ATKINS

Atkins Water
Process Engineering

Tulare IWTP Expansion

CIWEM NW
March 2006

Dr Stephen J. Palmer

Project

ATKINS

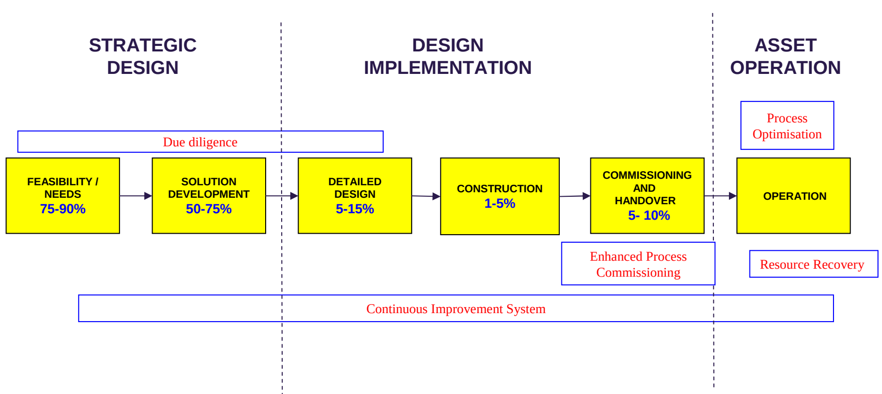
- **City of Tulare, California, USA.**
- **Population 50,000 (human); Cows 3-4 million**
- **Claimed to be ‘Dairy Capital of the World’**
- **City served by a municipal wastewater treatment plant & much larger Industrial Wastewater Treatment Plant (IWTP)**
- **Seeking to expand Industrial Wastewater Treatment Plant (IWTP)**

Project Definition

- **Cease and Desist** against existing IWTP requires compliance by 2009 with revised effluent quality limits including:
  - Average BOD 40mg/l
  - Average TSS 40mg/l
  - 10mg/l $N0_3$-N
  - Probable Electrical Conductivity: 750µmhos/cm

- IWTP effluent blended with Domestic WTP effluent; discharged to irrigation ponds for subsequent use
- Potential impact on groundwater drives requirement for EC limit
- Existing Domestic WTP already being up-rated for nitrate nitrogen compliance
- IWTP Capacity to increase from existing 6.65MGD ultimately to 12MGD (and 8MGD in DWTP)

Atkins Process Engineering Services



Project Progress and Atkins Role

ATKINS

- Multiple options developed for facility expansion for the City of Tulare in a Facility Masterplan
- Facility Masterplan now revised by Clients Engineering Service Provider to Amendment 1 Options; issued to the City in November 2005
- City of Tulare appointed Atkins to:
  - review the proposed design solutions and add value to solution development process where the opportunity exists
  - prepare a specification and contract documents that will enable the City of Tulare to seek bids for provision of the required expansion capacity

Methodology

ATKINS

INITIALDATA COLLATION → PRELIMINARY SITE VISIT → PROCESS AUDIT DESIGN → PROCESS AUDIT → ASSET DIAGNOSTIC REPORT → SOLUTION DEVELOPMENT & OPTION ASSESSMENT → SELECTED SOLUTION IMPLEMENTATION

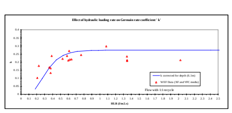
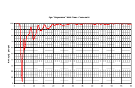
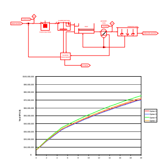





Figure 2 The Asset Optimisation Work Process

Risk Management Methodology

ATKINS

Project **R**isk **A**nalysis and **M**anagement (PRAM)

1) Qualitative Risk Analysis

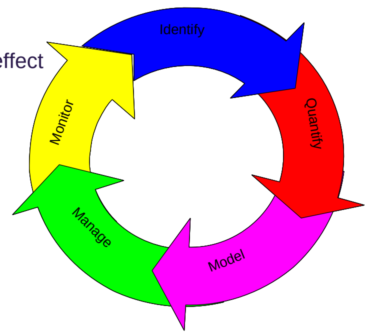
- It identifies, describes, assesses and enhances understanding of risks

2) Quantitative Risk Analysis

- Modelling risk in order to quantify its combined effect on the project

3) Risk Management

- responds to identified risks in order to minimise exposure



Risk Management Methodology

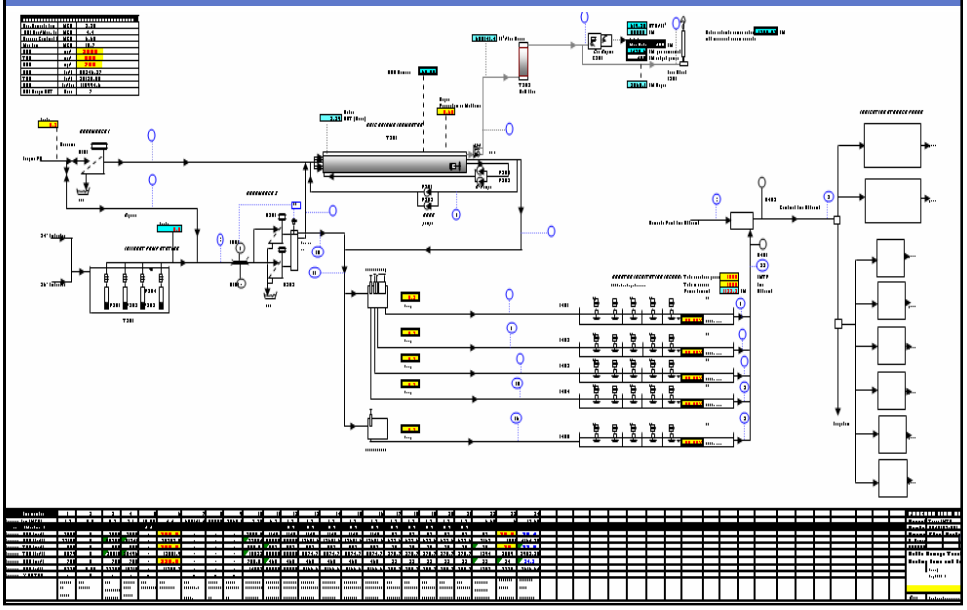
ATKINS

The risk management process should be used throughout the life of a project:

- Identification: Risk process used as a decision support tool.
- Select: Risk analysis considers both positive and negative aspects of the Project (threats and opportunities) and Project alternatives.
- Define: Emphasis changes to actual plans and budgets.
- Execution: Periodic Risk assessments are undertaken to ensure project is close to plan.

Benchmark Existing Assets: Present IWTP

ATKINS



Process Audit: Benchmark of existing IWTP

ATKINS

- Original IWTP facility provided for first stage anaerobic bio-treatment of bulk of wastewater followed by subsequent blend of anaerobic effluent and raw wastewater to partially aerated, facultative lagoons (AFLs)
- Original design was for more relaxed consent; Cease and Desist Order and new discharge consent requires higher efficiency process
- Original design concept of maximising upstream anaerobic followed by downstream aerobic excellent in whole life cost terms. *NEW proposals increase proportional and net energy demand in future*
- BVF performance is the pinch-point for present plant; unit never achieved **design 80% BOD removal** (until recent operational change); loads above design then passed to AFLs overloading these and compromising compliance

What is BVF?
What is it not?

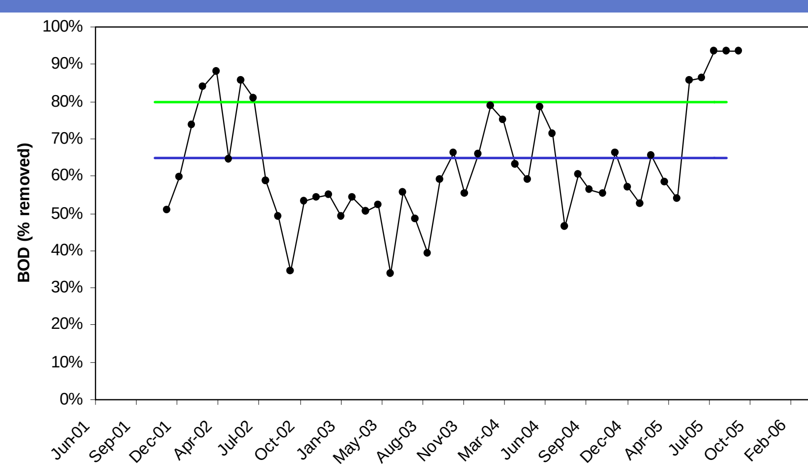
ATKINS

- BVF is an unheated, short design HRT (7 day) anaerobic biological treatment system consisting of a shallow, very low aspect covered rectangular tank (1:24); system includes alkali addition and recycle; internal mixing later added by ADI
- Described as anaerobic contact process:- but lacks uniform mixing in anaerobic treatment zone and downstream biomass recovery in sedimentation tank with concentrated biomass recycle;
- System most similar to anaerobic lagoons but is significantly different from typical design practice

	Covered Anaerobic Pond	Plug Flow Digester	Complete Mix Digester	ADI BVF
Depth (ft)	13.1 – 26.2	9.8	-	25
OLR (lb VS/1000 ft³/d)	>6.2	62.4 – 187.3	74.9	32.9
HRT (d)	50-90	20-40	20-23	7
Waste handling	Flushing	Scraping	Scraping	
Pretreatment	None	Premix-tank	Premix-tank	None
% Solids	0.5 – 3	9-13	3-10	0.8
Construction	Earthen Pond	Concrete, steel, plastic etc	Concrete, steel, plastic etc	Covered Recirculating Pond
Inflow	Several times per day	Daily	Several times per day	Continuous
Temperature	Psychrophilic	Mesophilic	Mesophilic	Mesophilic
Mixing	Usually passive	Passive	Active mixing	Usually Passive

BVF Performance : Percent BOD removal

ATKINS

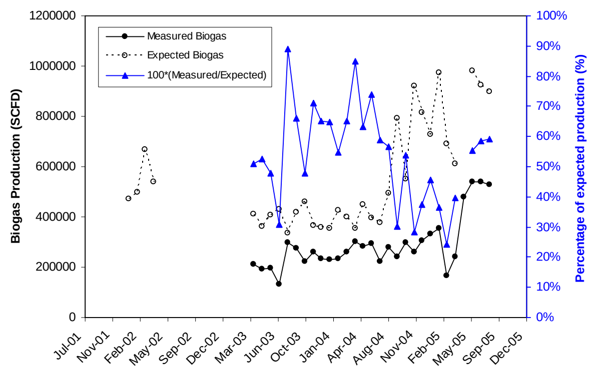


- **BOD removal (all data) = 62% +/- 18%**
- BOD removal (after addition of WAS) = 90% +/- 4%
- BOD removal (before addition of WAS) = 59% +/- 16%

BVF Characteristics before and after May/June 05

ATKINS

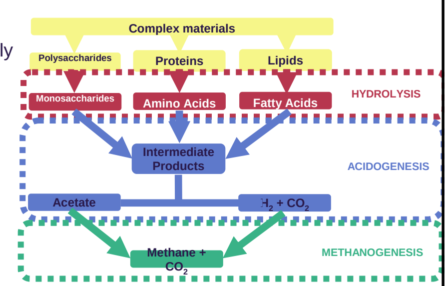
- BVF performance appears unrelated to BOD or COD loading,
- BVF exerts no consistent demand for Nitrogen, Phosphorus or alkali
- Gas yield consistently below theoretical expectations
- VSS content of RANs decreasing; floor solids deposition observed
- Following addition of tank stored Waste activated sludge, performance has improved to approximately 90%; **gas yield significantly improved**



BVF Performance in context :Critical Anaerobic Biotreatment Criteria

ATKINS

- Waste breakdown a sequential process of three stages by bacterial biomass
- Sufficient biomass required for successful process; usually requires some form of biomass capture and return;
- Vessel biomass (solids) residence time must be greater than minimum time needed to degrade waste material
- Solids residence time (SRT) is only equal to reactor Hydraulic residence time (HRT) when reactor uniformly mixed;
- Uniform mixing requires sufficient energy input to suspend reactor biomass
- **Minimum residence time a function of waste material, temperature and mixing provision, biomass growth rate and detention**
- Methanogenic stage which releases usable methane requires pH > 6.5; hence potential alkali requirement



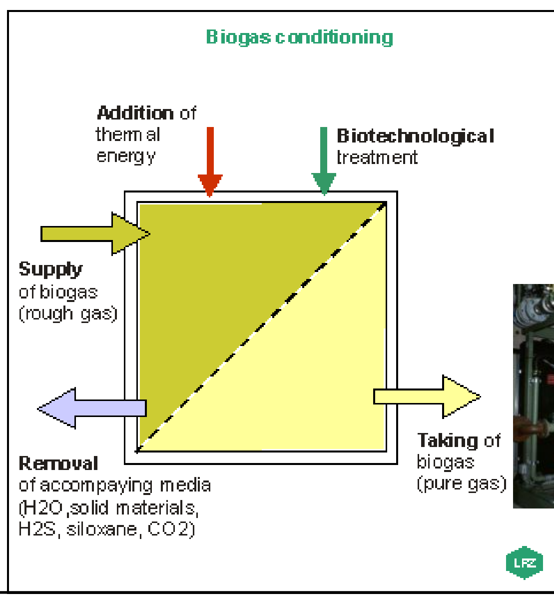
ESP Proposals for Solutions: Re-use of existing BVF and Consequent Issues

ATKINS

- Performance has improved to approximately 90% following WAS addition
- BVF would appear to have been biomass limited prior to sludge (WAS) addition
- WAS addition not optimal measure; waste digested sludge addition from domestic plant MADs preferable in future
- **Existing BVF unit issues:**
  - Reactor size
  - Seasonality
  - Mixing
  - Availability
  - Energy reclaim

BVF Energy Reclaim: Need for Efficient Biogas processing

ATKINS



Solution Development: ESP Sponsored Pilot Study

ATKINS

- Pilot study examined Pilot BVF and downstream pilot SBR
- Some risks with conclusions drawn from pilot study; e.g.

- Similitude issues between pilot and full scale BVF
  - HRT and SRT of pilot and full scale unit
  - Geometric similitude lacking
  - Temperature
  - Upstream pre-acidification on pilot; not present on full scale

- Similitude issues between pilot and full scale MSBR
  - Dynamic similitude (e.g. control and
  - Geometric similitude lacking

- Pilot study dissimilar to full scale in a number of areas but did offer proof of principle of anaerobic treatment followed by aerobic activated sludge-SBR; main issue is EC compliance, data interpretation requires care

Client ESP Proposed Design Options

ATKINS

Five basic ESP options

- Option 6: Flow split 50%:50% BVF and downstream blend to conventional Activated sludge with WAS digestion in conventional Mesophilic Anaerobic Digesters

- Option 7: Flow split 50%:50% BVF and downstream blend to Fixed film Bioreactor plus SBR Activated sludge

- Option 8: Flow split 50%:50% BVF and downstream blend to (M)SBR Activated sludge with WAS digestion in conventional Mesophilic Anaerobic Digesters

- Option 9: No flow split;100% aerobic treatment in (M)SBR Activated sludge with WAS digestion in existing BVF

- ESP Recommended Option: No flow split, aerobic treatment in (M)SBR with WAS digestion in existing 129 MG (maximum available existing) FSL capacity

ESP Recommended Option: Atkins Technical Review

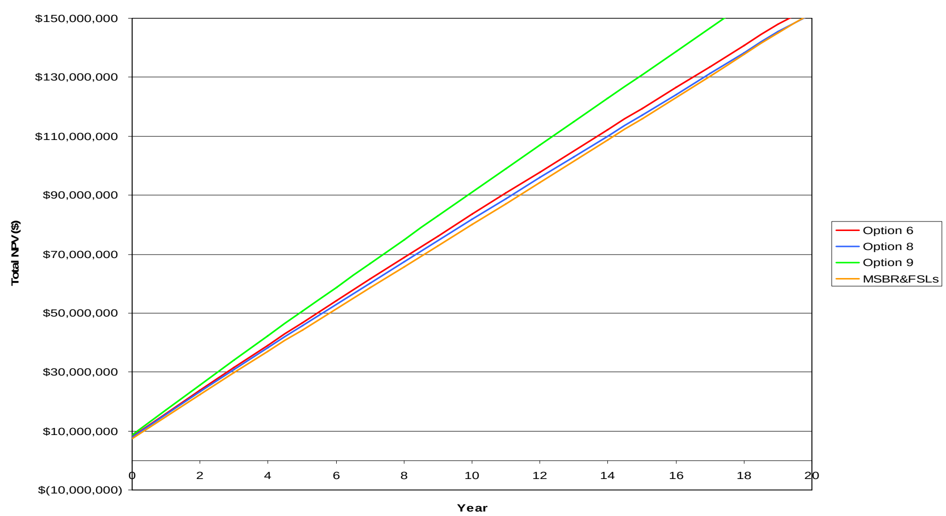
ATKINS

ESP Recommended Option: 100% aerobic treatment in (M)SBR with WAS digestion in existing 129 MG (maximum available existing) FSL capacity

- Performance Assessment
  - BOD and TSS compliance can be achieved met but organic loading and sludge (WAS) production higher
  - Nitrate nitrogen compliance can be achieved
  - EC compliance not assured
  - WAS digestion in FSLs will not work as designed
- Design Issues
  - Design appropriate but OTE for FBDA optimistic
  - WAS-only digestion; 50% VSS destruction assumption too high
  - No odour control
  - No odour survey or odour mapping to support buffer land design
- Risks
  - MSBR control and operation; FBDA performance, Sludge bulking
  - More staff required; but processes are more complex in control and flow switching for MSBR
  - MSBR discharge weir arrangement relatively new
  - Low rate WAS digestion In FSLs will offer major odour risk

ESP Options Review by Atkins: Whole Life Costs

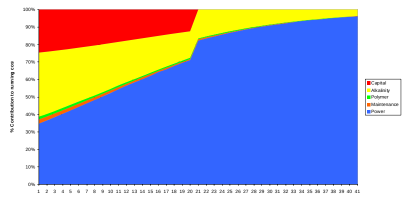
ATKINS



ESP Design option Risks

ATKINS

- Financial Assessment
  - 20 year NPV - for operational costs only and this confined to power cost only
  - No integrated NPV for capital and operational costs
  - Power cost inflation a major future risk



- Capacity Provision

  Extend capacity to 8MGD - which may be fully utilised as soon as 2009/2010
  - Design should consider expansion to 12MGD in this design horizon

Atkins Option Cost and Investment Driver Review

ATKINS

20year NPV costs options 6,8, and 9 versus SBR & FSLs with power inflation at 12%.

OVERALL NPV (MM$)				
	Option 6	Option 8	Option 9	SBR and FSLs
20 years	**136**	**133**	**150**	**134**

Option	Atkins Original weighting Score (%)	Stakeholder Survey weighted Score (%)	Rank
6	70	68	2
8	82	82	1
9	61	60	4
7	47	47	5
MSBR & Facultative Lagoons	66	64	3

ESP Option Review by Atkins: Evaluation of Stakeholder Preferences

ATKINS

Assessment Element		Primary Criterion	Secondary Criteria				Weighting % of Total unadjusted score to achieve maximum 100pts	Score	Criterion unadjusted score	Weighted sub- Total	Cumulative Total
1	Capital Cost	Cumulative capital cost for project; *use this data in Whole life cost (NPV) calculation*	Total US$				1.0	1 to 5 * weighting	3	3	3
2	Operational Cost	Cumulative operational cost per annum: *use this data in Whole life cost (NPV) calculation*	Total energy cost:	Staff:	Chemicals:	Chemicals:	1.0	1 to 5 * weighting	4	4	7
3	Whole life cost	Project Lifetime, NPV of asset over this period	Asset Design Life (yrs):	Total Capital (US$):	Annual Operational Costs: (US$)	Discount Rate%:	4.0	1 to 5 * weighting	4	16	23
4	Performance	Predicted Compliance with Consent		%			4.0	1 to 5 * weighting	3	12	35
5	Operability	Ease of Operation; maintenance demands, need for extra training or institutional strengthening					2.0	1 to 5 * weighting	4	8	43
6	Integration	For projects with existing assets; Compatability with existing assets Ease of integration with existing assets					2.0	1 to 5 * weighting	4	8	51
7	Availability	System Average Design Availability; Probability of attaining design availability, reliability and impact of lack of availability					1.0	1 to 5 * weighting	4	4	55
8	Constructability	Ease of Construction; effect of ground conditions, ease of tie-in (linkage) with any existing assets, construction impact on any existing operations					1.0	1 to 5 * weighting	2	2	57
9	Sustainability	Rating as sustainable development; Defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [Brundtland Commission ,1987].					1.0	1 to 5 * weighting	4	4	61
10	Footprint	Landtake; reflecting significance of land demand					1.0	1 to 5 * weighting	3	3	64
11	Planning	Planning Burden; reflecting significance of planning burden on cost and schedule					1.0	1 to 5 * weighting	3	3	67
12	Schedule	Schedule Implications of project; any Challenges to schedule, reflecting importance of schedule					1.0	1 to 5 * weighting	3	3	70
							Total 60pts unweighted maximum		Project Value	70.0	%

ESP Options: Atkins Review Summary

ATKINS

- Existing ESP Assessment does not give integrated (capital and full operational cost) NPV or investigate other risk areas
- Atkins provide integrated 20 year NPV and include allowance for maintenance and also include chemical costs in operational costs
  - Option is lowest CAPEX <u>but</u> 2^{rd} lowest NPV , ie whole life cost overall, of 5 options, but poor on operational costs
- Atkins semi-quantitative assessment including operability, availability, sustainability and constructability
  - For all factors, ESP recommended option is 3^{rd} best as it carries significant design and non-compliance risks as it now stands

ATKINS

Atkins Recommendations

- **Installation of an enhanced ESP proposed Option 8, with appropriate ancillary systems**
  - **Upstream Grit and FOG removal; waste FOG to WAS mesophilic anaerobic digestion and also biogas processing and storage capacity for Cogen**

- **Staged investment to build parallel anaerobic treatment capacity equivalent to the BVF during the first 10 years of the concession; replace BVF and increase net energy demand by increasing potential for biogas generation**

ATKINS