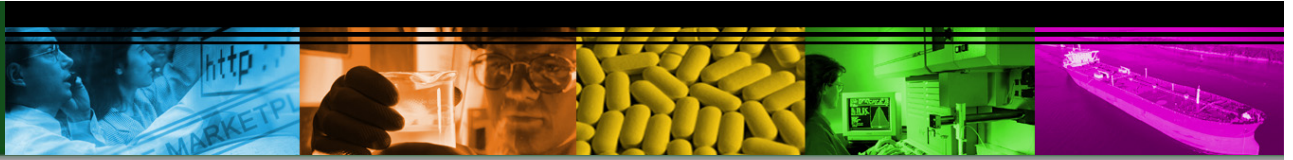


EpSelon : an Expert System for Selecting Industrial Effluent Treatment Processes

Howard Phillips, Aspen Technology Ltd

Dr Peter Martin CEng FIChemE, Perspekt Process

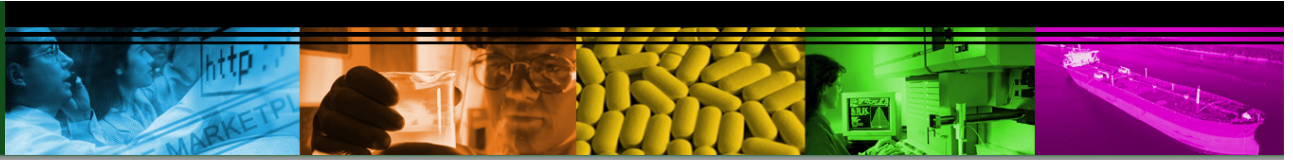




Overview

- **Purpose and Specification**
- **Place in Aspen Ltd's Product Range**
- **Process Manual and Process Experts**
- **Knowledge Building**
- **Content and Features**
- **Delivery**
- **Consultancy and Training Services**
- **Live Software Demonstration**

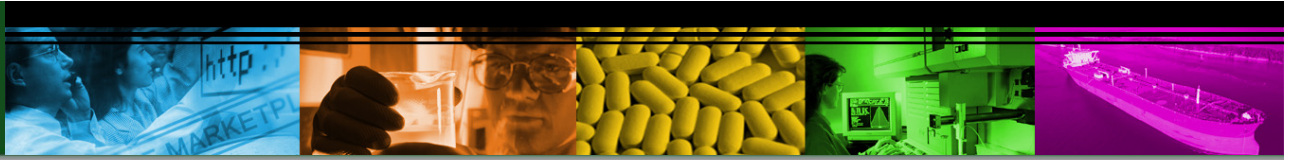




What is EpSelon?

EpSelon (Effluent Process Selection, Hands On) is a software product comprising an expert system for wastewater treatment selection combined with a detailed knowledge base:

- **To provide the engineer or technologist with tools to select or specify processes and plant for wastewater treatment**
- **Provide a logical approach to selection**
- **To describe effluent treatment and disposal technologies, and identify where they would be used**



Origins and Provenance

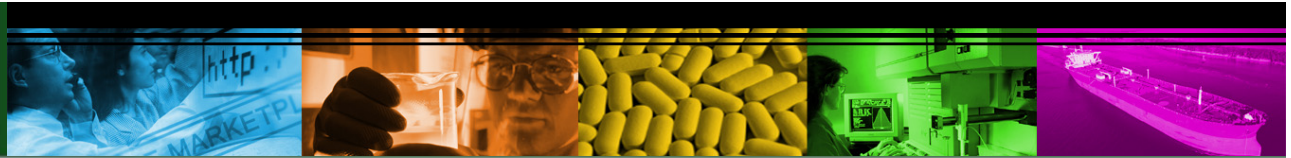
1988 – 1995: EPC (Effluent Processing Club):

- Led by AEA Technology (Harwell) and WRc (Swindon/Medmenham)
- DTI-supported consortium to advise industry, water utilities and vendors of best practice, legislation and management in wastewater treatment
- Response to tightening regulation and impetus to greater environmental responsibility

1995 – 2005: AEA Technology/Aspen Technology Ltd:

- Knowledge and expertise progressively updated and embodied in electronic documents and software
- 2000 - Process Manual, Process Experts and Process Tools launched

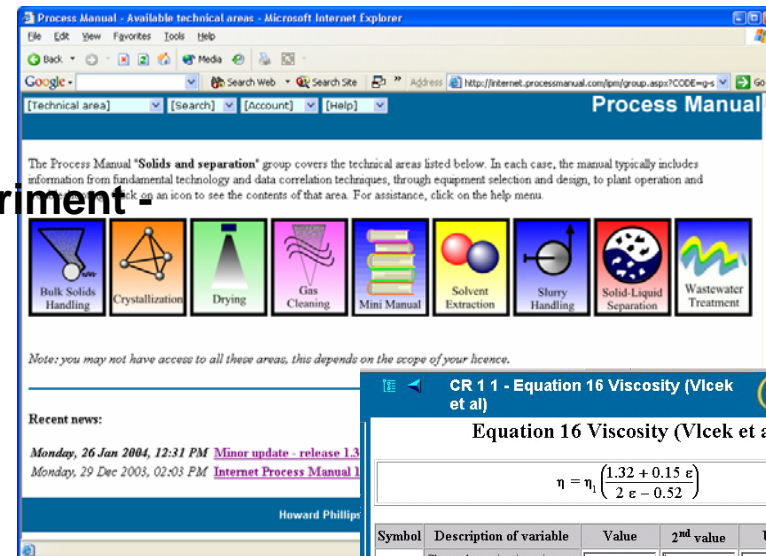
Process Manual etc. also embody the expertise base of SPS (Separation Processes Service) and Wet Solids Handling Project, with expertise in gas cleaning, solid-liquid separation, drying, crystallization, solvent extraction, slurry and sludge handling



Process Manual and Process Experts – General Features

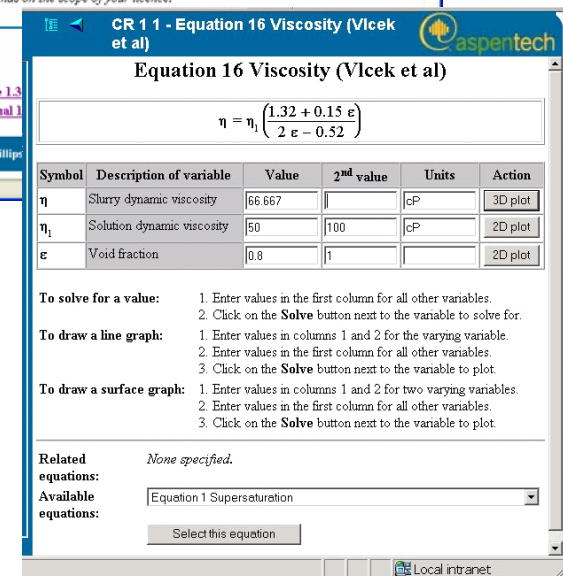
Process Manual:

- Rigorous theory - validated by experiment - proven in industry
- Structured knowledge
- Web-based knowledge deployment
- Live equations



Process Experts:

- Different tasks, common structured approach
- Allow user to select processes or plant, or to troubleshoot



Equation 16 Viscosity (Vlcek et al)

$$\eta = \eta_1 \left(\frac{1.32 + 0.15 \epsilon}{2 \epsilon - 0.52} \right)$$

Symbol	Description of variable	Value	2 nd value	Units	Action
η	Slurry dynamic viscosity	66.667		cP	3D plot
η_1	Solution dynamic viscosity	50	100	cP	2D plot
ϵ	Void fraction	0.8	1		2D plot

To solve for a value:

1. Enter values in the first column for all other variables.
2. Click on the **Solve** button next to the variable to solve for.

To draw a line graph:

1. Enter values in columns 1 and 2 for the varying variable.
2. Enter values in the first column for all other variables.
3. Click on the **Solve** button next to the variable to plot.

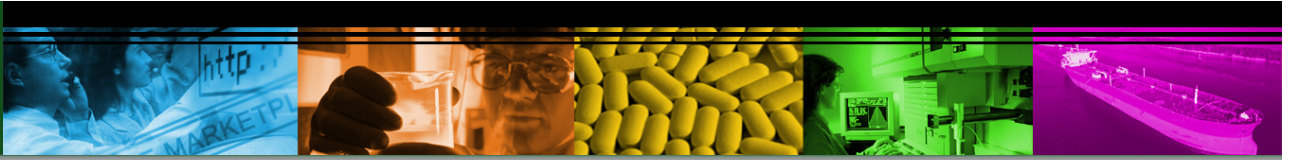
To draw a surface graph:

1. Enter values in columns 1 and 2 for two varying variables.
2. Enter values in the first column for all other variables.
3. Click on the **Solve** button next to the variable to plot.

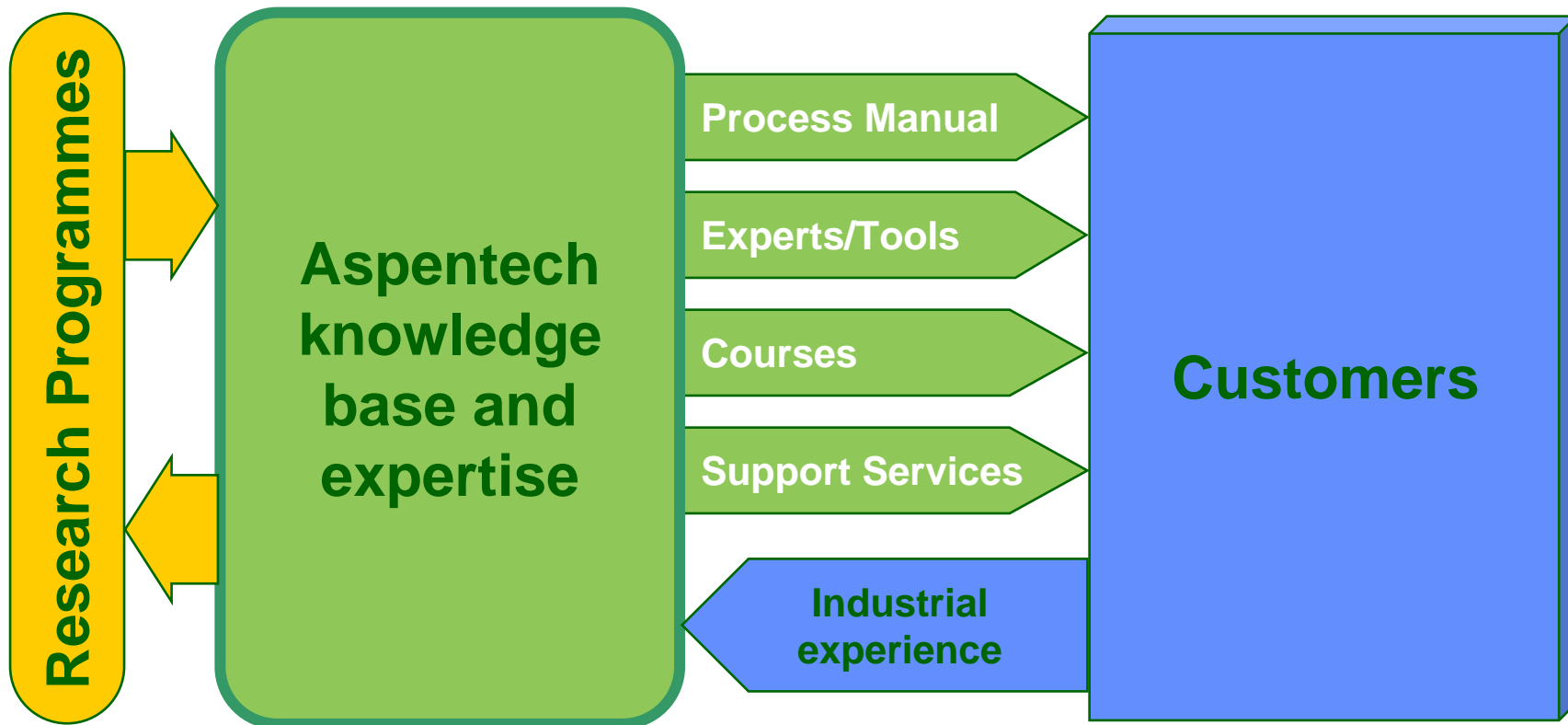
Related equations: *None specified.*

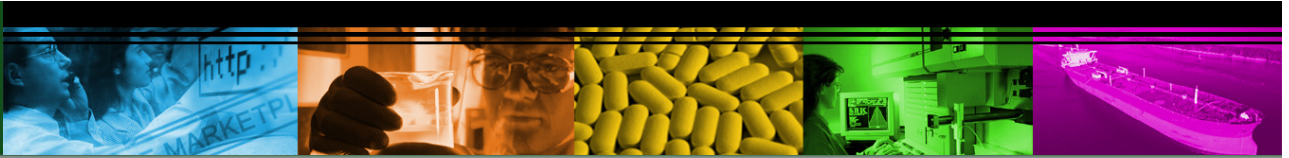
Available equations: Equation 1 Supersaturation

Select this equation

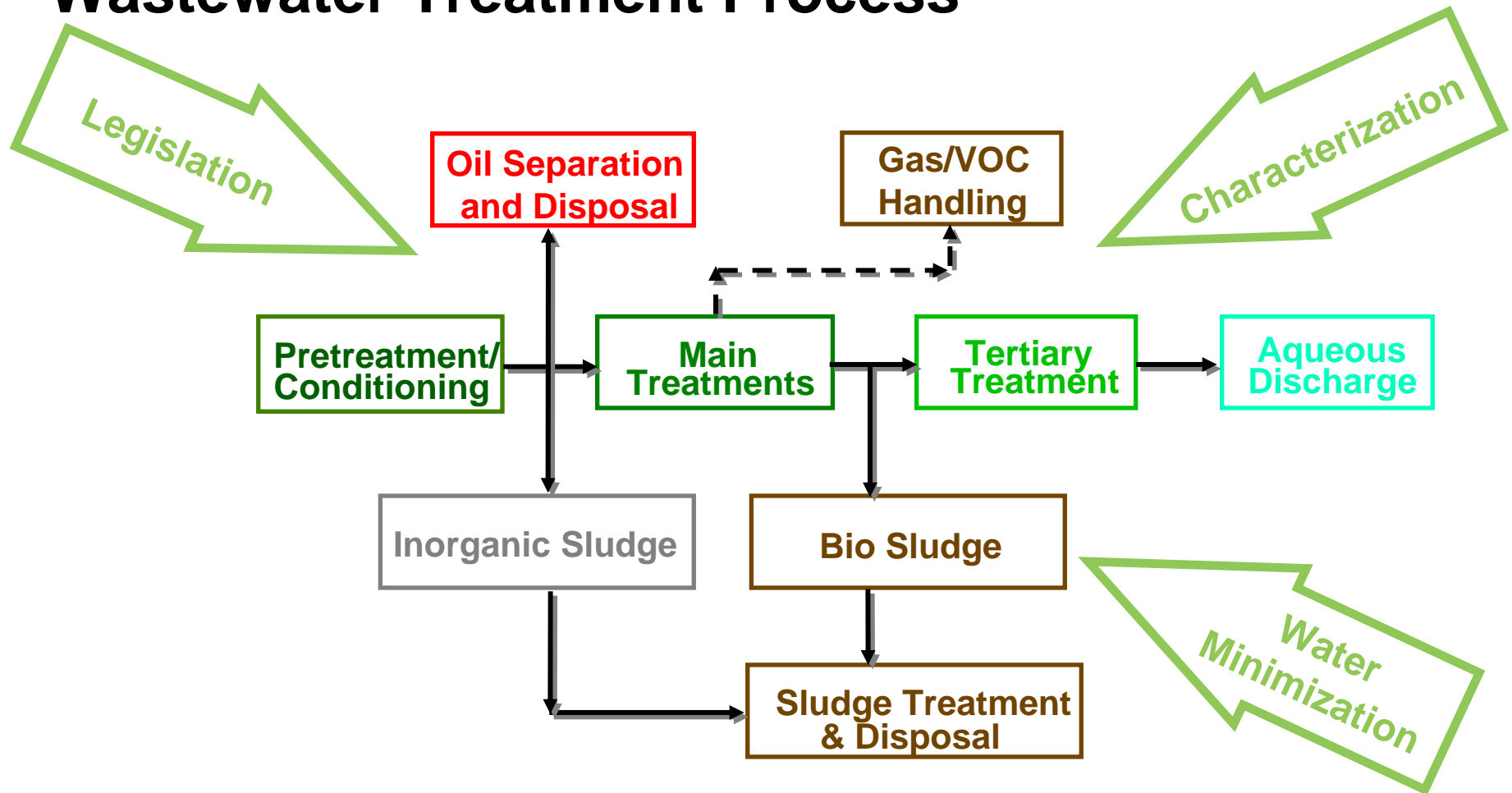


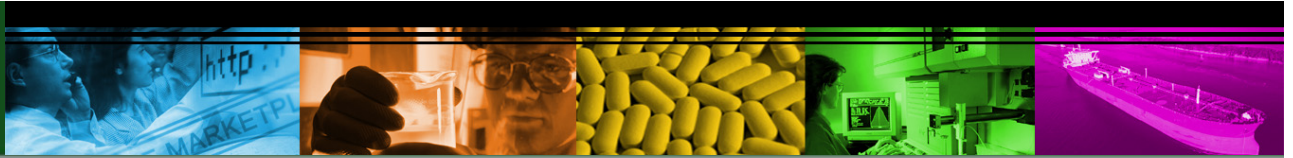
Expertise Development Cycle





Wastewater Treatment Process





EpSelon: Summary

Expert System (Process Expert)

Discursive expert system
for process selection

Based on 'Live Decision
Trees'

Acts as an Intelligent index
for knowledge base

**Context-sensitive
reference**



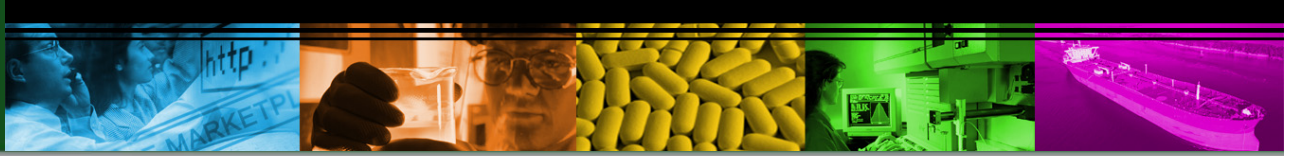
Knowledge Base (Process Manual)

All aspects of treatment and
ancillary processes covered

Background detail for
Expert, or used stand-alone

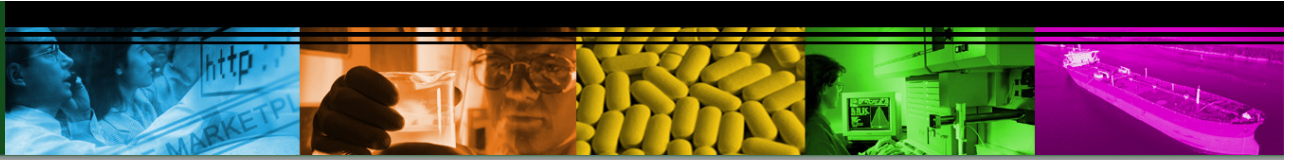


Outline process costing
(by live equations)



EpSelon Process Manual: Features

- **Analytical Methods (Lab and On-line)**
- **Underlying Science**
- **Independent Technology Reviews**
- **Emerging Technologies**
- **Process/Equipment Selection**
- **Costing Formulae**
- **Conceptual Design Criteria**
- **Key References**



EpSelon Process Manual Content

Vol 1. Management Issues & Legislation

Vol 2. Process Selection and Costing

Vol 3. Common Problem Areas

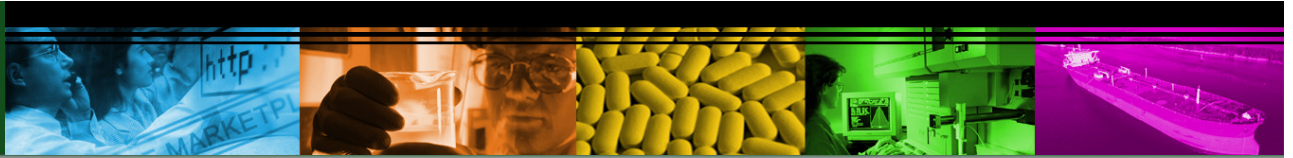
Vol 4. Biological Processes

Vol 5. Chemical Processes

Vol 6. Physical Processes

Vol 7. Gas cleaning

Vol 8. Land remediation



Problem- or Technology-Driven Content

PROBLEM	TECHNOLOGY	Mechanical	Precipitation/Floccon.	Biological Aerobic	Biological Anaerobic	Chemical Redox	Membrane	Adsorption & IX
Oil-Water Separation								
Heavy Metals								
Trace Organics								
Recalcitrant Organics								
Anions								
Saline Streams								
Sludge								



Browsing Interface

Browsing Buttons

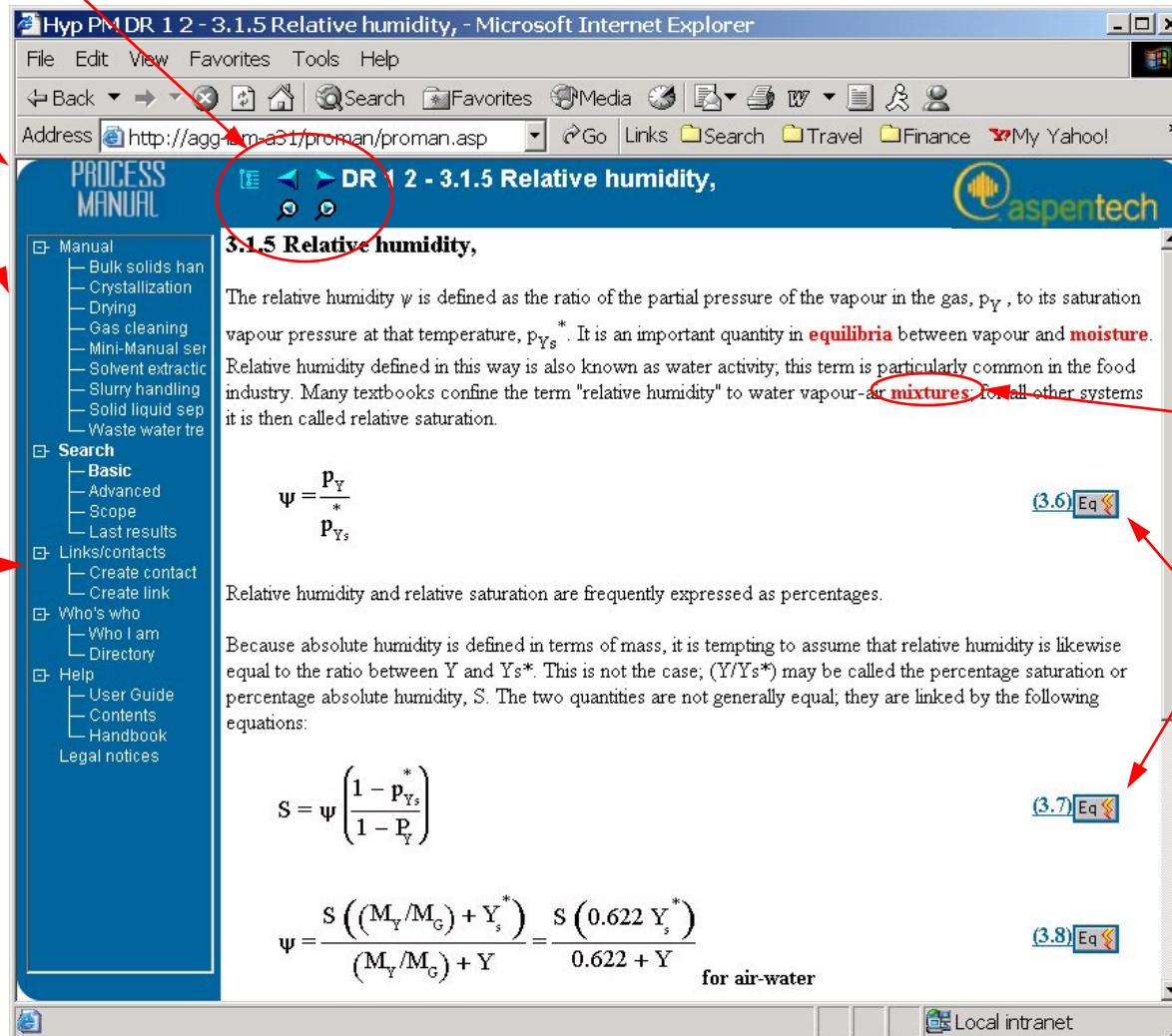
Title frames

Main menu

Content frame

Search hits

Links to live equations



3.1.5 Relative humidity,

The relative humidity ψ is defined as the ratio of the partial pressure of the vapour in the gas, p_Y , to its saturation vapour pressure at that temperature, $p_{Y_s}^*$. It is an important quantity in **equilibria** between vapour and **moisture**. Relative humidity defined in this way is also known as water activity; this term is particularly common in the food industry. Many textbooks confine the term "relative humidity" to water vapour-**air mixtures** for all other systems it is then called relative saturation.

$$\psi = \frac{p_Y}{p_{Y_s}^*} \quad (3.6) \text{ Eq}$$

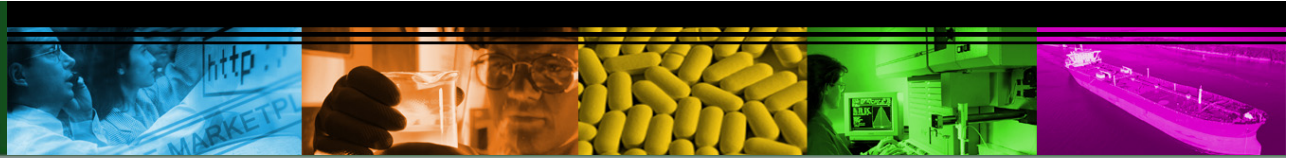
Relative humidity and relative saturation are frequently expressed as percentages.

Because absolute humidity is defined in terms of mass, it is tempting to assume that relative humidity is likewise equal to the ratio between Y and Y_s^* . This is not the case; (Y/Y_s^*) may be called the percentage saturation or percentage absolute humidity, S . The two quantities are not generally equal; they are linked by the following equations:

$$S = \psi \left(\frac{1 - p_{Y_s}^*}{1 - p_Y} \right) \quad (3.7) \text{ Eq}$$

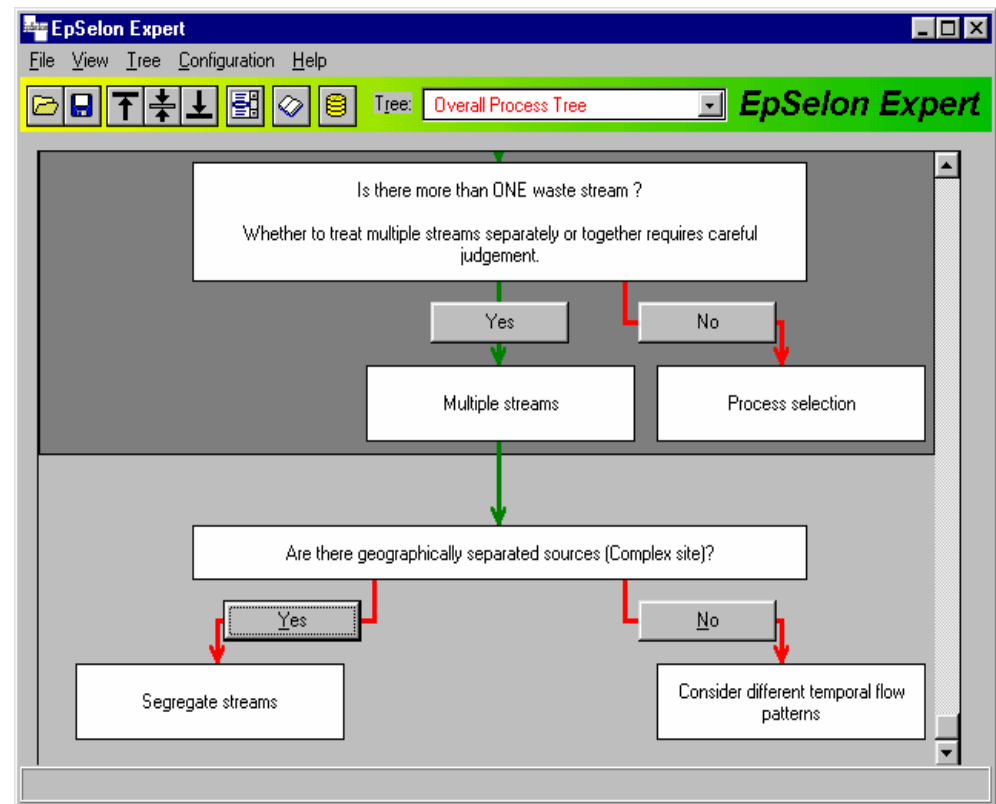
$$\psi = \frac{S \left((M_Y/M_G) + Y_s^* \right)}{(M_Y/M_G) + Y} = \frac{S (0.622 Y_s^*)}{0.622 + Y} \quad (3.8) \text{ Eq}$$

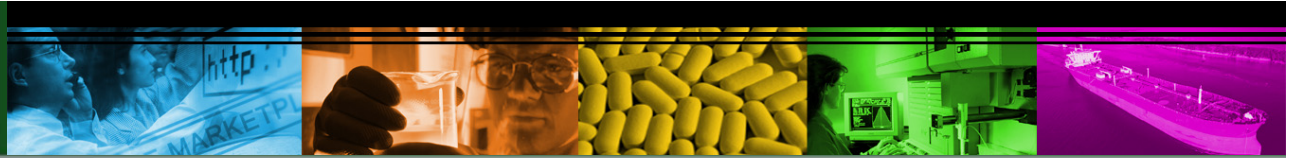
for air-water



EpSelon Expert – Evolution

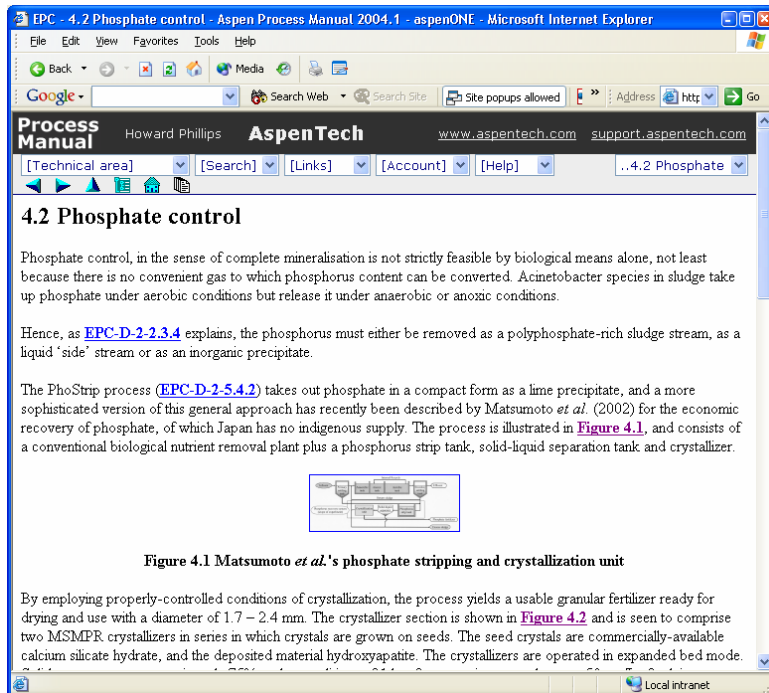
- Question-and-answer consultation
- Possible ideas suggested throughout consultation process
- Consultation tree shows decision path
- Links to detailed information in WWT Process Manual





EpSelon Delivery Platform

- Web based solution delivered via internet
- EpSelon knowledge base forms the Waste Water Treatment technical area of the Process Manual product
- EpSelon expert system is part of the Process Experts product



4.2 Phosphate control

Phosphate control, in the sense of complete mineralisation is not strictly feasible by biological means alone, not least because there is no convenient gas to which phosphorus content can be converted. *Acinetobacter* species in sludge take up phosphate under aerobic conditions but release it under anaerobic or anoxic conditions.

Hence, as [EPC-D-2-2.3.4](#) explains, the phosphorus must either be removed as a polyphosphate-rich sludge stream, as a liquid 'side' stream or as an inorganic precipitate.

The PhoStrip process ([EPC-D-2-5.4.2](#)) takes out phosphate in a compact form as a lime precipitate, and a more sophisticated version of this general approach has recently been described by Matsumoto *et al.* (2002) for the economic recovery of phosphate, of which Japan has no indigenous supply. The process is illustrated in [Figure 4.1](#), and consists of a conventional biological nutrient removal plant plus a phosphorus strip tank, solid-liquid separation tank and crystallizer.


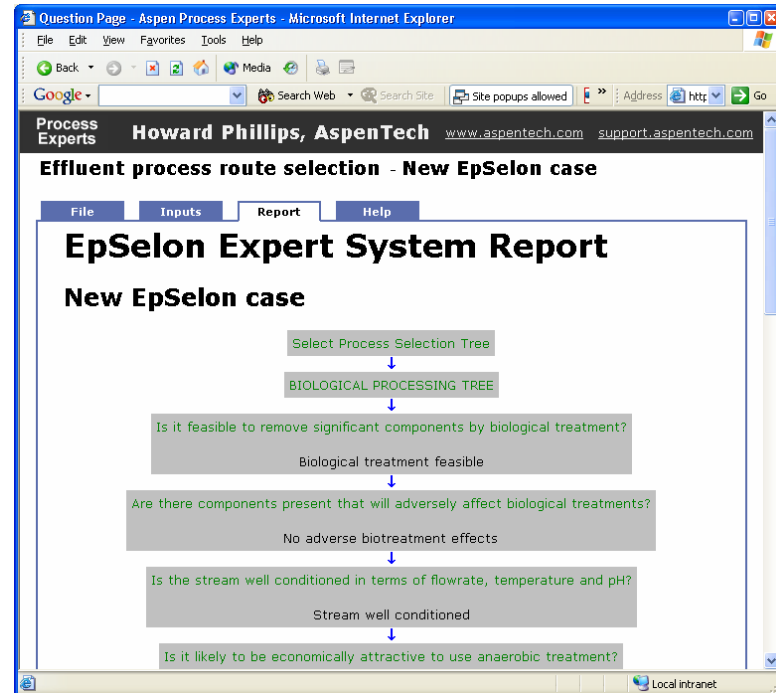


Figure 4.1 Matsumoto *et al.*'s phosphate stripping and crystallization unit

By employing properly-controlled conditions of crystallization, the process yields a usable granular fertilizer ready for drying and use with a diameter of 1.7 – 2.4 mm. The crystallizer section is shown in [Figure 4.2](#) and is seen to comprise two MSMPR crystallizers in series in which crystals are grown on seeds. The seed crystals are commercially-available calcium silicate hydrate, and the deposited material hydroxyapatite. The crystallizers are operated in expanded bed mode.

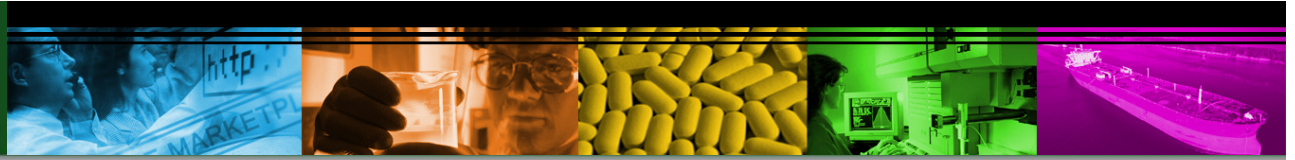


EpSelon Expert System Report

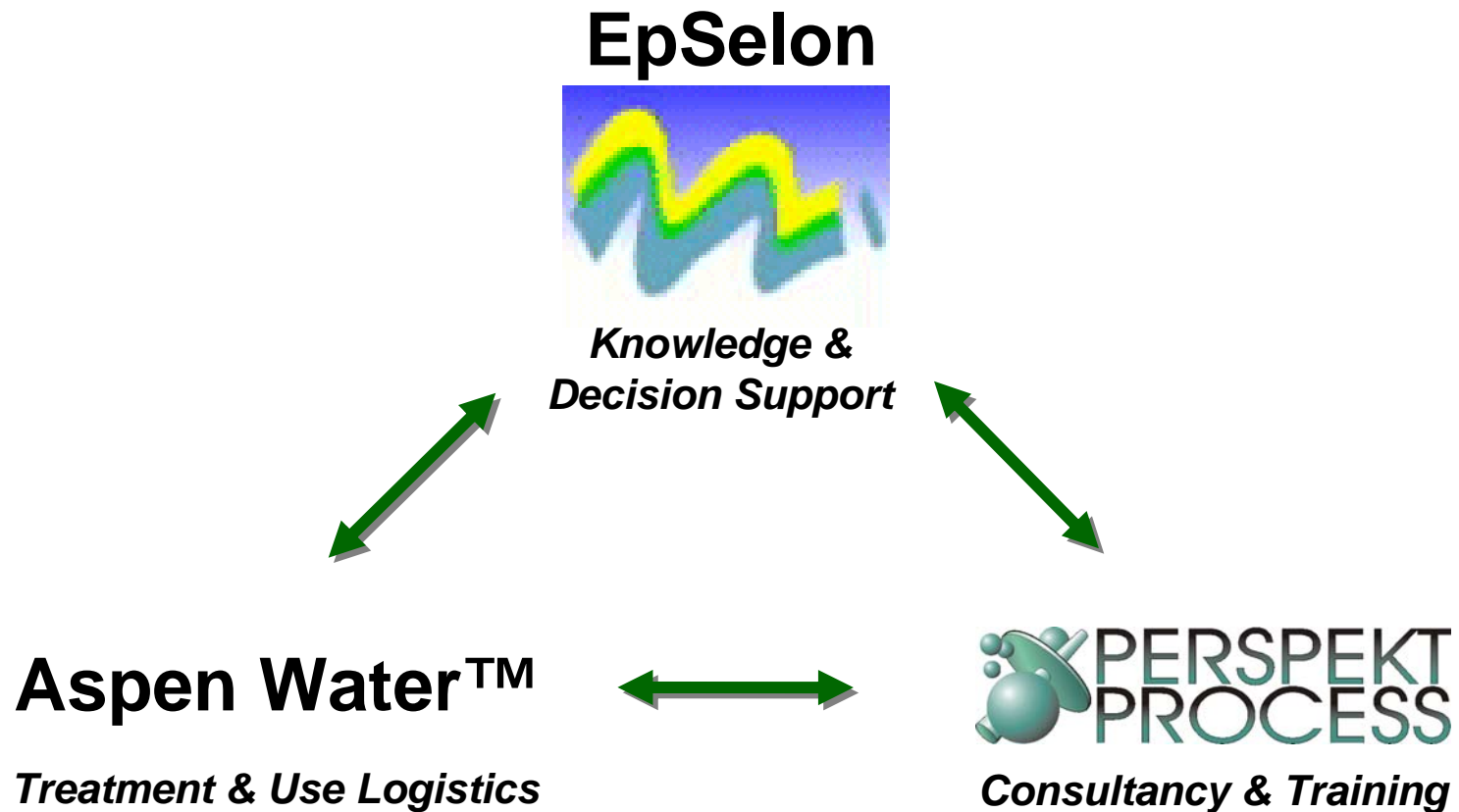
New EpSelon case

```

graph TD
    A[Select Process Selection Tree] --> B[BIOLOGICAL PROCESSING TREE]
    B --> C{Is it feasible to remove significant components by biological treatment?}
    C --> D[Biological treatment feasible]
    D --> E{Are there components present that will adversely affect biological treatments?}
    E --> F[No adverse biotreatment effects]
    F --> G{Is the stream well conditioned in terms of flowrate, temperature and pH?}
    G --> H[Stream well conditioned]
    H --> I{Is it likely to be economically attractive to use anaerobic treatment?}
  
```

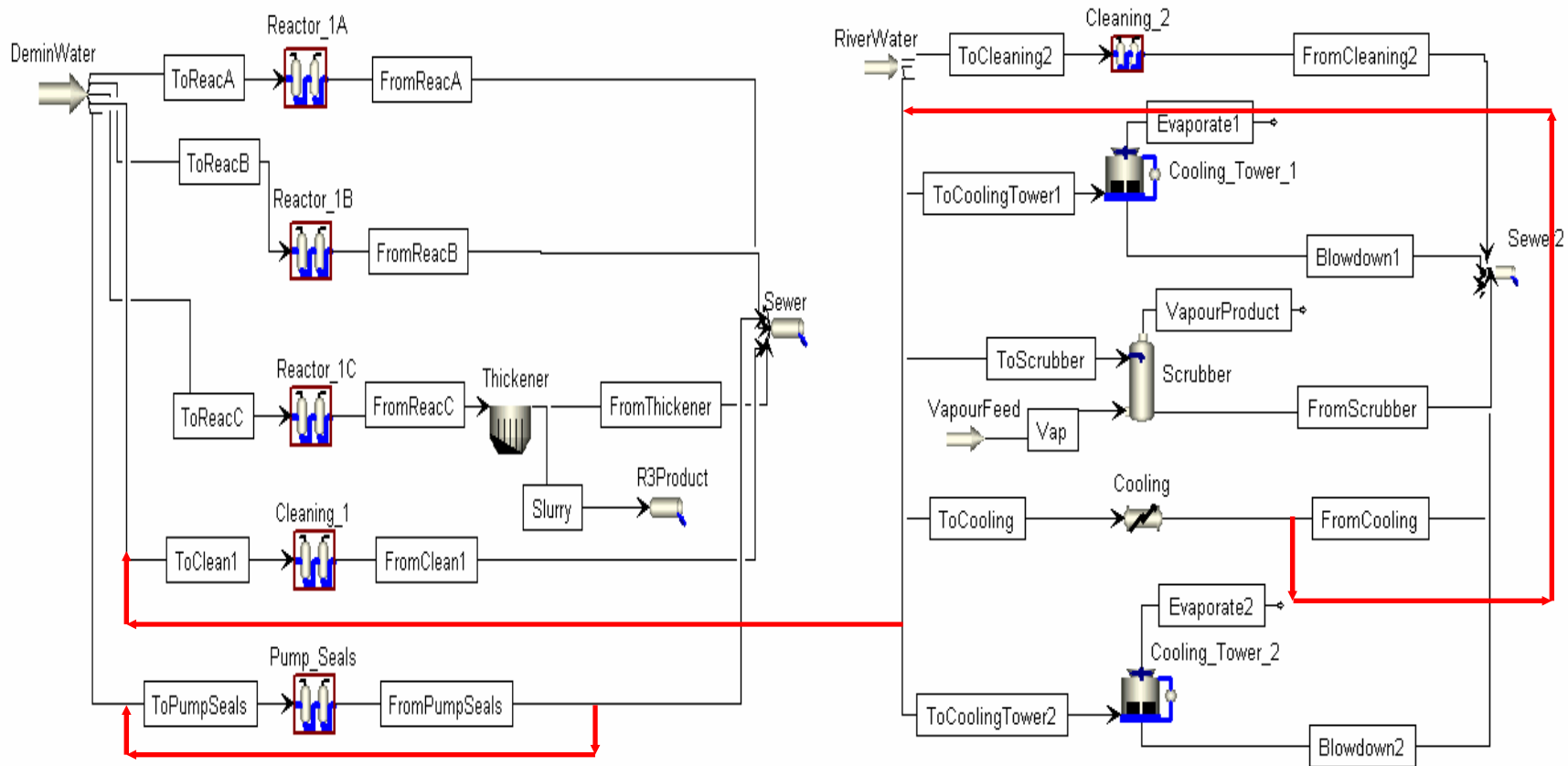


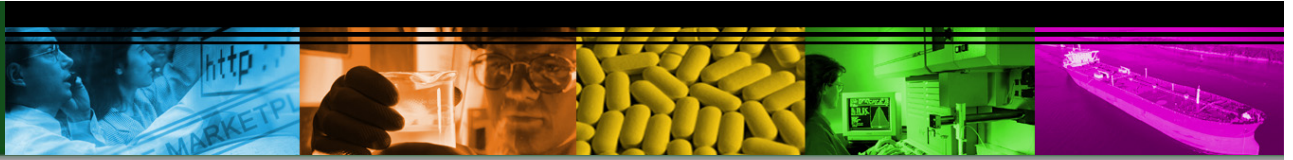
Complete Service





Aspen Water™ - Design Evolution





EpSelon and Perspekt Process



Process engineering plus associate mechanical engineer and chemist

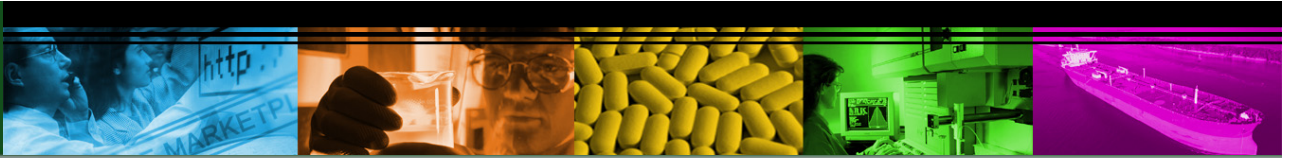
Independent consultancy in water treatment and separations

Long association with EpSelon product

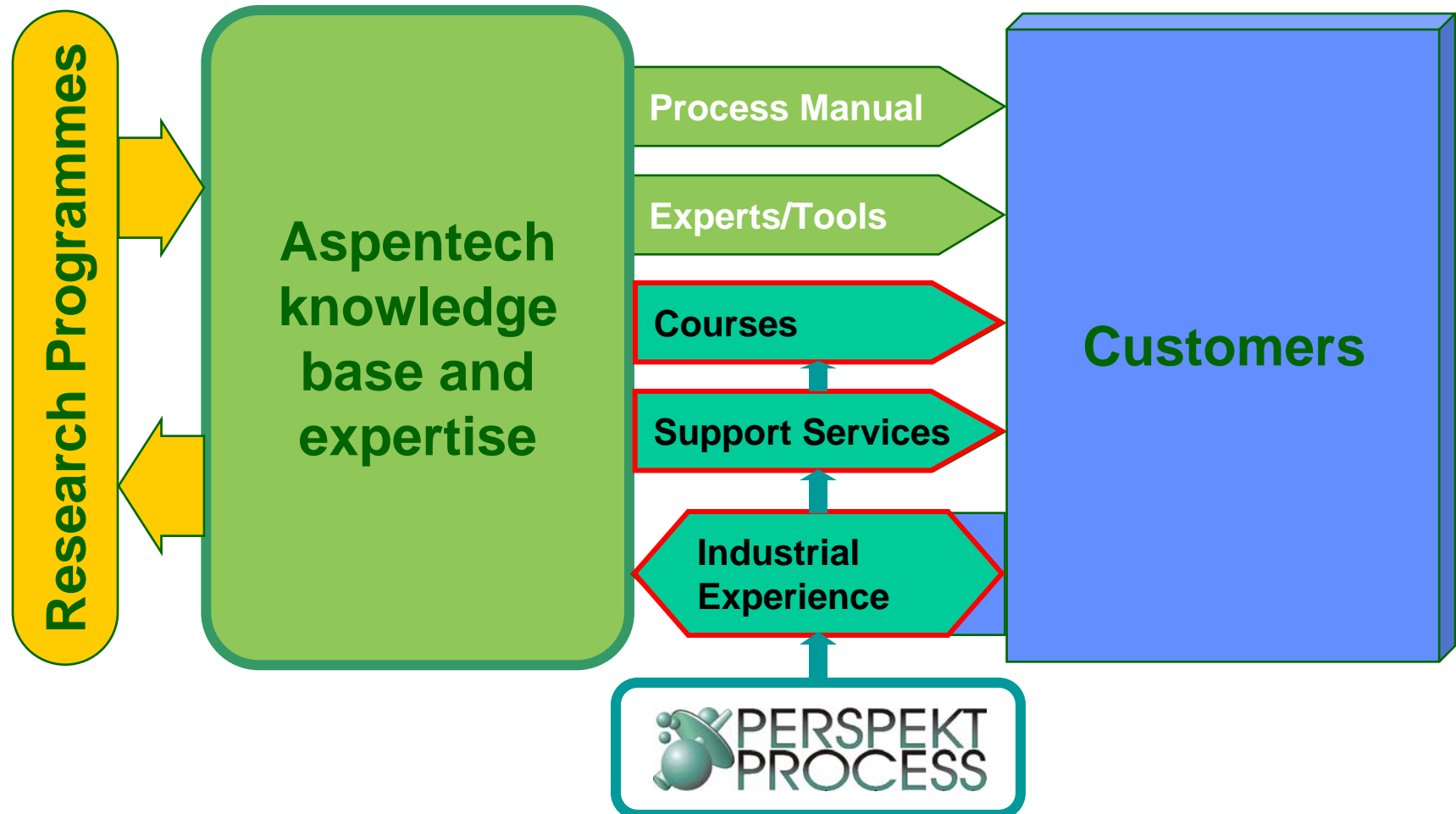
- **Consultant to Aspentech**
- **Contributor to WWT Manual**

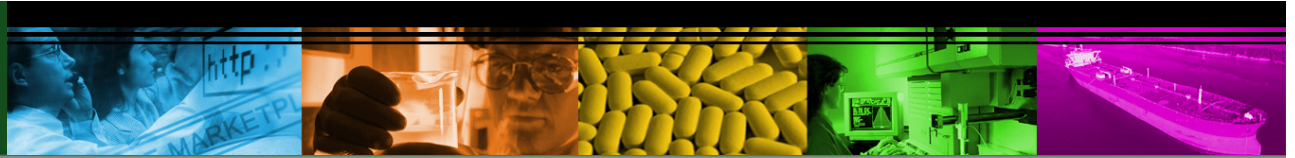
Offer:

- **Consultancy & troubleshooting**
- **Process and mechanical design**
- **Process and equipment critique and selection**
- **Short training courses**



The Development Cycle; Aspentech and Perspekt





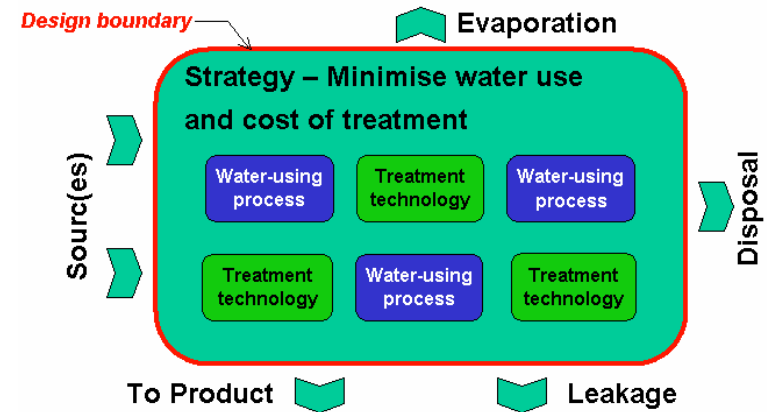
Short Course

Duration: 2-3 days

Content:

Water treatment process engineering:

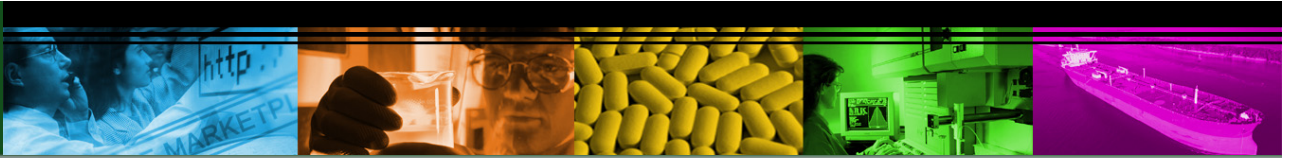
- Characterising & measuring contamination
- Objectives and strategy, especially for multiple contaminants
- Physical and mechanical processes
- Chemical processes
- Biological processes, aerobic and anaerobic
- Tertiary & polishing processes
- Recent improvements and hybrid processes
- Solid wastes disposal



Water use and treatment strategy:

- Process selection and integration
- Reuse, recycling and regeneration
- Using partially contaminated water
- Segregation vs. co-treatment
- Targetting & minimising water use for multiple processes
- Multiple contaminants; the place of software such as Aspen Water

The balance between engineering and strategy can be adjusted to suit customer



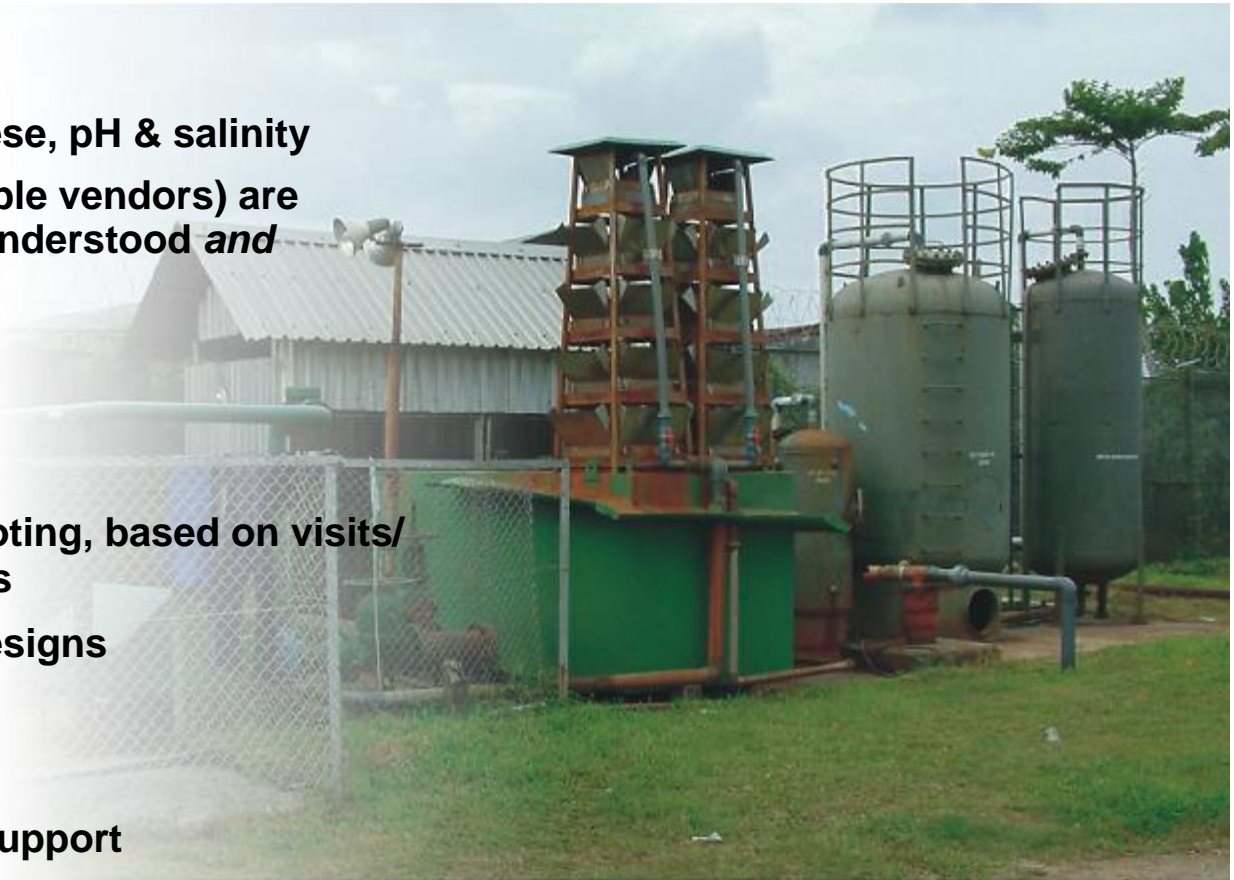
Consultancy Example: Treatment of Iron-Rich Drinking Water for Oil Major - Nigeria

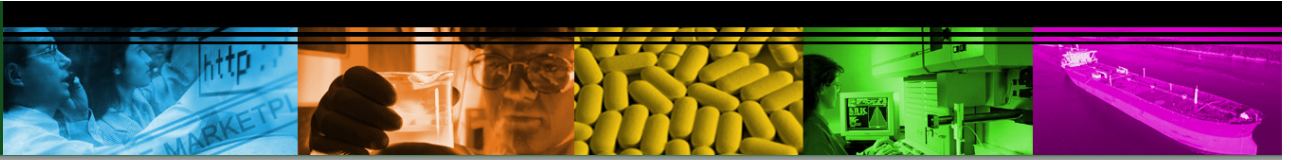
Challenge:

- 10+ sites; iron, manganese, pH & salinity
- Existing WTPs (by multiple vendors) are inadequate *and* poorly understood *and* poorly maintained

Perspekt Offering:

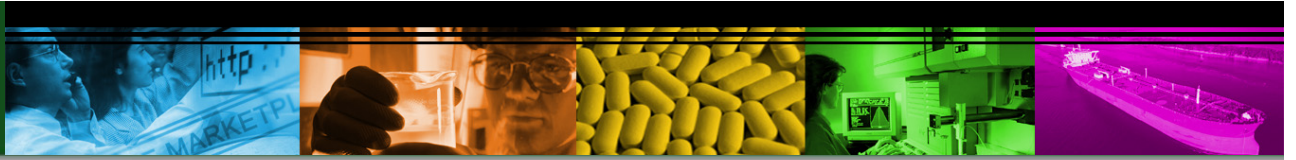
- Critique and troubleshooting, based on visits/ observation and analysis
- New conceptual plant designs
- Training of key staff
- Detailed design
- Vendor evaluation and support





Strengths of EpSelon

- **Draws on expertise of:**
 - **Specialists**
 - **Utilities**
 - **Industrialists**
 - **Vendors**
- **Strong on technology and cross-technology problem solving**
- **Regular updates**
- **Powerful, flexible web-based delivery**
- **Consultancy services and training available**



Further Information

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