Upgrades

- Existing Digesters were Retrofitted
  - Corrosion repairs
  - Odor Control Improvements
  - Piping modifications
  - Insulation improvements
  - Heat exchanger upgrades
  - Heat recovery system
  - New boilers





# Today's Digesters



# Lab-Scale Primary Objectives

- Determine if existing mesophilic digesters could be converted thermophilic
- Develop full-scale startup procedure for thermophilic conversion
- Investigate impacts of batch mode operation

# Lab-Scale Reactors

- Four – 14 L Stainless Steel Reactors
  - 11L working volume
- Continuous biogas flow measurement
- Key parameters measured
  - Volatile Acids
  - Alkalinity
  - pH
  - Ammonia
  - TS/VS



# Experiment 1

Objective	To determine the feasibility of converting mesophilic seed to thermophilic seed				
Main Configuration	Temp	2 day increase	2 day increase	4 day increase	Mesophilic Control
	Reactor	R1	R2	R3	R4
	Final OLR Goal (lb VS/ft <sup>3</sup> -d)	0.17			

Biogas (ft<sup>3</sup>/d)

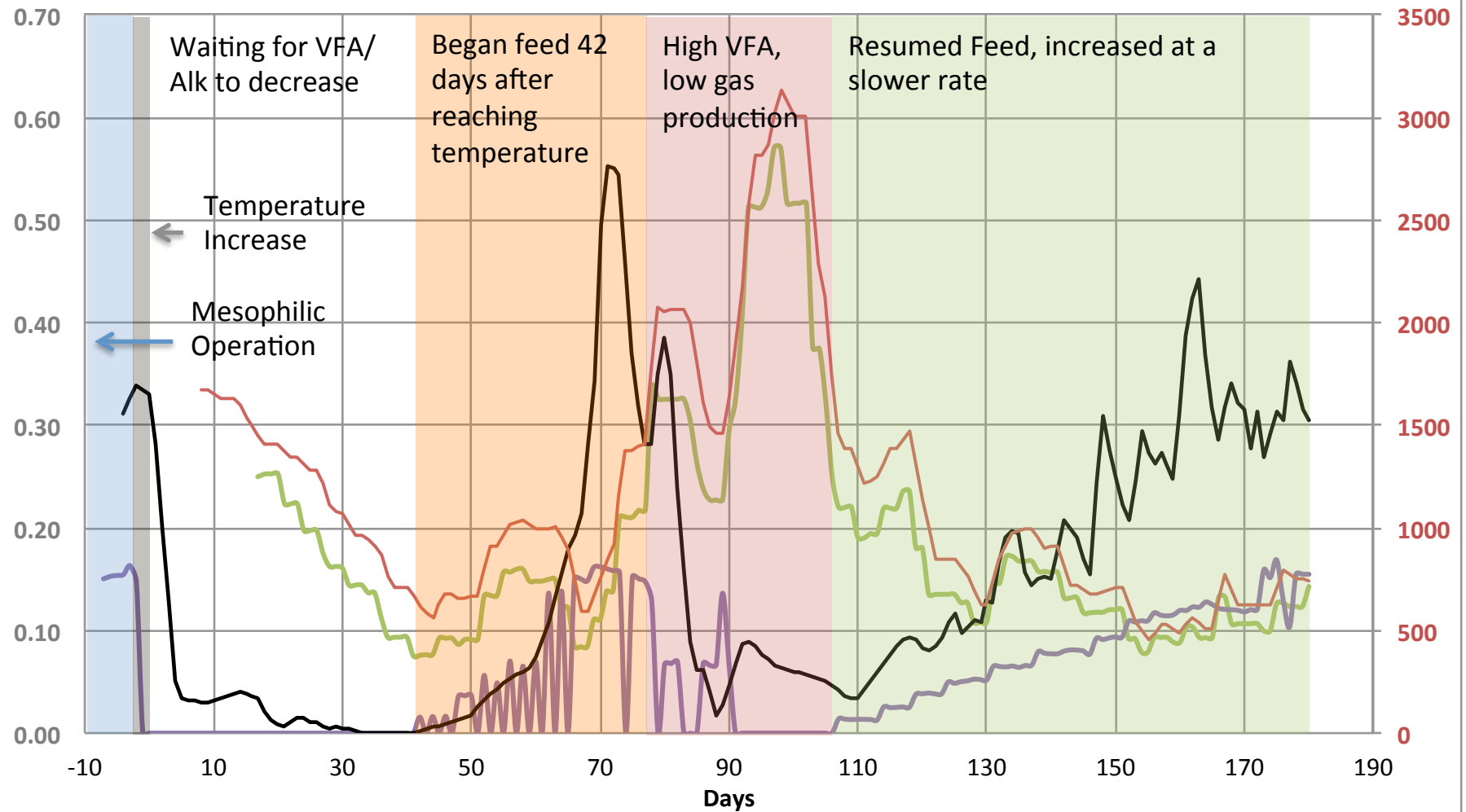
VFA/Alk ratio

OLR (lb VS/ft<sup>3</sup>)

## Experiment 1 - Reactor 1 Temperature Increased Over 2 Days

VFA/Alk Ratio OLR Biogas VFA

VFA (mg/L)



## Experiment 1 - Reactor 3 Temperature Increased Over 4 Days

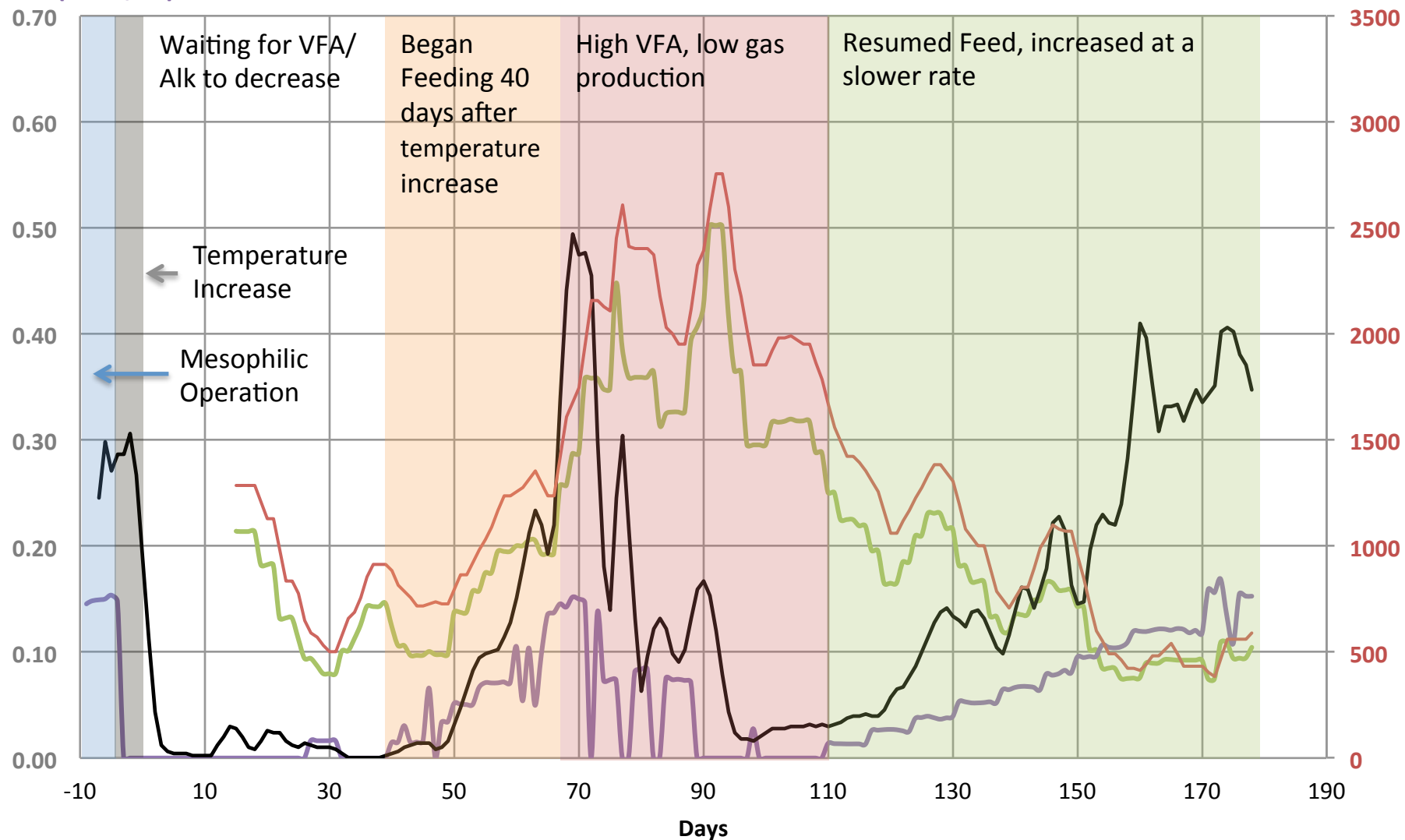
Biogas (ft<sup>3</sup>/d)

VFA/Alk ratio

OLR (lb VS/ft<sup>3</sup>)

VFA/Alk Ratio OLR Biogas VFA

VFA (mg/L)





# Experiment 2

Objective	To repeat and confirm results from Experiment 1	
Main Configuration	Temp	4 day increase
	Reactor	R2&R4
	Final OLR Goal (lb VS/ft <sup>3</sup> -d)	0.17

Biogas (ft<sup>3</sup>/d)

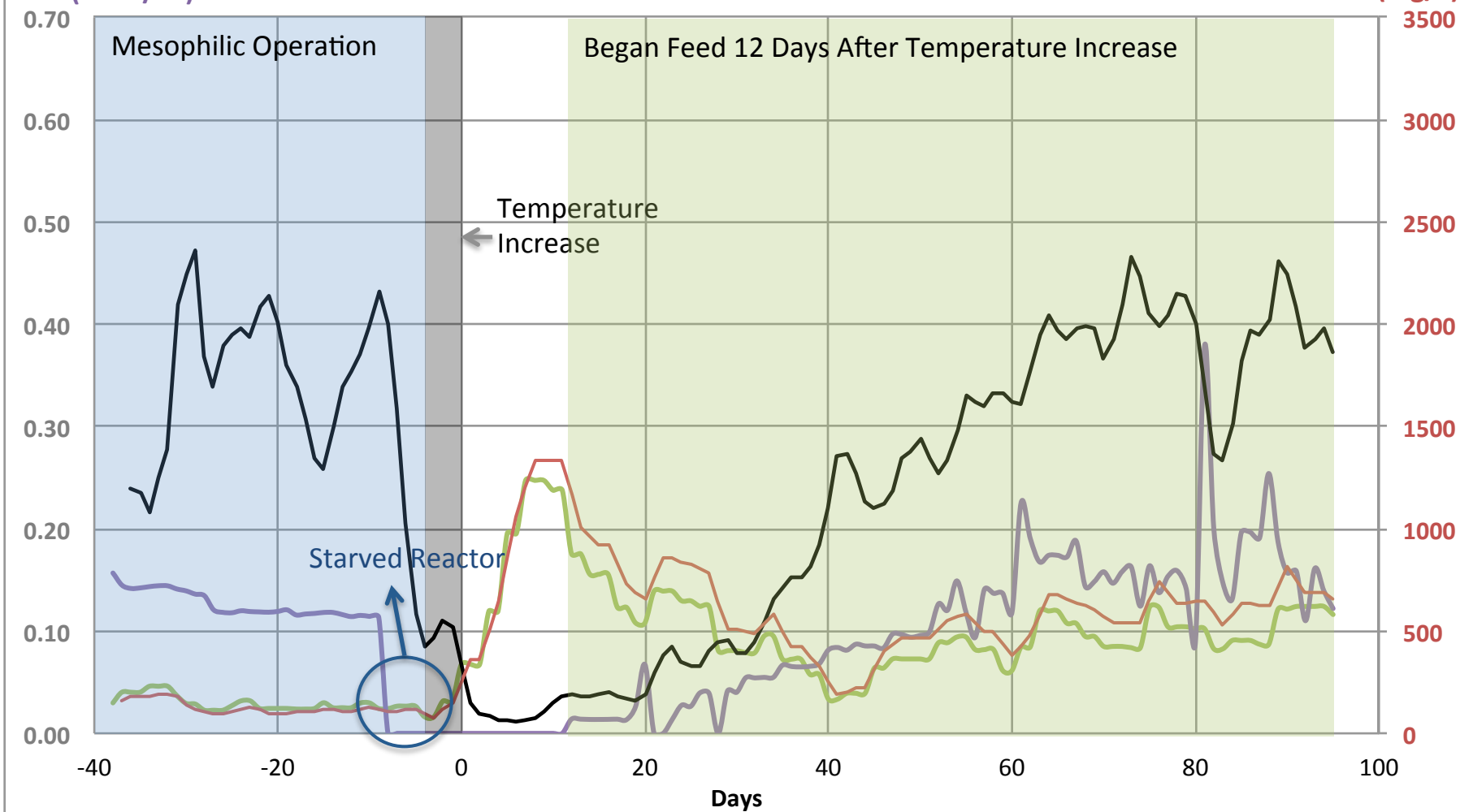
VFA/Alk ratio

OLR (lb VS/ft<sup>3</sup>)

## Experiment 2 - Reactor 2

VFA/Alk Ratio OLR Biogas VFA

VFA (mg/L)



Biogas (ft<sup>3</sup>/d)

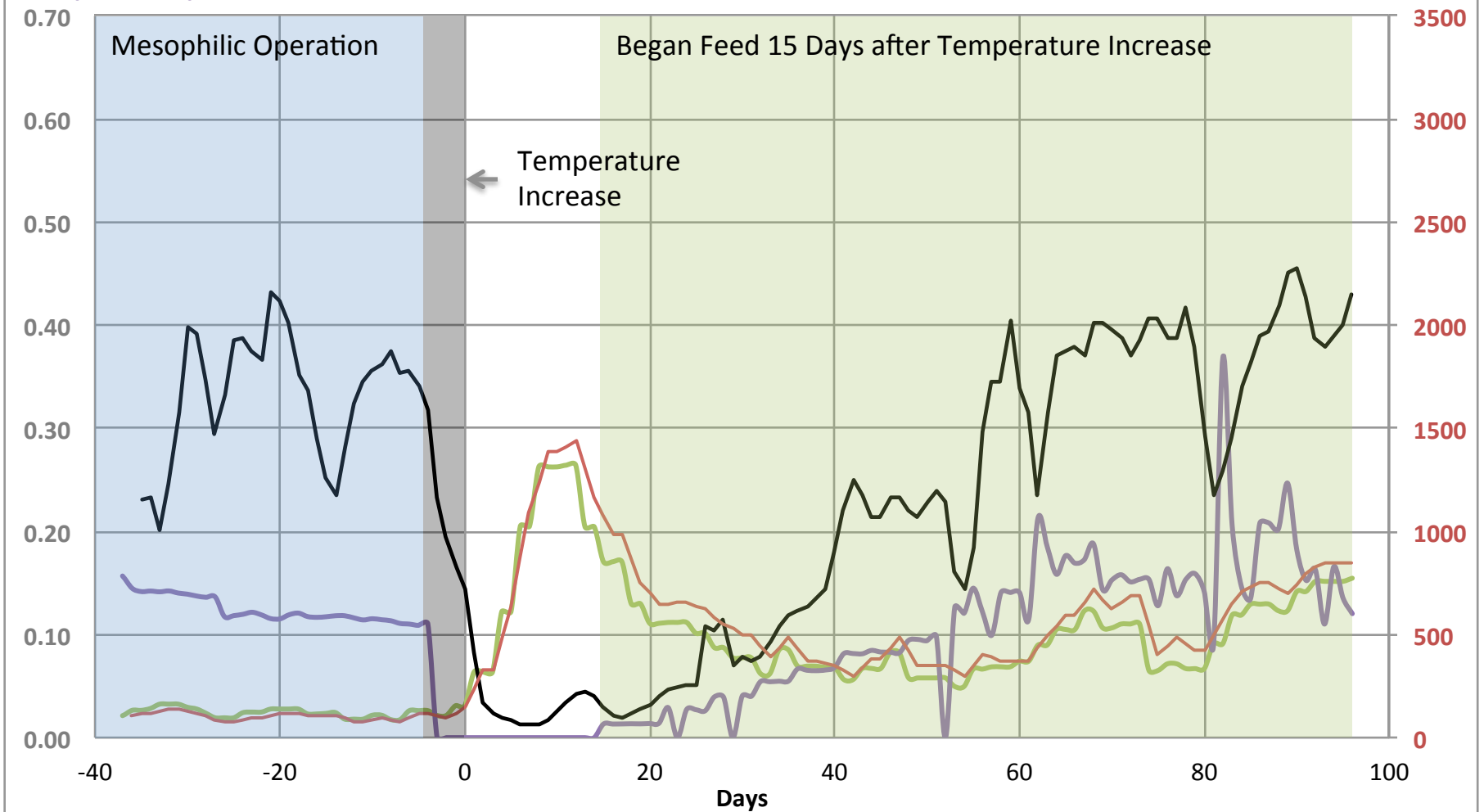
VFA/Alk ratio

OLR (lb VS/ft<sup>3</sup>)

## Experiment 2 - Reactor 4

VFA/Alk Ratio OLR Biogas VFA

VFA (mg/L)



# Experiment 3 - Transition to Batch Mode

	Cycle = Fill-Hold-Draw	OLR (lb VS/ft <sup>3</sup> -d)
Initial Conditions	Flow Through Operation	0.17
Phase 1	Cycle 1 - 7	0.25
		0.13
		0.13
Phase 2	Cycle 8 - 14	0.34
		0.08
		0.08
Phase 3	Cycle 15 - 21	0.42
		0.04
		0.04
Batch OLR Achieved	Cycle 22	0.51
		0.00
		0.00

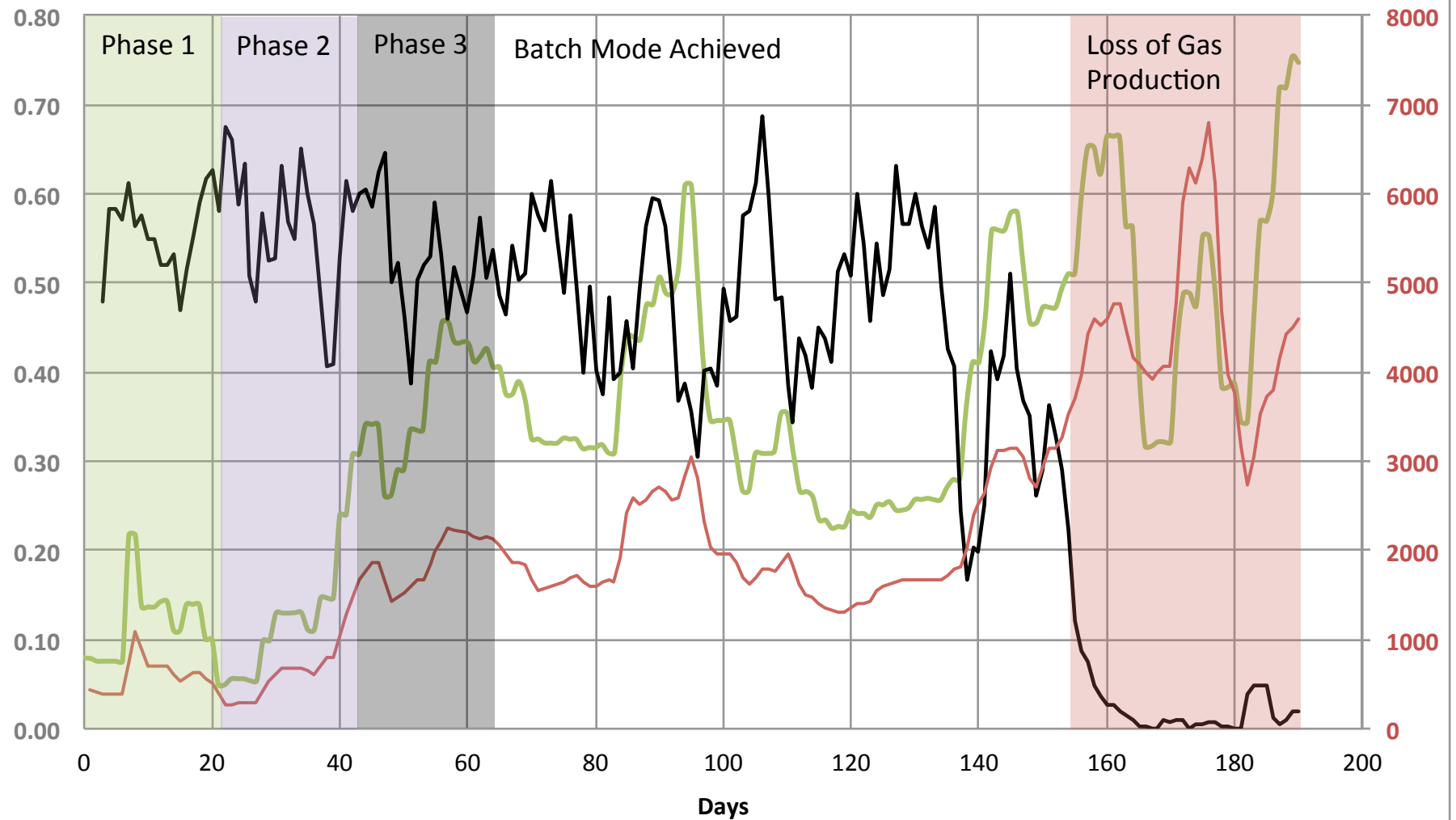
Biogas (ft<sup>3</sup>/d)

VFA/Alk ratio

### Experiment 3 - Reactor 1

VFA/Alk Ratio — Biogas — VFA

VFA (mg/L)



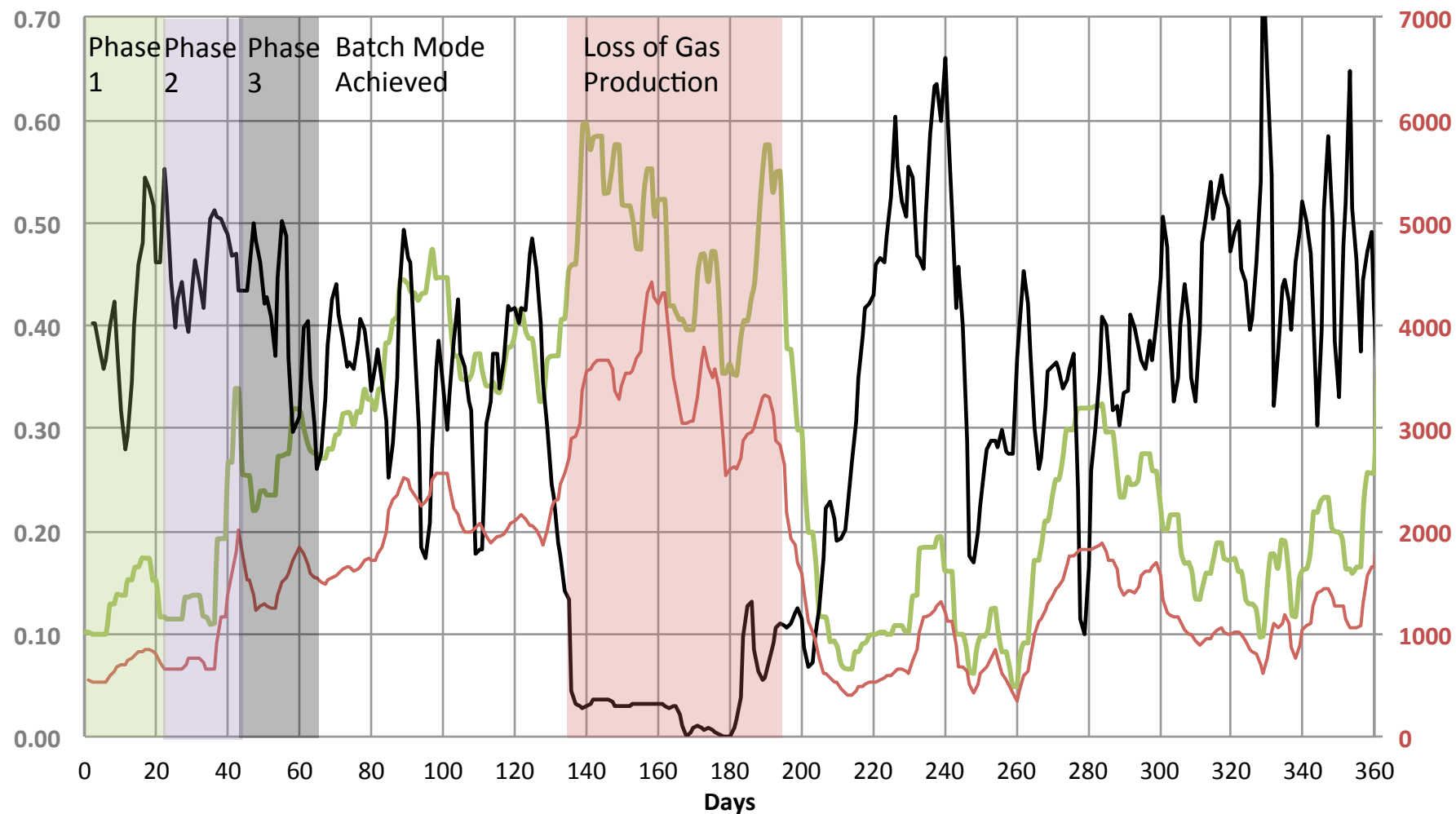
Biogas (ft<sup>3</sup>/d)

VFA/Alk ratio

## Experiment 3 - Reactor 2

VFA/Alk Ratio — Biogas — VFA

VFA (mg/L)





# Modified Feed Strategy

	Modified OLR (lb VS/ft <sup>3</sup> -d)
Flow Through Operation	0.17
Phase 1	0.25
	0.00
	0.00
Phase 2	0.34
	0.00
	0.00
Phase 3	0.42
	0.00
	0.00
Batch OLR Achieved	0.51
	0.00
	0.00

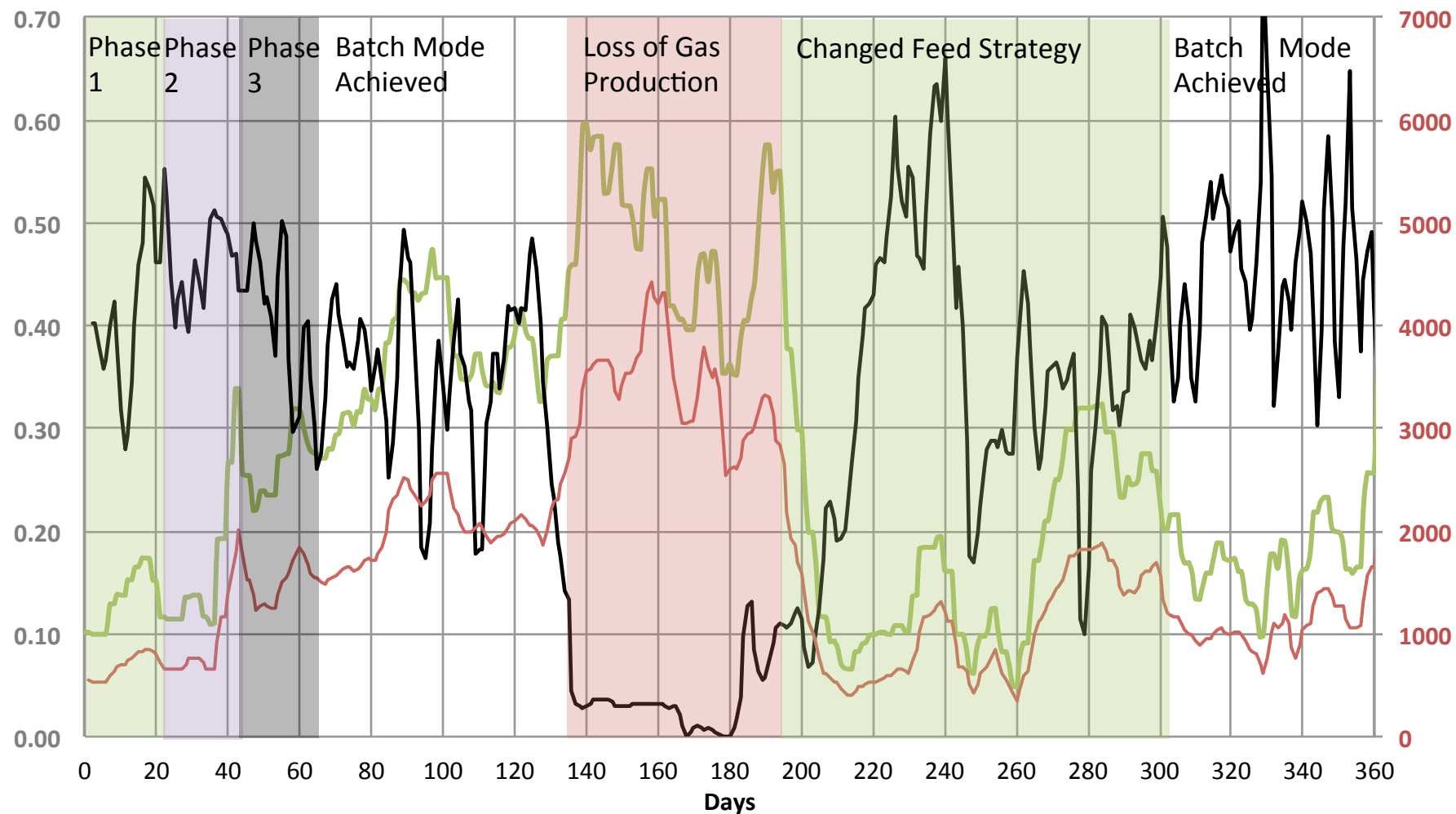
Biogas (ft<sup>3</sup>/d)

VFA/Alk ratio

## Experiment 3 - Reactor 2

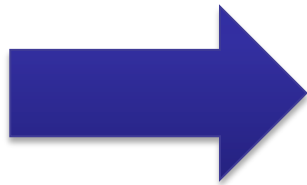
VFA/Alk Ratio — Biogas — VFA

VFA (mg/L)



# Key Lab-Scale Findings and Impact on Full-Scale Startup

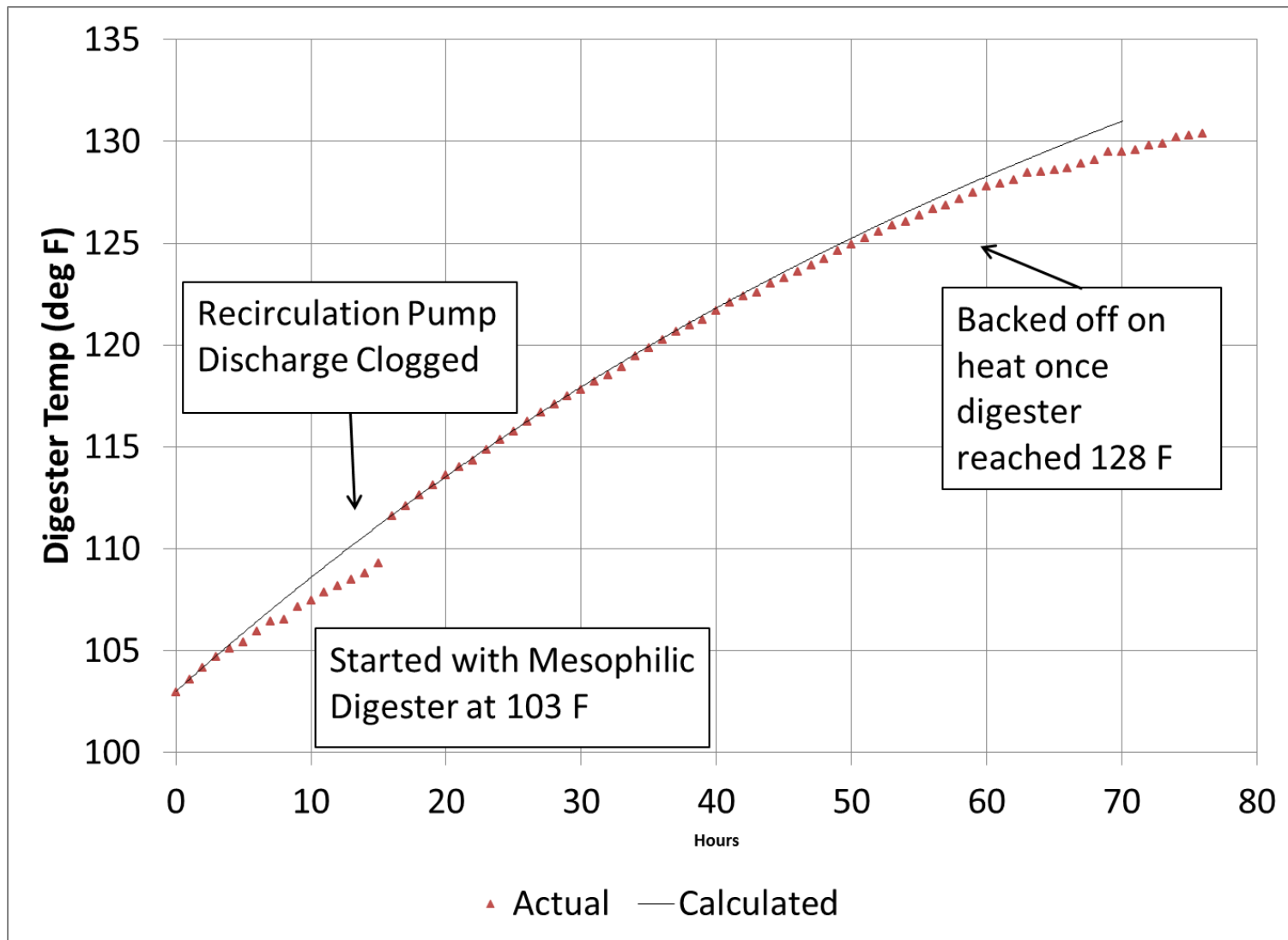
- Maintain Strict Temperature Control
  - Resulted in automating temperature control strategy in full-scale digesters
- Conservative Feed Strategy
  - Decision to “starve” digesters prior to temperature increase
  - Increase Feed to Digesters Weekly
- Transition from Flow Through to Batch Operation
  - Changed feed strategy to slowly ramp up overall OLR
  - One digester will be converted from flow through to batch mode while maintaining 3 mesophilic digesters



# Full-Scale Implementation

Step	Date	Description
1	January 7 – 19, 2016	“Starve” Digester 4
2	January 19 – 23, 2016	Increase Temperature from 95 to 131 Degrees F
3	February 9 – March 29, 2016	Increase Digester feed from 5,000 to 30,000 while operating in flow through mode
4	June 6 – 10, 2016	Temperature increase for Digester 3 after starvation

# Temperature Increase





Biogas ( $\times 10^6$  ft<sup>3</sup>/d)

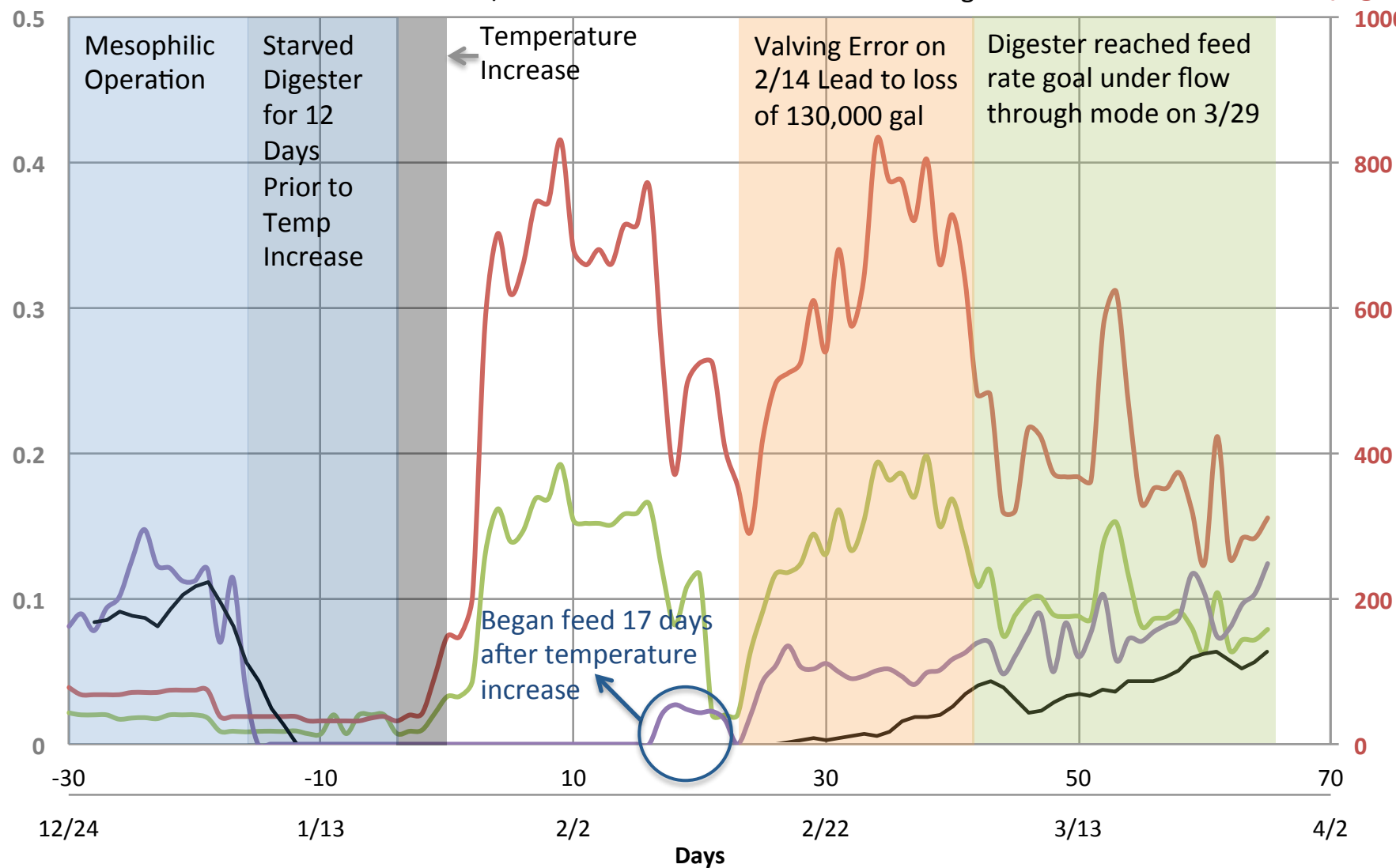
VFA/ALK Ratio

OLR (lb VS/ft<sup>3</sup>)

## Full Scale Startup - Digester 4

VFA/Alk Ratio OLR VFA Biogas

VFA (mg/L)



# Conclusions

Parameter	Lab-Scale vs. Full-Scale	Comments
Stringent Temperature Control	<input checked="" type="checkbox"/>	Closely monitored during full-scale startup
Biogas Production Trends	<input checked="" type="checkbox"/>	Expected gas production to stop during transition
Feed Strategy	<input checked="" type="checkbox"/>	Conservative approach
Volatile Acids	<input checked="" type="checkbox"/>	High peaks in lab-scale reactors likely from slug feeding
Flow Through to Batch Mode	<input checked="" type="checkbox"/>	Full-Scale success anticipated

# Acknowledgements

- Oceanside Plant Staff
  - Operations
  - Maintenance
  - Laboratory
  - Instrumentation & Controls
  - Distributed Control Systems
- Process Engineering Team (Co-Authors)
  - Alexandre Miot
  - Karla Guevarra
  - Bonnie Jones (retired)
- TPAD Design Team – CH2M



Questions?