NORAM Bio Systems Inc.

Biological Treatment Technologies

VERTAD™

VERtical Auto-Thermophilic Aerobic Digestion

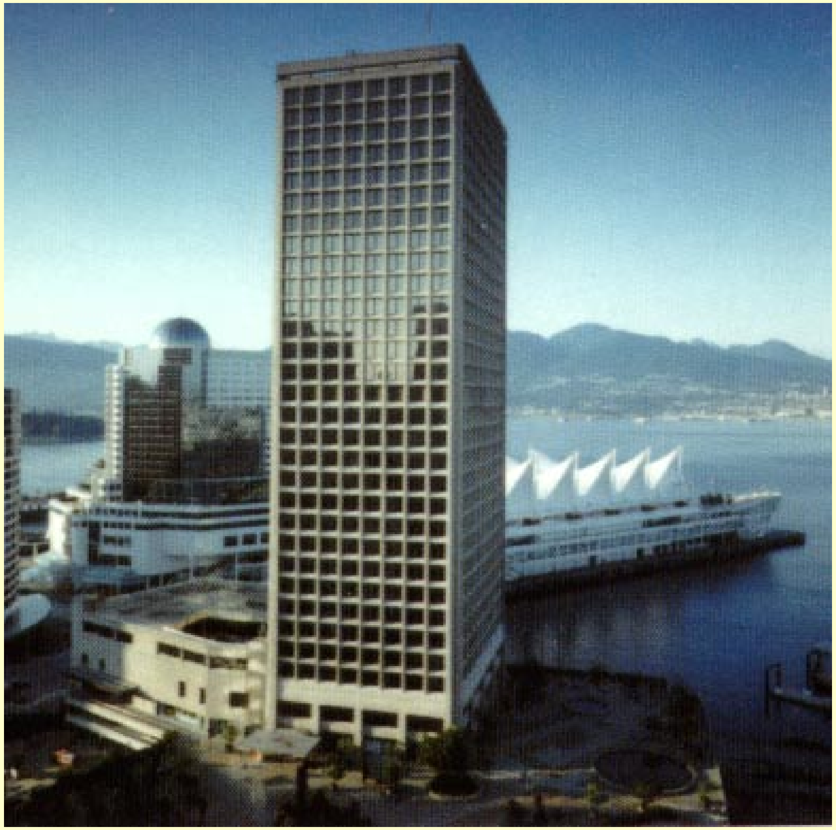
NORAM Bio Systems Inc.
Biological Treatment Technologies

Agenda

- **Company Profile - Noram**
- **VERTAD™**
  - Process Description & Details
  - Applications & Advantages
  - Existing Demonstration Plant
- **Demonstration Plant Opportunities**
- **Questions and Discussion**

NORAM Bio Systems Inc.
Biological Treatment Technologies

NORAM
Facts and Figures



- Private company
- Founded in 1988
- Approximately 100 employees
- Specialty

- R&D, major BCRI shareholder

NORAM Bio Systems Inc.
Biological Treatment Technologies

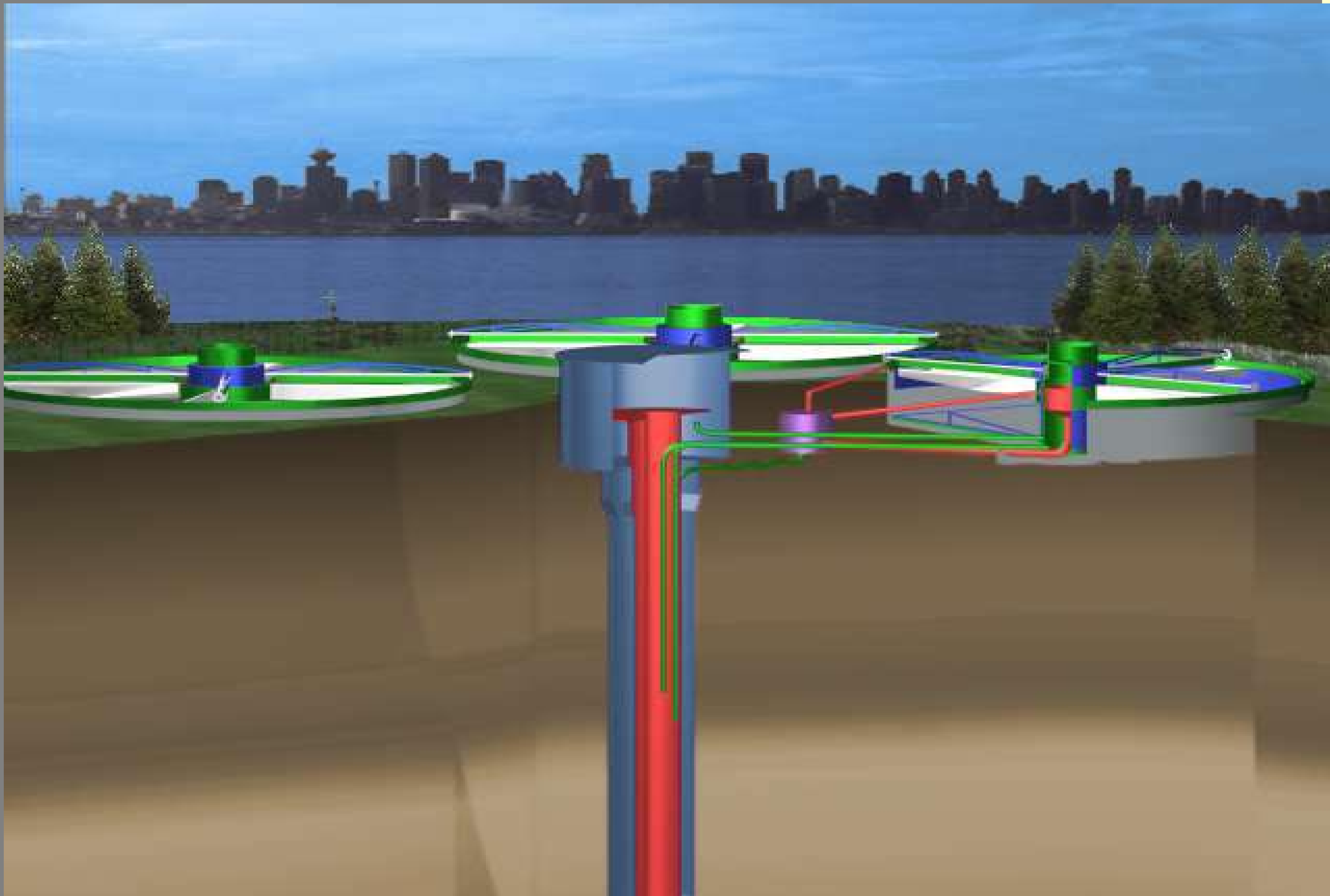
VERTAD™
Vertical Auto-Thermophilic Aerobic Digestion

Conventional Treatment

Typical Treatment Plant Layout

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTREAT™ & VERTAD™
Small Footprint Requirement



NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTREAT™ Retrofit
Potential Treatment Plant Layout

137,300 sq ft = 3.2 acres

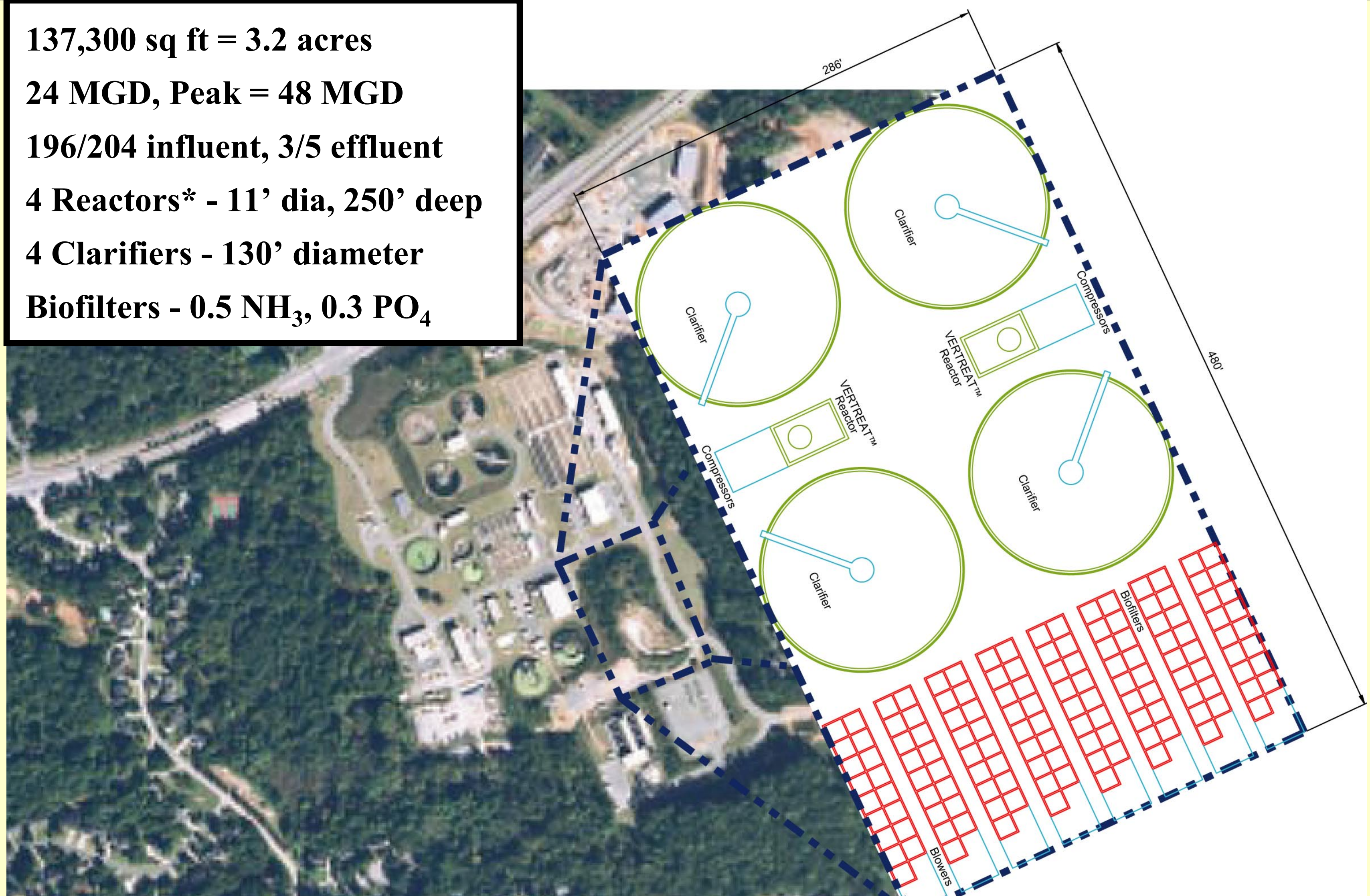
24 MGD, Peak = 48 MGD

196/204 influent, 3/5 effluent

4 Reactors* - 11' dia, 250' deep

4 Clarifiers - 130' diameter

Biofilters - 0.5 NH_3, 0.3 PO_4



*Could use two 16' diameter Reactors

VERTAD™ Retrofit
Potential Digestion Plant Layout

17,300 sq ft = 0.4 acres

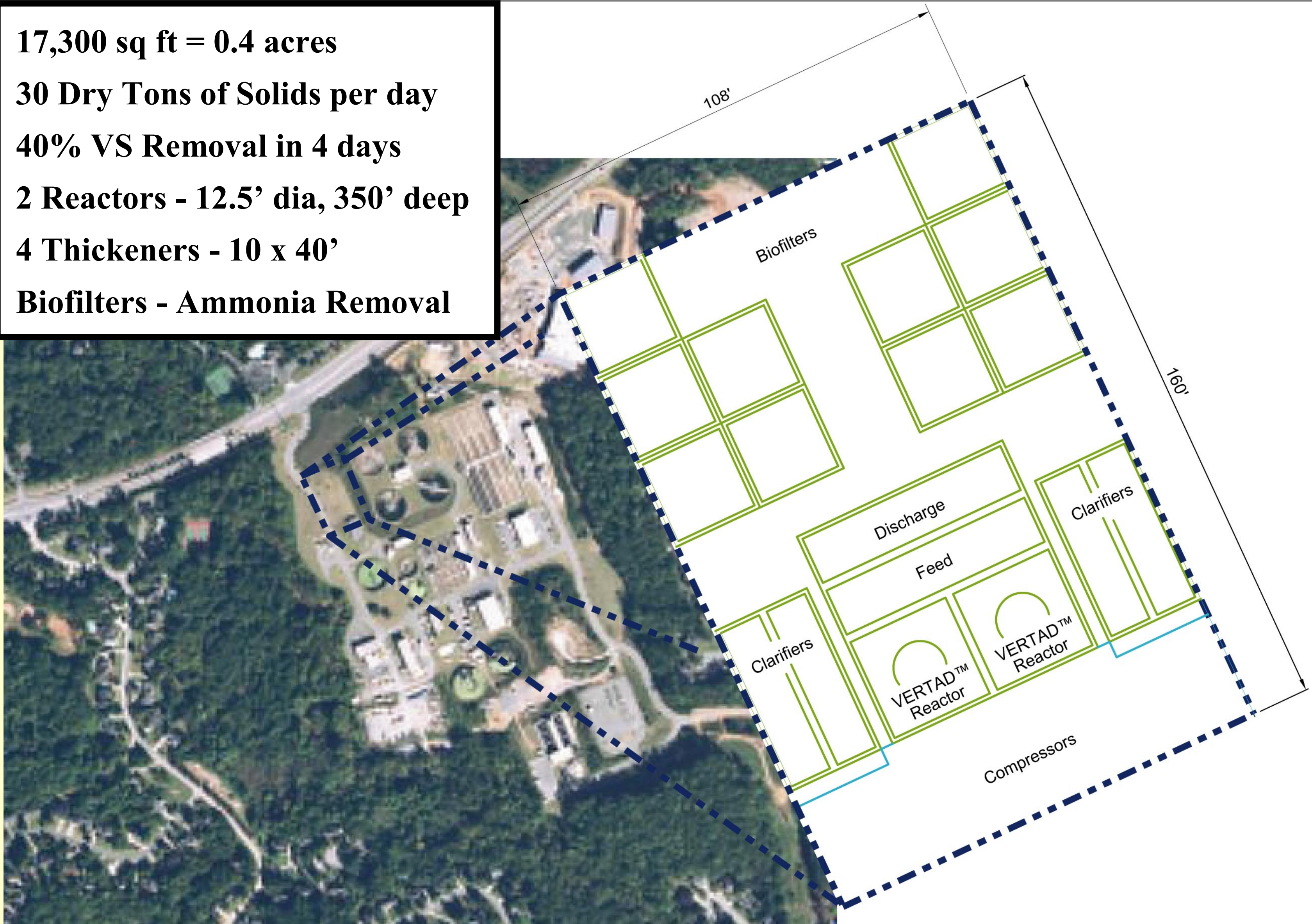
30 Dry Tons of Solids per day

40% VS Removal in 4 days

2 Reactors - 12.5’ dia, 350’ deep

4 Thickeners - 10 x 40’

Biofilters - Ammonia Removal



NORAM Bio Systems Inc.
Biological Treatment Technologies

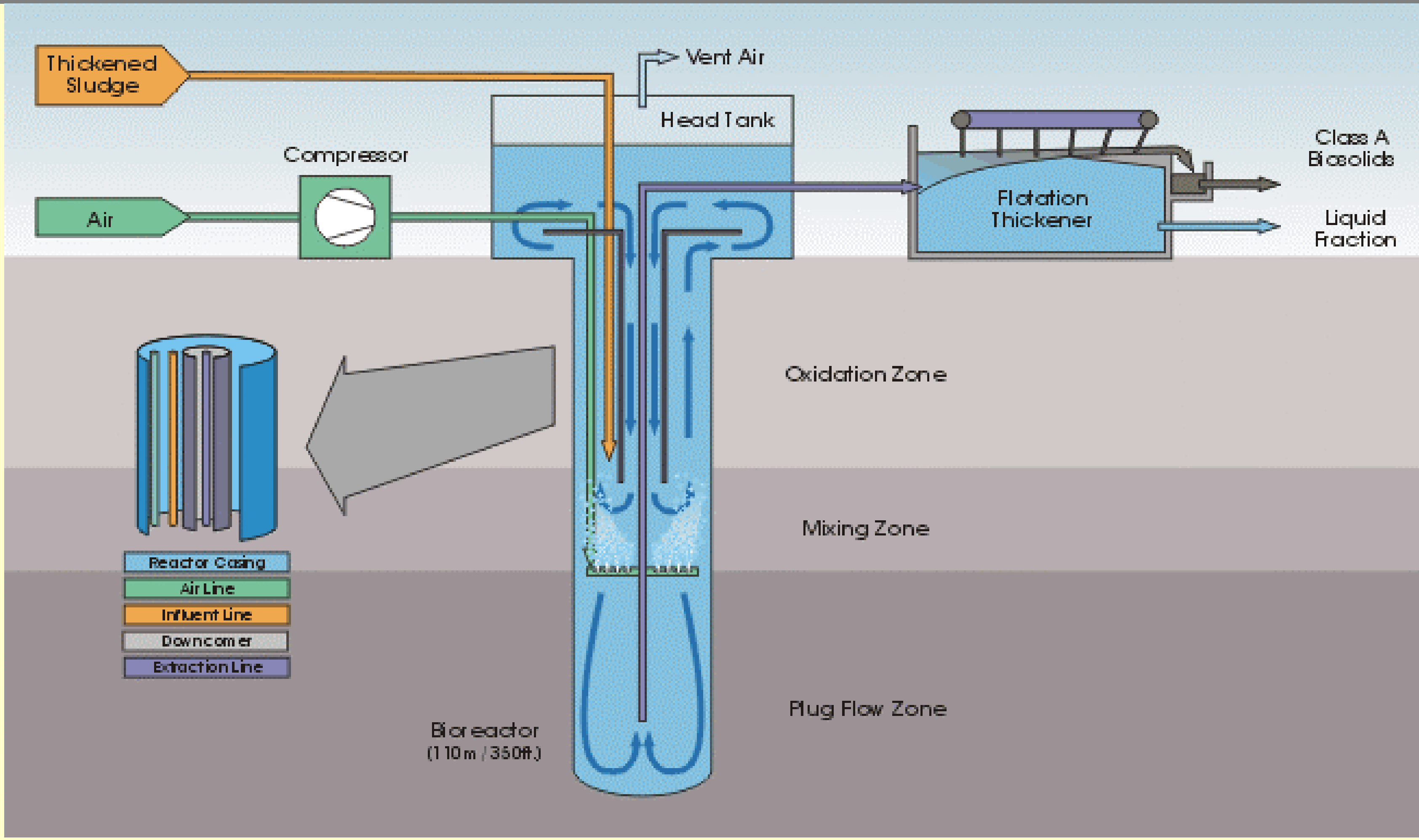
EPA CFR-503
Biosolids Regulations

	Class 'B'	*Class 'A'*
Vector Attraction	>38% VSR	>38% VSR
Pathogens	Reduced	Virtually Eliminated
Site Restrictions	Yes	No
Example	Anaerobic Digestion	VERTAD™

- **Class A biosolids require both vector attraction and pathogen reduction**

NORAM Bio Systems Inc.
Biological Treatment Technologies

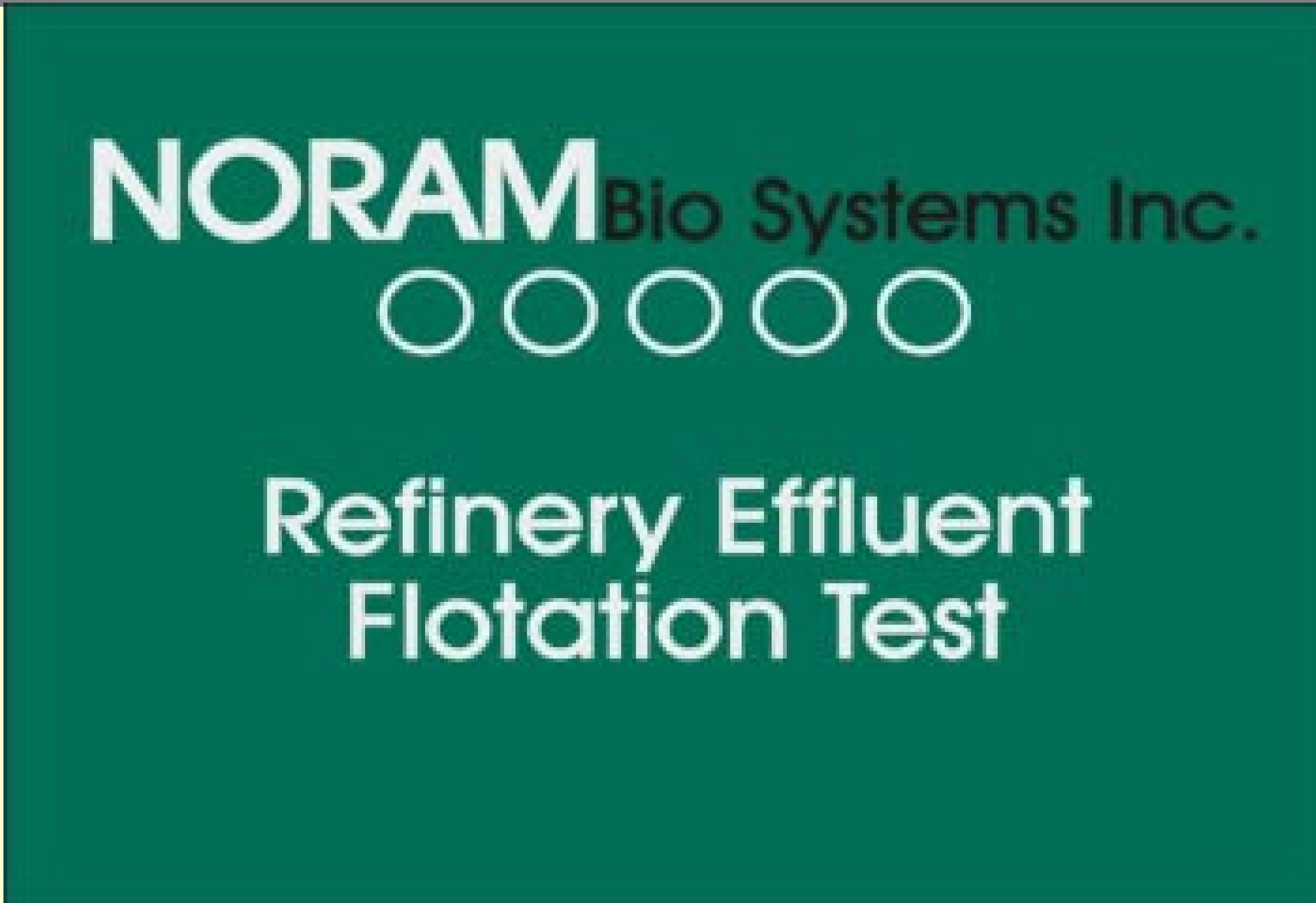
VERTAD™
Reactor Features & Stages



Bioreactor: **300 - 350 ft deep, 2 - 12 ft diameter**

NORAM Bio Systems Inc.
Biological Treatment Technologies

Flotation Test
Chevron Refinery, Burnaby, BC



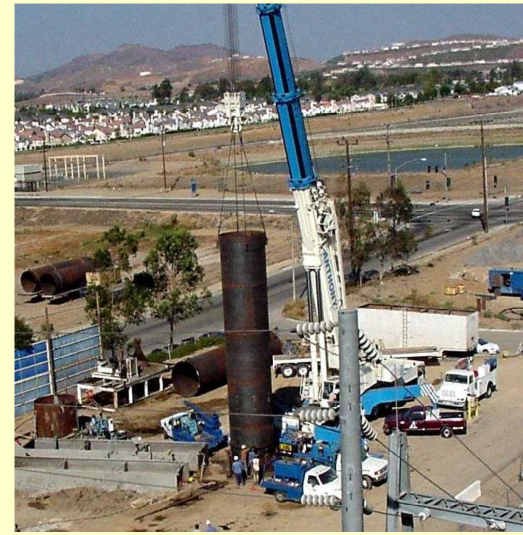
NORAM Bio Systems Inc.
Biological Treatment Technologies

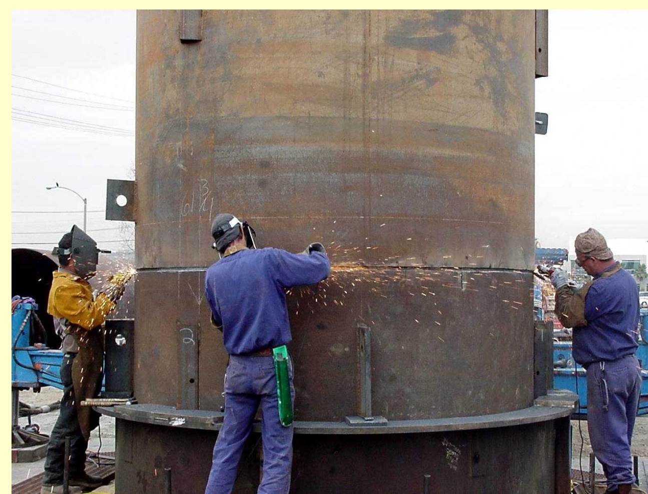
VERTAD™ Process Advantages

- Produces Class A Biosolids in short SRT
- Efficient land utilization (low footprint)
- Decreased haul traffic & odour concerns
- Simple flotation thickening to 10% TS
- Dewaters to > 30% cake solids
- Heat recovery for process & space heating

NORAM Bio Systems Inc.
Biological Treatment Technologies

Reactor Installation
250,000 Population Equivalent





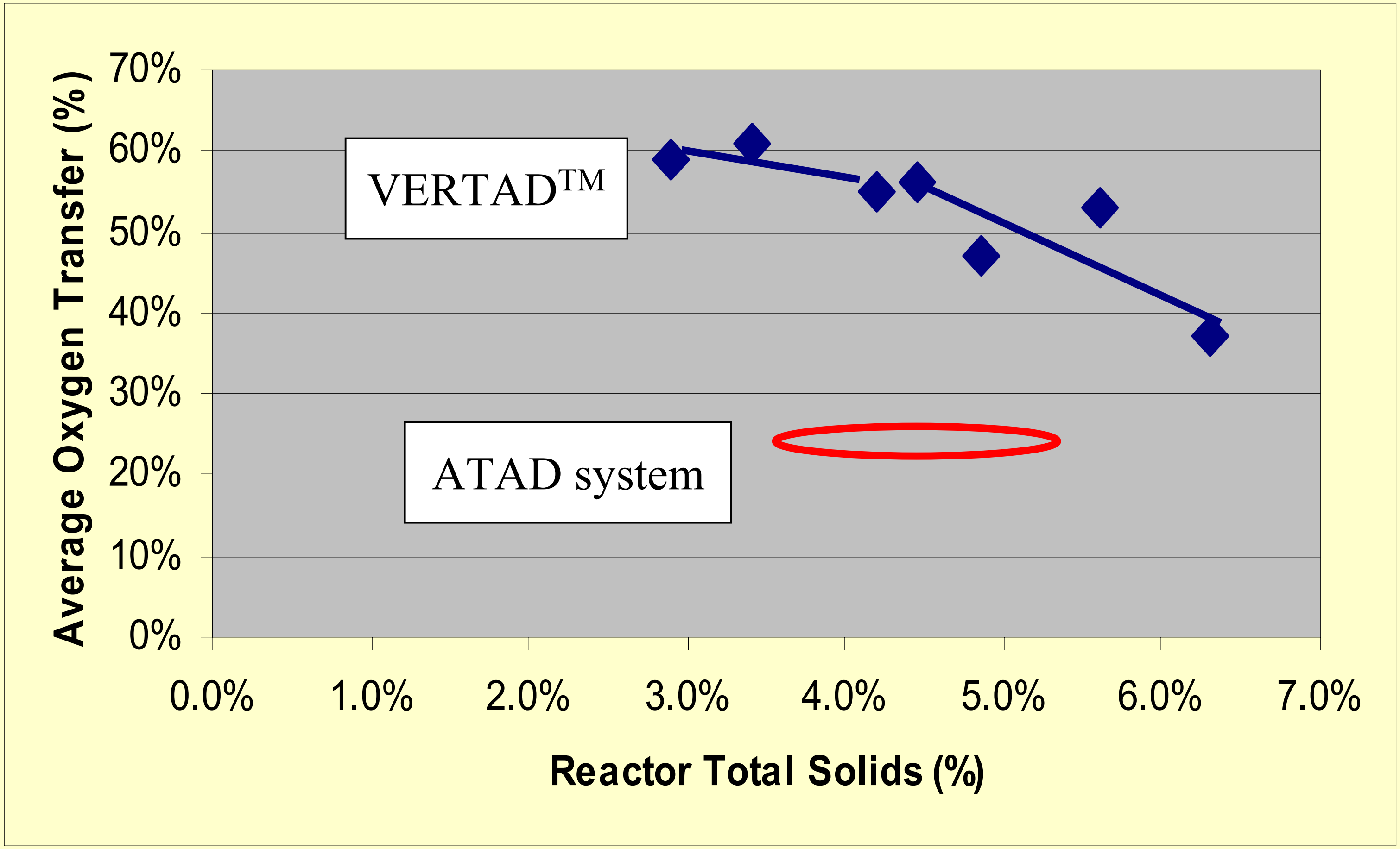
NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
The Shack

- 5000 population equivalent facility in Renton, WA
- Loading at 500 - 1500 lbs/day
- 350 ft deep, 2 ft diameter Bioreactor

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Oxygen Transfer Data



- Greater than 50% oxygen transfer (@ 4.5% TS)

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Volatile Solids Reduction

Test	HRT (days)	Temp (°C)	Aeration (scfm)	VS Dest. (%)
Dec '98	4	56	56	40.9
Sept '99	4	65	80	42.2
Nov '99	3.4	56	36	42.3
*Dec '99	5.5	61	30	43.5

* Test period initially ran for several days at 50% VS destruction.

- 7 log reduction in fecal coliform.
- Fecal Coliform and Salmonella below detection limits.

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Odour Control in VERTAD

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Comparison with Anaerobic Digestion

	Anaerobic	VERTAD
VSR	55%	>40%
HRT	25 - 30 days	4 days
Offgas Control	H_2S, CH_4	trace NH_3
Land Use	High	Low
Cake Solids	>23%	>30%

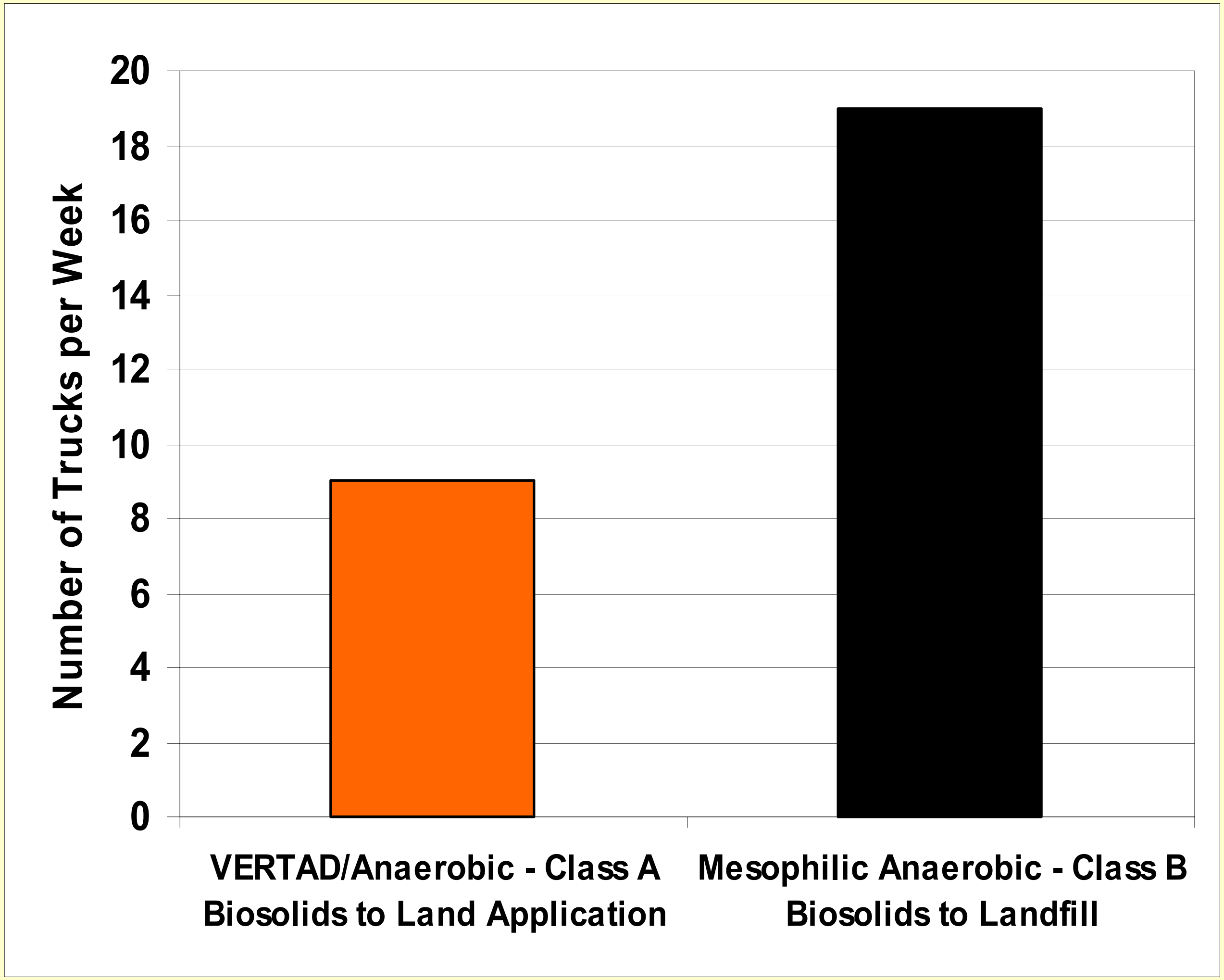
- **> 80% FOG destruction in Vertad**
- **70% destruction with 15-day dual digestion**

NORAM Bio Systems Inc.
Biological Treatment Technologies

15 MGD Biosolids Production

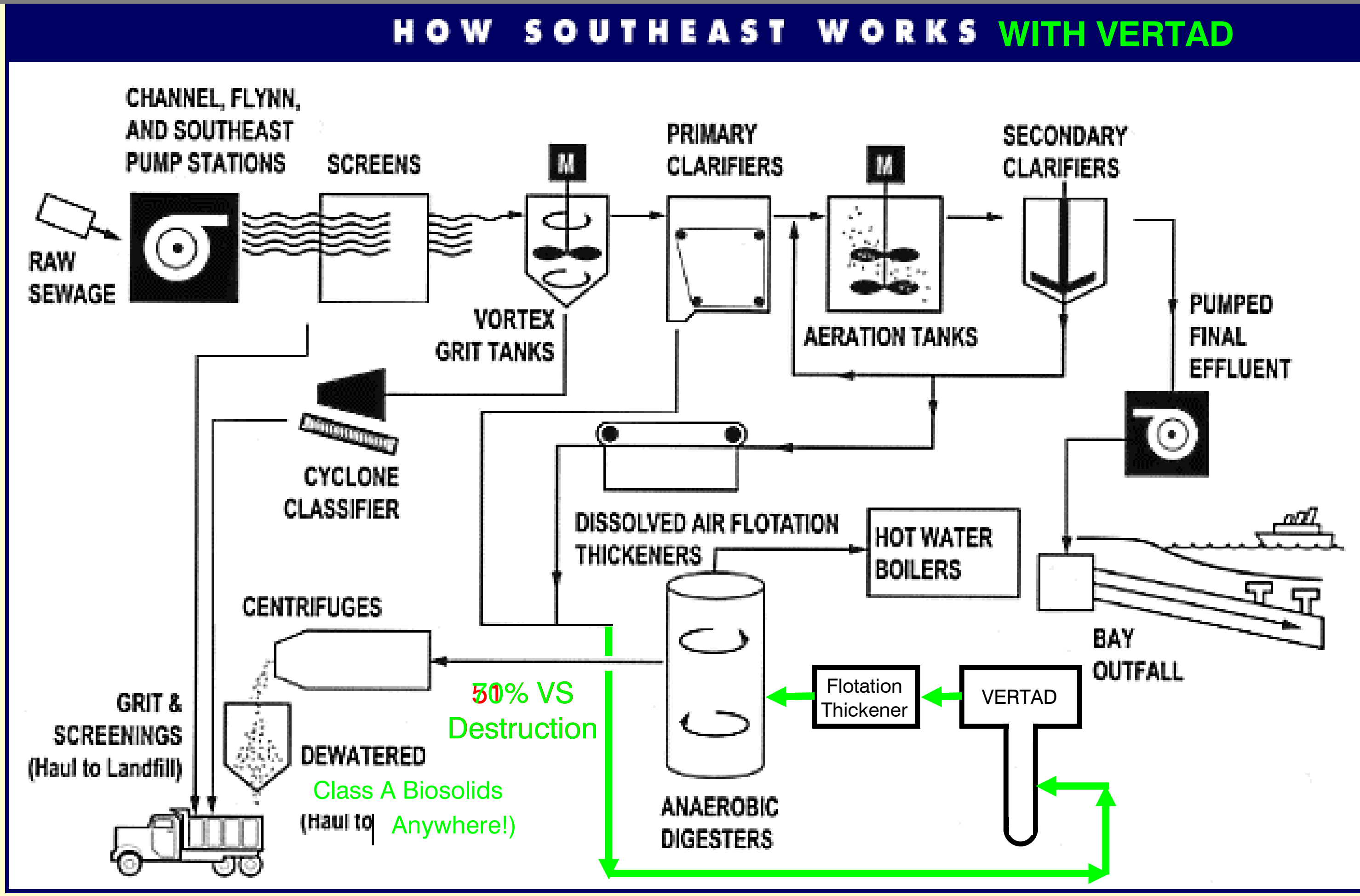
Beneficial Reuse of Biosolids

Reduced Trucks and Haul Cost with VERTAD™



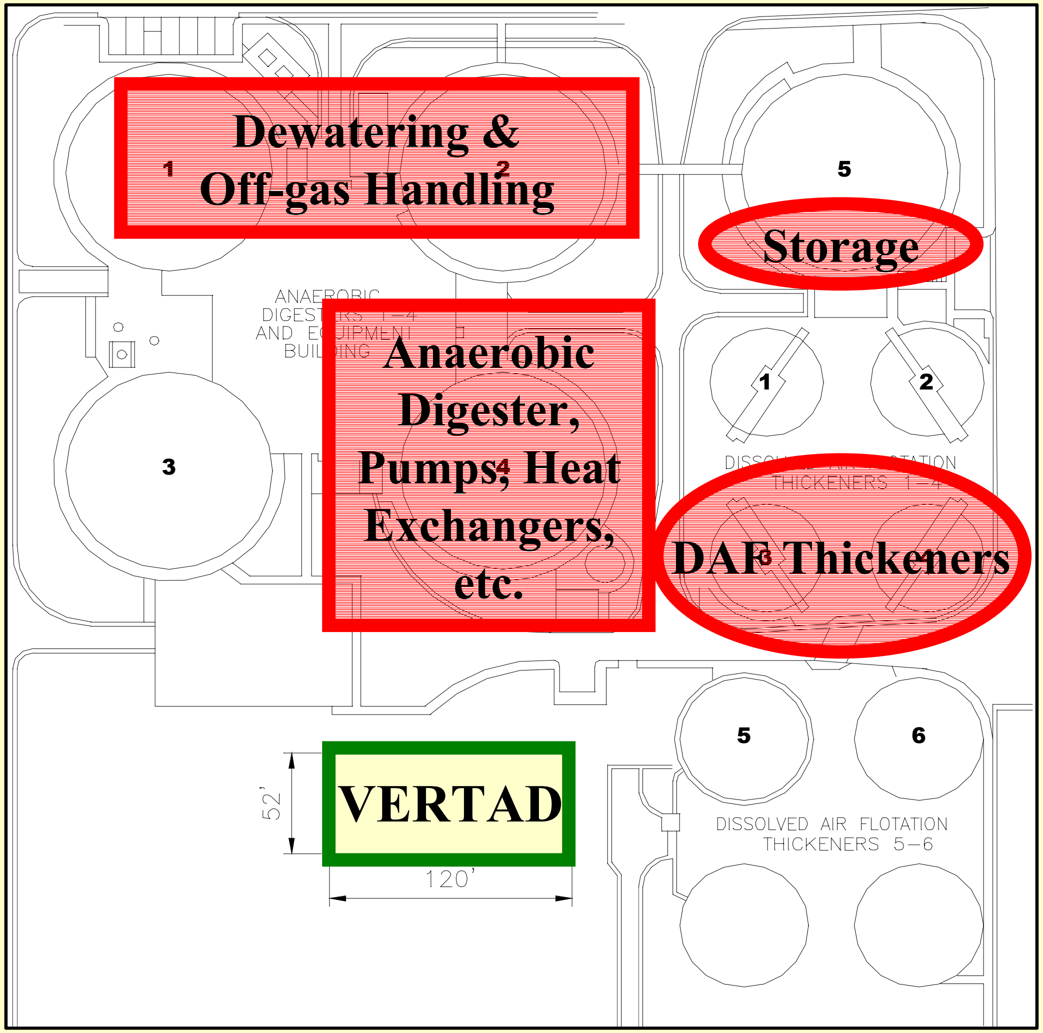
NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Sample Retrofit Flowsheet



- Current: 51% VS destruction (>70% total w. VERTAD™)
- Heat Anaerobic digesters with hot water from VERTAD™

VERTAD™
Sample Footprint - 25 dry ton/day



Anaerobic Facility:

- 1 Digester is 7853 ft^2
- Class B Biosolids

VERTAD™ Facility:

- Total = 6240 ft^2
- Class A Biosolids
- Digesters, Biofilters, Centrifuges, HXs, Flotation, Storage

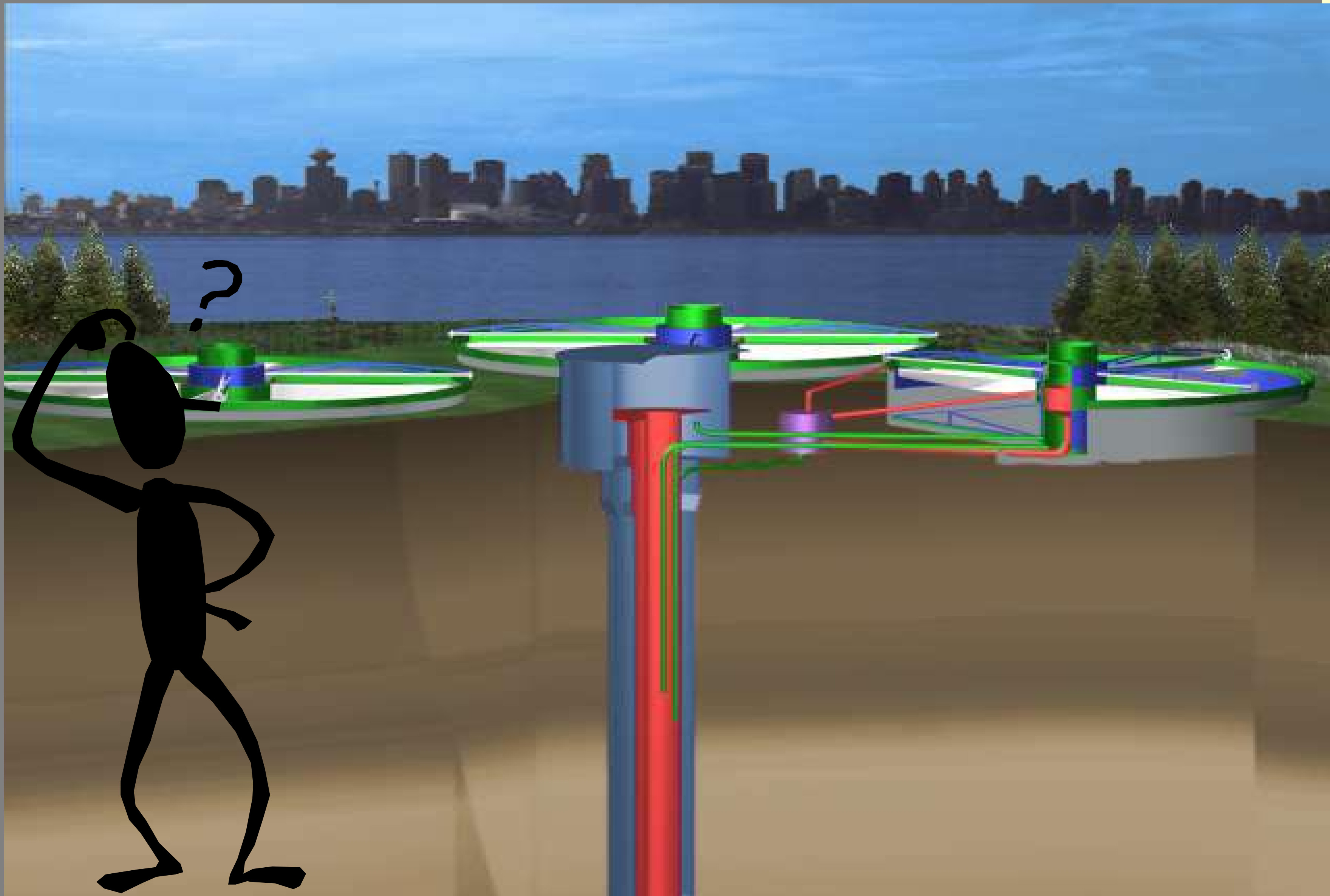
NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Summary of Advantages

- **Class A Biosolids production in 4 days**
- **Low space requirement & visual impact**
- **Fully enclosed - no nuisance odours**
- **Dewaters to > 30% cake solids**
- **Decreased hauling traffic**
- **Synergy with anaerobic digestion**

NORAM Bio Systems Inc.
Biological Treatment Technologies

Questions?



NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTREAT™ & VERTAD™

Additional Slides

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™ Demonstration Facility

Opportunities for Class A Biosolids Production

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Demonstration Plant Objectives

Concept:

- Demonstration VERTAD Facility

Major Objectives:

- Meaningful design data for Participating City
- Dual Digestion (combine with Anaerobic)
- Float Thickening of VERTAD™ Product
- Dewaterability of VERTAD™ Product
- Beneficial Reuse of Class A Biosolids
- Compare VERTAD™ & Anaerobic Products

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Demonstration Plant Sizing Basis

Plant Sizing Assumptions:

- 4 Dry Tons/day (40,000 population equivalent)
- >40% VS Removal in 4 days
- Class A Product

Study Goals:

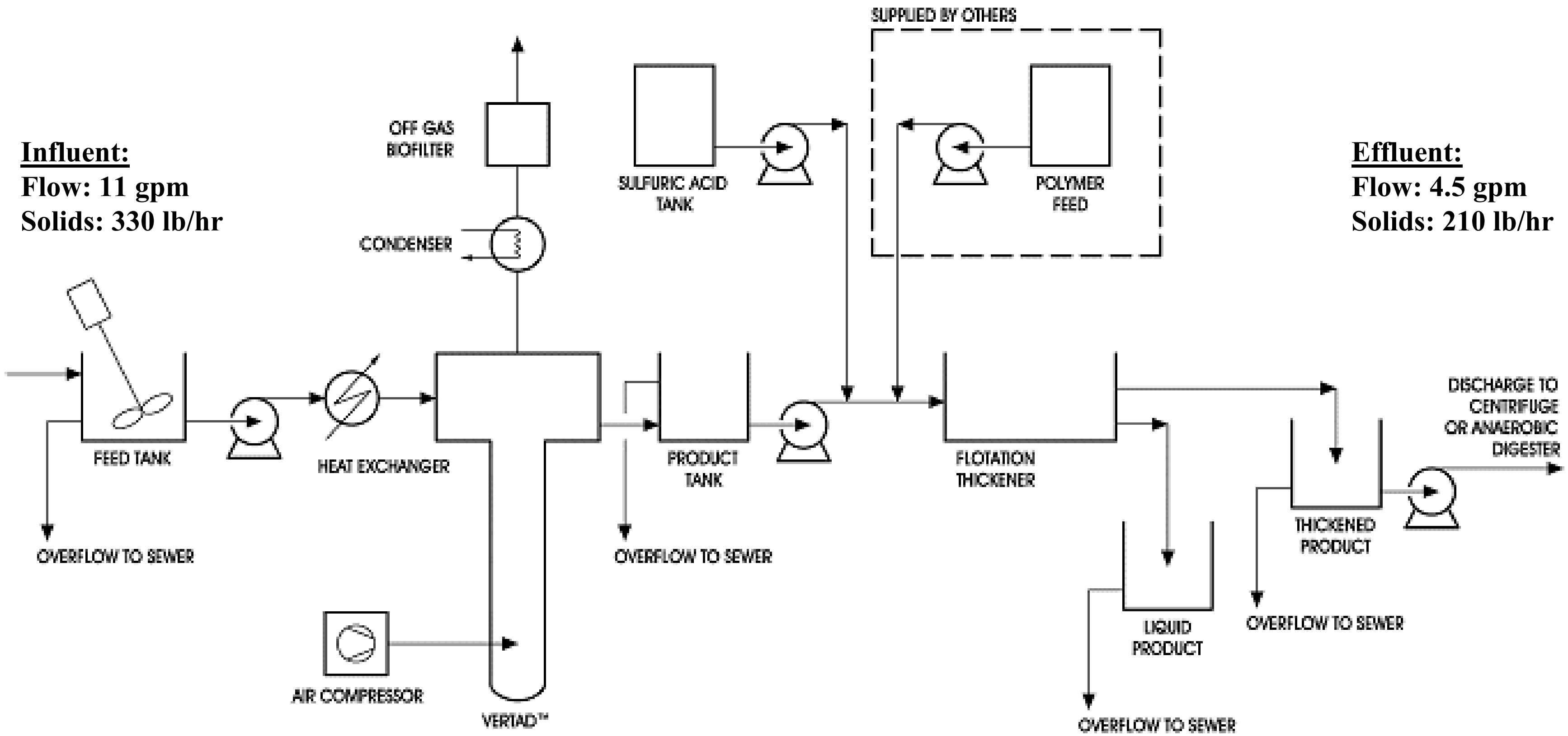
- Dual Digestion (>70% destruction)
- Flotation Thickening to >10% Solids
- Dewater Product to >30% Cake Solids
- Test Fertilizer Value of Class A Biosolids

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Proposed Demonstration Plant Flowsheet

Influent:
Flow: 11 gpm
Solids: 330 lb/hr

Effluent:
Flow: 4.5 gpm
Solids: 210 lb/hr



- Decoupled the reactor and clarifier (allows testing of different solids loading rates)

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Potential Demonstration Plant Layout

3200 sq ft = 0.07 acres

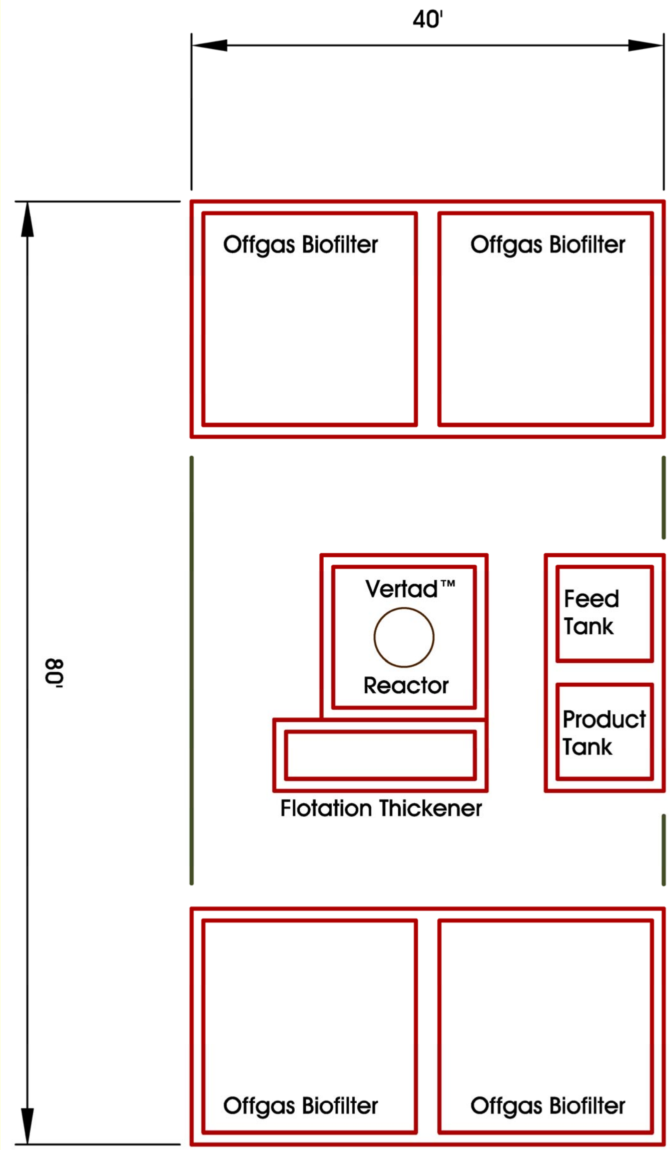
4 Dry Tons of Solids per day

40% VS Removal in 4 days

1 Reactor - 5.0’ dia, 350’ deep

1 Thickener – 4’ x 16’

Biofilters - Ammonia Removal



NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTREAT™ & VERTAD™

Additional Technical Slides

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTREAT™ & VERTAD™
Plant Reference List

List of All Deep Shaft and VERTREAT/VERTAD Plants

Year	Contractor	Location	Owner	Type of Waste	Design Capacity BOD Load [kg/day]	Design Capacity Flow Rate [m3/day]	Design Capacity Population Equivalent	Technology
				MUNICIPAL				
1977	MKK	Toyonaka, Japan	Toyonaka City	Domestic	700	2,400	9,000	ICI Deep Shaft
1978	PWT	Tilbury, UK	Anglian Water Auth.	Domestic/Industrial	7,050	8,800	93,000	ICI Deep Shaft
1980	DSTI	Portage, Canada	City of Portage	Domestic/Industrial	5,500	13,600	73,000	ICI Deep Shaft
1980	MKK	Matsushima, Japan	Matsushima Town	Domestic	80	500	1,000	ICI Deep Shaft
1980	DSTI	Virden, Canada	Town of Virden	Domestic	568	2,300	8,000	ICI Deep Shaft
1981	LURGI	Leer, Germany	City of Leer	Domestic/Industrial	12,480	15,000	165,000	ICI Deep Shaft
1985	TAKENAKA	Osaka, Japan	Kitano Hankyu Bldg.	Domestic/Industrial	334	530	4,000	ICI Deep Shaft
1985	TAKENAKA	Osaka, Japan	Yoshimoto Hilton	Domestic	250	500	3,000	ICI Deep Shaft
1986	TAKENAKA	Osaka, Japan	Umeda Centre Bldg.	Domestic	68	272	1,000	ICI Deep Shaft
1986	KAJIMA	Ibaraki, Japan	Kanto-spa	Food and Domestic	255	411	3,000	ICI Deep Shaft
1987	PWT	Tilbury, UK	Anglian Water Auth.	Domestic/Industrial	22,000	30,000	291,000	ICI Deep Shaft
1987	NKK	Mie, Japan	Aki-Tsu	Nightsoil	570	375	8,000	ICI Deep Shaft
1988	TAKENAKA	Tokyo, Japan	Tokyo Dome (Stadium)	Domestic Recycle	136	400	2,000	ICI Deep Shaft
1988	TAKENAKA	Tokyo, Japan	Mitsui-Hakozaki Bldg.	Domestic	170	401	2,000	ICI Deep Shaft
1988	TAKENAKA	Kanagawa, Japan	Toakosan IBM Yamato	Domestic Recycle	90	150	1,000	ICI Deep Shaft
1988	DSTI	Homer, Alaska, USA	City of Homer	Domestic	750	3,330	10,000	ICI Deep Shaft
1988	TAKENAKA	Osaka, Japan	Osaka Crystal Tower	Domestic Recycle	117	300	2,000	ICI Deep Shaft
1991	TAKENAKA	Osaka, Japan	Umeda Daiichi Seimei	Domestic Recycle	79	136	1,000	ICI Deep Shaft
1991	PWT	Tilbury, UK	Anglian Water Auth.	Domestic/Industrial	22,000	30,000	291,000	ICI Deep Shaft
1991	TAKENAKA	Tokyo, Japan	Hamacho Centre Bldg.	Domestic	72	170	1,000	ICI Deep Shaft
1992	NKK	Ryugasaki, Japan	Ryugasaki San. Assoc.	Nitrification	190	10,100	3,000	ICI Deep Shaft
1993		Southport, UK	NorthWest Water Auth.	Domestic	9,200	51,000	122,000	ICI Deep Shaft
1993		St. Agnes, UK	SouthWest Water Auth.	Domestic	240	1,550	3,000	ICI Deep Shaft
1998	DSTI & NORAM	Seattle, WA, USA	King County	Municipal Sludge	350 kg/d solids @ 4%		5,000	VERTAD Sludge Digestion
				INDUSTRIAL PLANTS - FOOD				
1975	ICI	Emlichheim, Germany	Emsland Staerke	Potato Processing	2,110	1,400	28,000	ICI Deep Shaft
1980	DSTI	Barrie, Canada	Molson's Brewery	Brewery	5,230	2,100	69,000	ICI Deep Shaft
1979	KUBOTA	Aichi, Japan	Aito Shokuhin	Corn Starch	16,500	8,880	218,000	ICI Deep Shaft
1979	KUBOTA	Nagoya, Japan	Kanetatsu Shokuhin	Fish Processing	1,600	800	21,000	ICI Deep Shaft
1979	KUBOTA	Osaka, Japan	Nissei	Food Processing	200	200	3,000	ICI Deep Shaft
1982	HITACHI	Yokkaichi, Japan	Shikishima Starch	Bread Production	3,000	4,000	40,000	ICI Deep Shaft
1983	KAJIMA	Niigate, Japan	Niigata Reizou	Fish Processing	300	200	4,000	ICI Deep Shaft
1984	NKK	Numazu, Japan	Numazu Fishery Un.	Fish Processing	8,400	600	111,000	ICI Deep Shaft
1988	KAJIMA	Niigata Reizou	Niigata Reizou	Fish Processing	620	200	8,000	ICI Deep Shaft
1988	MKK	Tokyo, Japan	QP Mayonnaise	Food	800	1,600	11,000	ICI Deep Shaft
1988	HITACHI	Kobe, Japan	Nippon Oil & Fats	Food	2,880	1,920	38,000	ICI Deep Shaft
1988	MKK	Chiba, Japan	Yukijirusi Dairy	Dairy Products	1,285	1,440	17,000	ICI Deep Shaft
1989	TAKENAKA	Nara, Japan	Yamoto Highmeal	Cattle Food	472	230	6,000	ICI Deep Shaft
1990	MKK	Tochigi, Japan	House Foods	Food	980	1,400	13,000	ICI Deep Shaft
1990	KAJIMA	Osaka, Japan	Daiei, Ibaraki Food Centre	Food	1,050	1,094	14,000	ICI Deep Shaft
2000	NORAM	Corona, CA, USA	Golden Cheese	Dairy	13,600	3,000	180,000	VERTREAT
				INDUSTRIAL PLANTS -PULP & PAPER				
1978	ICI	Prudhoe, UK	Kimberly Clark	Pulp/Waste Paper	6,600	22,000	87,000	ICI Deep Shaft
1980	HITACHI	Ohtsu, Japan	Ohtsu Itagemi	Cardboard	3,200	20,000	42,000	ICI Deep Shaft
1983	MKK	Tokyo, Japan	Dainippon Printing	Printing Plant	740	2,000	10,000	ICI Deep Shaft
1984	HITACHI	Ehime, Japan	Ehime Pulp	Pulp/Waste Paper	2,450	7,000	32,000	ICI Deep Shaft
1984	HITACHI	Tokyo, Japan	Jujo Itagami	Pulp/Waste Paper	7,290	15,000	96,000	ICI Deep Shaft
1987	HITACHI	Tokyo, Japan	Nihon Shigyo	Pulp/Waste Paper	4,500	15,600	60,000	ICI Deep Shaft
1988	MKK	Shikoku, Japan	Daio Seishi, Kawanoe	Pulp/Waste Paper	8,640	45,000	114,000	ICI Deep Shaft
				INDUSTRIAL PLANTS - GENERAL				
1979	MKK	Iwate, Japan	Fuji Chemicals	Sodium Alginate	250	500	3,000	ICI Deep Shaft
1980	HITACHI	Shizuoka, Japan	Ihara Chemicals	Pesticide Production	30,000	1,500	397,000	ICI Deep Shaft
1981	ICI	Wilton,UK	ICI Petrochemicals	Terephthalic Acid	8,590	2,560	114,000	ICI Deep Shaft
1982	MKK	Tokyo, Japan	Toyo Municipal, Koto	Incinerator Scrubbing	400	1,000	5,000	ICI Deep Shaft
1983	MKK	Kashima, Japan	Nippon Phenol	Phenol Production	3,380	1,656	45,000	ICI Deep Shaft
1983	MKK	Yokohama, Japan	Nippon Kokan, Keihin	Steel Production	400	6.72	5,000	ICI Deep Shaft
1984	HITACHI	Nagoya, Japan	Daihachi Chemicals	Plastics Production	180	120	2,000	ICI Deep Shaft
1988	MKK	Chiba, Japan	Keiyo Kogyo	Contract Waste	1,061	810	14,000	ICI Deep Shaft
1991	HITACHI	Nagoya, Japan	Daihachi Chemicals	Pastics/Plasticisers	133	38	2,000	ICI Deep Shaft
1992	DSTI	Kuan Yin, Taiwan	ICI Taiwan	Terephthalic Acid	10,300	3,720	136,000	ICI Deep Shaft
1992	SHI	Kohap, South Korea	Kohap Textile Co.	Textiles	2,610	125	35,000	ICI Deep Shaft
1992	DSTI	Vancouver, Canada	Chevron	Oil Refinery	1,030	2,290	14,000	VERTREAT
				INDUSTRIAL PLANTS - BIOTECH				
1986	TAKENAKA	Hokkaido, Japan	Novo Biochemicals	Enzyme	300	350	4,000	ICI Deep Shaft
1988	HITACHI	Kanagawa, Japan	Toyo Jozo	Alcohol/Pharma	2,500	1,000	33,000	ICI Deep Shaft
1992	DEEL	Billingham, UK	ICI Bio Products	General Fermentation	11,200	1,600	148,000	ICI Deep Shaft

Tilbury, UK
60 MLD, 44 000 kg BOD/day

Southport, UK
51 MLD, 9 200 kg BOD/day

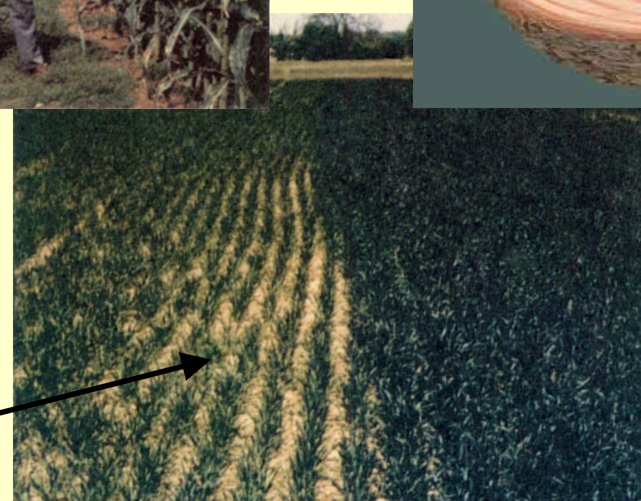
Golden Cheese, Corona, CA
4.5 MLD, 20 000 kg BOD/day

NORAM Bio Systems Inc.
Biological Treatment Technologies

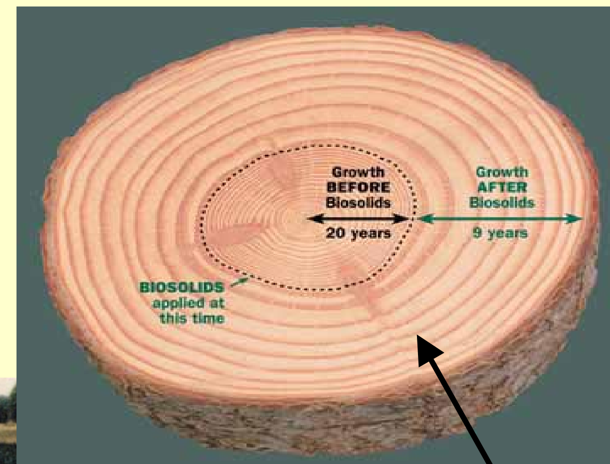
EPA CFR-503
Biosolids Regulations

- **Biosolids contain beneficial plant nutrients and soil conditioning properties.**

Corn



Oat Field



Douglas Fir

NORAM Bio Systems Inc.
Biological Treatment Technologies

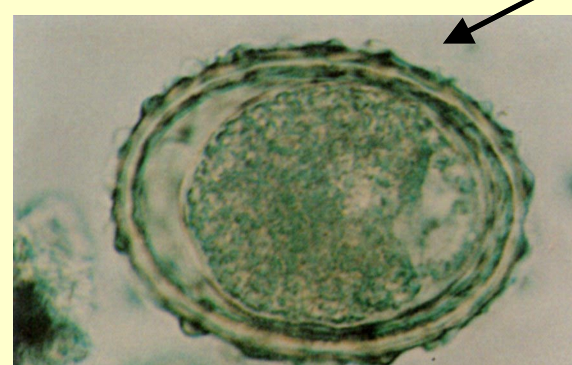
EPA CFR-503
Biosolids Regulations

- **Biosolids may contain pathogenic bacteria, viruses, protozoa, parasites, and other microorganisms that can cause disease.**

Trichuris egg

Tapeworm ova

Ascaris eggs



NORAM Bio Systems Inc.
Biological Treatment Technologies

EPA CFR-503
Biosolids Regulations

- Standards for the Use or Disposal of Sewage Sludge
- Effective March 22, 1993 (amended 1999)
- Goal: Protect public health and the environment from certain pollutants and organisms known to exist in Biosolids
- Developed guidelines for both “Class A” and “Class B” Biosolids

NORAM Bio Systems Inc.
Biological Treatment Technologies

EPA CFR-503
Biosolids Regulations

	Restricted?	
Site Type	***Class 'B'***	***Class 'A'***
Agricultural land	Yes	No
Forests	Yes	No
Public contact site	Yes	No
Lawn	Yes	No
Home garden	Yes	No

- **Restrictions for the harvesting of crops, grazing of animals, and public access on sites where Class B biosolids are applied.**

NORAM Bio Systems Inc.
Biological Treatment Technologies

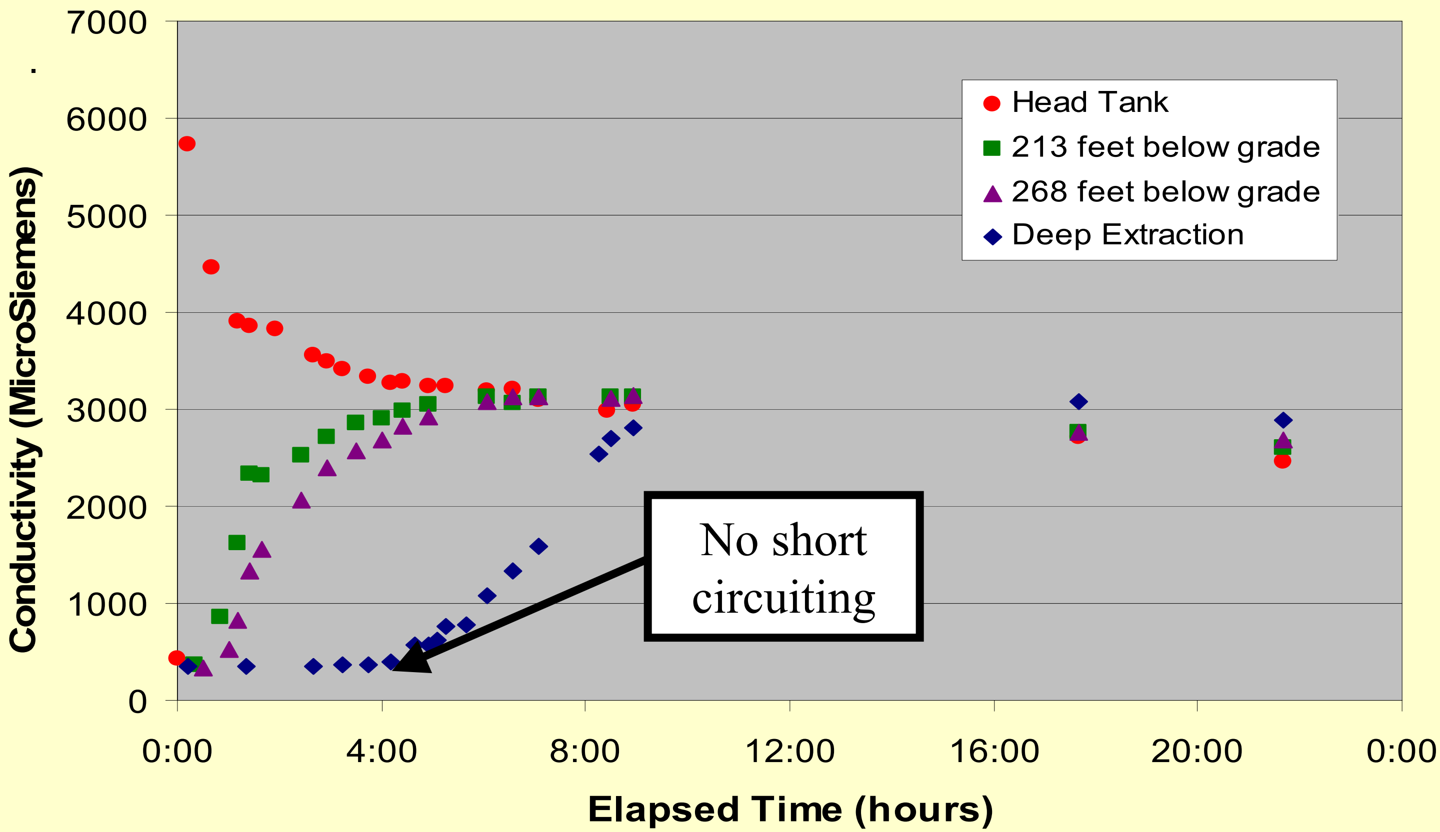
VERTAD™
VS, FOG, Org-N Reduction

Test	% VS Reduction	% Org-N Reduction	% FOG Reduction
Dec '98	40.9	57.9	91.7
Sept '99	42.2	49.8	80.8
Nov '99	42.3	44.1	N/A
Dec '99	43.5	49.9	80.4

- VS reduction meets Class A standards.
- Proteins & oils preferentially degraded.
- Very stable biosolids.

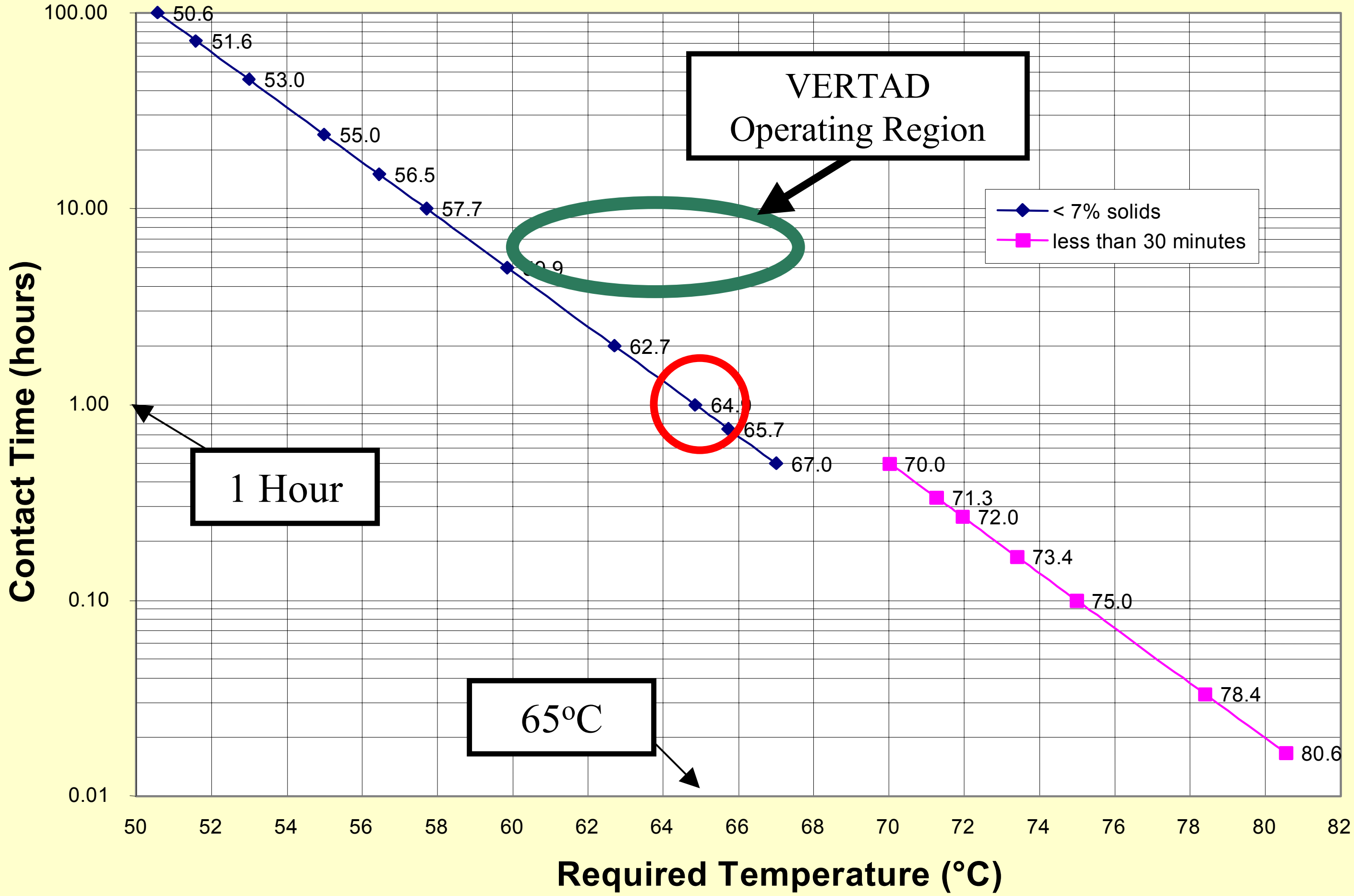
NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Salt Tracer Study



- **Continuous reactor design complies with EPA time-temperature requirements.**

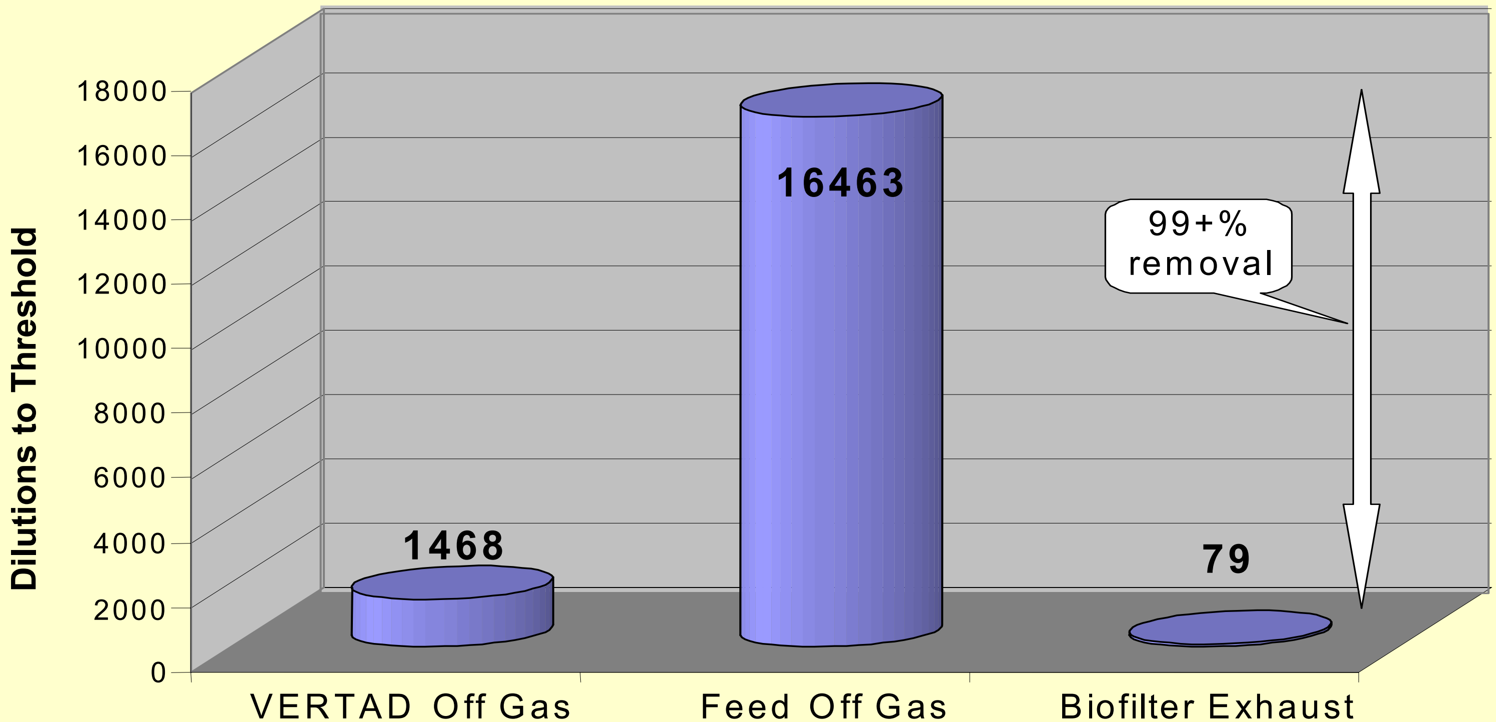
VERTAD™ Time-Temperature Requirements



- VERTAD™ operates above EPA time-temperature requirements.

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Odour Panel Results



- **Odour from feed tank treated to 99+% removal.**
- **Odour character descriptors of VERTAD™ off-gas included: compost, earthy & vegetation.**

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Lab Centrifuge Testing

Characteristic	Anaerobic	VERTAD™
Cake Solids (%)	12 - 14	31 - 34
Polymer Dose (lb/ton)	20.4	13.8
Capture Efficiency (%)	95	99.5

- The VERTAD™ product dewaters to a higher cake solids with a lower polymer dose than an anaerobic system.

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Dual Digestion Process

	11 day SRT Anaerobic	15 day Anaerobic w/ VERTAD™	11 day Anaerobic w/ VERTAD™
SRT (days)	11	15*	11*
VSR (%)	52	70*	67*
L CH_4/day	2.8	2.0	2.5
L CH_4/g COD	0.51	0.39	0.36

* - Overall Data - includes 4 day HRT and 40% VSR from VerTAD™

- **Synergistic - VERTAD™ degrades fats & proteins, anaerobic degrades cellulose.**
- **Combined had no foaming & better mixing.**
- **Dewatering indicated low polymer usage.**

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Comparison with Conventional ATAD

Characteristic	ATAD (Design)	ATAD (Case study)	VERTAD™ (Case study)
Power Usage (kWhr/ton TS feed)	442	520 - 641	315
Power Usage (kWhr/kg VS destroyed)	1.52	1.9 - 2.3	1.27
Aeration ($m^3/hr/m^3$ active volume)	4	N/A	1.7
Time for 40% VS reduction (days)	5 - 8	12 - 15	3.5
Average System OTE (%)	N/A	24%	50%

- Higher oxygen transfer efficiency leads to lower aeration rates, retention times and power usage.

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Capital Cost Savings

- The capital cost of a VERTAD™ system is lower than conventional plants of similar size.

Due to:

- Decreased land requirements - 10 to 20%
- Less surface tankage - 80% below grade
- Less dewatering equipment
- Fewer pumps, no mixers

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Operating Cost Savings

- **Low Power Consumption**
  - 315 kW·h/ton TS fed (ATAD=580 kW·h/ton)
- **Polymer Savings**
  - Less than 15 lb/ton used in dewatering
- **Trucking and Disposal Savings**
  - High solids content in product reduces handling
- **Operation & Maintenance Savings**
  - Unattended operation
  - Reduced equipment maintenance requirements

NORAM Bio Systems Inc.
Biological Treatment Technologies

VERTAD™
Other "Valuable" Advantages

- Value of Class A Biosolids
- Decreased maintenance in anaerobic digesters (reduced problems related to scum and foaming)
- Decreased hauling traffic and odour concerns
- Energy recovery to preheat the anaerobic digesters, control rooms, pools...

NORAM Bio Systems Inc.
Biological Treatment Technologies

Greenfield Facility
Potential Plant Schematic