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Hoplands te-cyc™ Process Description

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Proposal for Hoplands STW

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Te-Tech Process Solutions

Te-Tech Process Solutions Ltd is dedicated to the provision of advanced process technologies and conventional products and services for water and wastewater treatment.

Our in-house capability includes process, mechanical and electrical design, off-site manufacture and assembly, MCC & control panel design and manufacture, digital engineering, and real time control. Complimentary services include equipment service & maintenance and operational support.

Te-Tech Process Solutions are focused on efficient delivery through maximising off-site manufacture and assembly of our established water and wastewater treatment products and processes, including:

- **te-cyc™** – Cyclic Activated Sludge ‘Macroflocc’ biological wastewater treatment
- **te-ion™** – Advanced oxidation technology for water and wastewater treatment
- **te-mem™** – Advanced UF Membrane Filtration
- **te-mbr™** – Package UF Membrane Filtration
- **te-ro™** – Package High Efficiency Reverse Osmosis Membrane Filtration
- **te-uv™** – Package UV treatment
- **te-saf™** – Packaged Submerged Aerated Filters
- **te-sewpas™** – Airlift Sludge Removal Plant
- **Createch³⁶⁰** – Real Time Control and Plant Optimisation
- **Automation, Control & Technology** – MCCs, LV Switchboards, Local Control Panels, software System Integration

Our Heritage

Te-Tech Process Solutions Ltd is a Trant Engineering Ltd group company. Trant Engineering is one of the leading, privately owned engineering companies in the UK, established over 60 years and now employing over 1000 people with a turnover approaching £200M. We are a truly multi-disciplinary company delivering a range of complex projects in the Energy, Process & Water, Defence, Oil & Gas and Nuclear Sectors in the UK and Internationally with clients such as National Grid, Exxon Mobil, BP, Shell UK, Wessex Water, Severn Trent Water, Southern Water, Thames Water, and the Ministry of Defence.

Trant Engineering provide a full range of multi-discipline engineering services including upfront design, procurement, manufacture and assembly, installation, project delivery and commissioning.

Advanced technology and innovation are at the core of the overall business to ensure delivery of high quality, efficient solutions to our clients.

Contents

1. Process Description	4
1.1 Biological Selector Zone.....	5
1.2 OUR Control	5
1.3 Decanter	6
1.4 te-cyc™ Process Cycles.....	6
1.5 Operational Simplicity of the te-cyc™ Process.....	8
1.6 Advantages of the te-cyc™ Process	8
1.7 Operation & Maintenance.....	10
1.8 Carbon Reduction	10
Appendix A – References.....	13

1. PROCESS DESCRIPTION

The **te-cyc™** System is the most advanced SBR system worldwide using cyclic activated sludge technology to treat wastewater. **te-cyc™** is a sequencing batch reactor technology combining all treatment steps including treatment of wastewater as well as settling of sludge in one basin.



The main difference of **te-cyc™** to other SBR systems is a biological **SELECTOR** on the front end of the reactor with sludge recycling from the main aeration part to suppress bulking sludge. It also allows for co-current nitrification/denitrification in the aerated part of the tank and enhanced biological phosphorus removal.

The second key advantage compared to conventional SBR systems is the **OUR** (Oxygen Uptake Rate) control system to regulate aeration intensity according to the actual demands (flow and loads) of the process.

The third main feature is an advanced high-rate motor driven **DECANTER** to withdraw solid free and scum free treated effluent from the basins.

The combined features of the **te-cyc™** technology provide unique process advantages compared to conventional technologies, including:

- Single stage treatment with no requirement for separate primary or final settlement stages.
- Small footprint, typically 50% less than many alternative solutions.
- Significant energy savings compared to conventional SBRs or AS plants enhanced by the OUR process control system.
- Reduced chemical consumption.
- Capital cost savings.
- Simultaneous nitrification / denitrification.
- Biological Phosphorous removal.
- Simple, low maintenance operation.
- Available in standard package and modular off-site manufactured units.
- Versatile and resilient to flow and load fluctuations.



Compact



Cost Effective



Innovative



Resilient



DfMA



Sustainable



Flexible

1.1 Biological Selector Zone

The incorporation of a biological **Selector** within the **te-cyc™** process distinguishes it from all other technologies. The incorporation of this process feature removes the need for an anoxic mixing sequence. The biological **Selector** simplifies the operation of the process and ensures the biological selection of predominantly flock-forming micro-organisms.

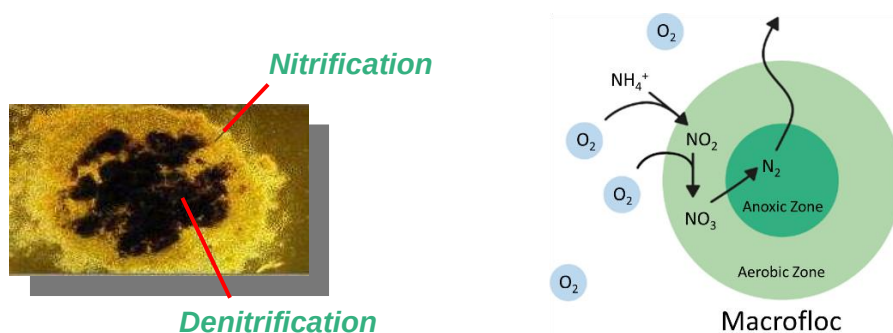
The biological **Selector** operates under essentially anoxic to anaerobic reaction conditions, the readily degradable soluble organic fraction of the wastewater (COD and BOD) is rapidly removed by enzymatic transfer mechanisms of the bacteria.

High sludge loading in the **Selector** suppresses the growth of filamentous bacteria, primarily because the filamentous bacteria have a larger specific surface than the flock forming bacteria. Consequently, filamentous bacteria grow better than the flock forming bacteria under low food supply (F/M ratio or sludge loading). The selector generates high food supply for the bacteria; hence the advantage of the filamentous bacteria is lost and the flock forming bacteria grow better than the filamentous bacteria. Typical SVI values of the **te-cyc™** process are below 100 ml/g, with experience at some reference plants at 50 ml/g.

These conditions enable the creation of ‘**macroflocs**’, which due to their size, create an internal gradient with respect to aerobic and anoxic / aerobic environments.

The flock forming bacteria allow for co-current nitrification/denitrification in the aerated part of the **te-cyc™** basin. Nitrification takes place on the surface of the flock; denitrification occurs inside the flock. Therefore, no mixers or additional cycles for denitrification are required, which simplifies the process.

The combination of anaerobic **Selector** and aerobic conditions (the aerated part of the **te-cyc™** reactor) increases the growth of phosphorus-accumulating organisms (PAOs). These bacteria can take up more phosphorus, enabling “enhanced biological phosphorus uptake” (bio-P).



1.2 OUR Control

The **OUR** (Oxygen Uptake Rate) process control uses dissolved oxygen measurement to provide process oxygen supply according to flow and load. In this way, the oxygen demand of the biomass is measured within the actual process basin and is subsequently used as a control parameter to automatically regulate the duration of the aeration cycle and the rate of aeration.

Process oxygen requirements in a facility can be easily measured by this oxygen uptake rate of the biomass. This methodology provides a true in-basin method for the efficient use of energy providing significant energy cost savings over alternative process solutions.

1.3 Decanter

In the decant phase, the mechanically driven decant weir moves from the top water level to the bottom water level to remove approximately one third of the reactor volume which will be clear treated effluent. The decant weir also features a scum guard which prevent floating solids from discharging into the treated effluent. At the end of the decant phase, the decant weir is returned to its parking position. Towards the end of the decant phase, a portion of the settled surplus sludge at the base of the reactor is discharged. The rate at which the decant weir is lowered and, hence, the rate of treated wastewater discharge, can be varied during the decant phase.

1.4 **te-cyc™** Process Cycles

The **te-cyc™** process specifically refers to the use of variable volume treatment in combination with a biological **Selector** and **OUR** process control. The following process sequences are part of the technology:

1.4.1 FILL - AERATION Cycle

Aeration is the period when the process air is switched on with influent in the basin. The aeration mode can be adapted individually in the SCADA system according to the actual requirements based on flow and load variations. During the fill/aeration cycle the water level inside the basin increases from bottom water level to top water level according to actual flow. Less than design load operation typically requires the adaptation of the duration and the intensity of the aeration cycle by means of the **OUR** process control. During the fill-aeration cycle return sludge from the aeration zone is recirculated into the biological **Selector**.



Fill / Aerate

1.4.2 SETTLEMENT Cycle

The settling cycle starts after the fill / aeration cycle to separate the sludge from the liquid. The inflow, aeration and RAS pumps are stopped to prevent turbulence in the basin which would be detrimental to the effective settlement of solids. The sludge mass forms a sludge blanket, in which the activated sludge **macrofloc** particles adhere and the mass settles within the confines of the blanket leaving a top layer of clear supernatant. The settled sludge layer has a mean biomass concentration of around 10 g/l in typical municipal wastewater applications.



Settle

1.4.3 DECANTING Cycle

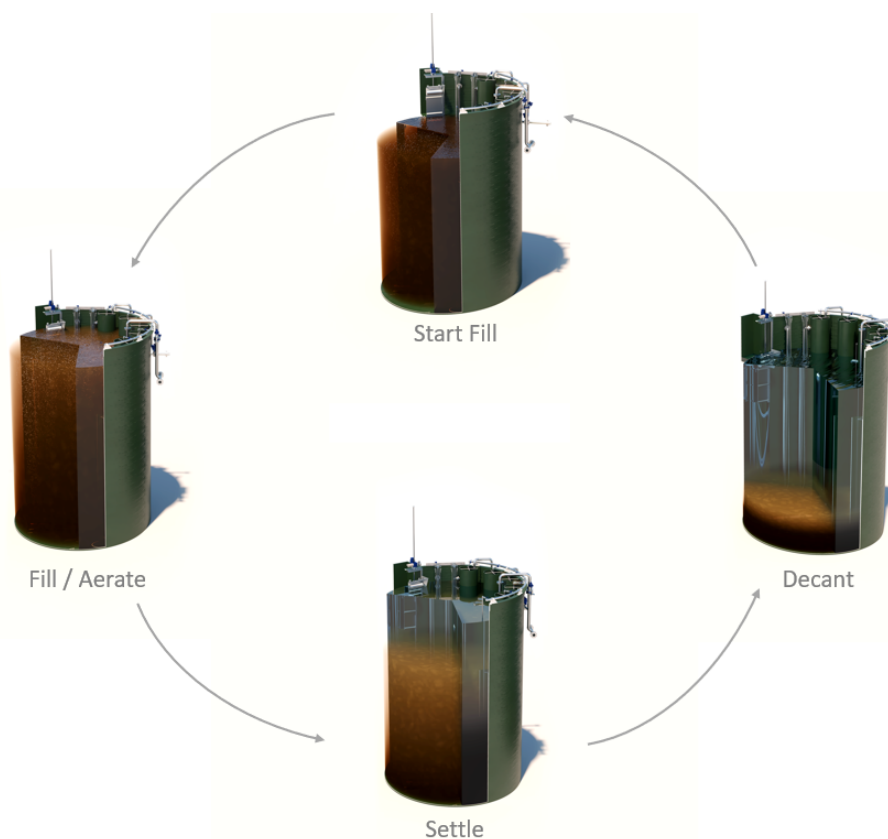
During decanting there is no inflow to the basin. Just before the end of the settling cycle the **Decanter** travels slowly from its parking position to the top water level and rests there until the decanting cycle starts. In the pre-set cycle time, the **Decanter** withdraws the supernatant from top water level to bottom water level, then it returns to its parking position by reversal of the drive. Surplus sludge is discharged from the **te-cyc™** basin towards the end of the decanting phase.



Decant

All the phases detailed above in sequence constitute one overall cycle, which is then repeated. A timetable for a typical 3-basin design is illustrated below, demonstrating a continuous influent and effluent flow.

Time (h)	1.33	1.67	2.66	4
Time (mins)	80	100	160	240
Basin 1	Fill/Aerate	Aerate	Settle	Decant
Basin 2	Aerate	Settle	Decant	Fill/Aerate
Basin 3	Decant	Fill/Aerate	Aerate	Settle



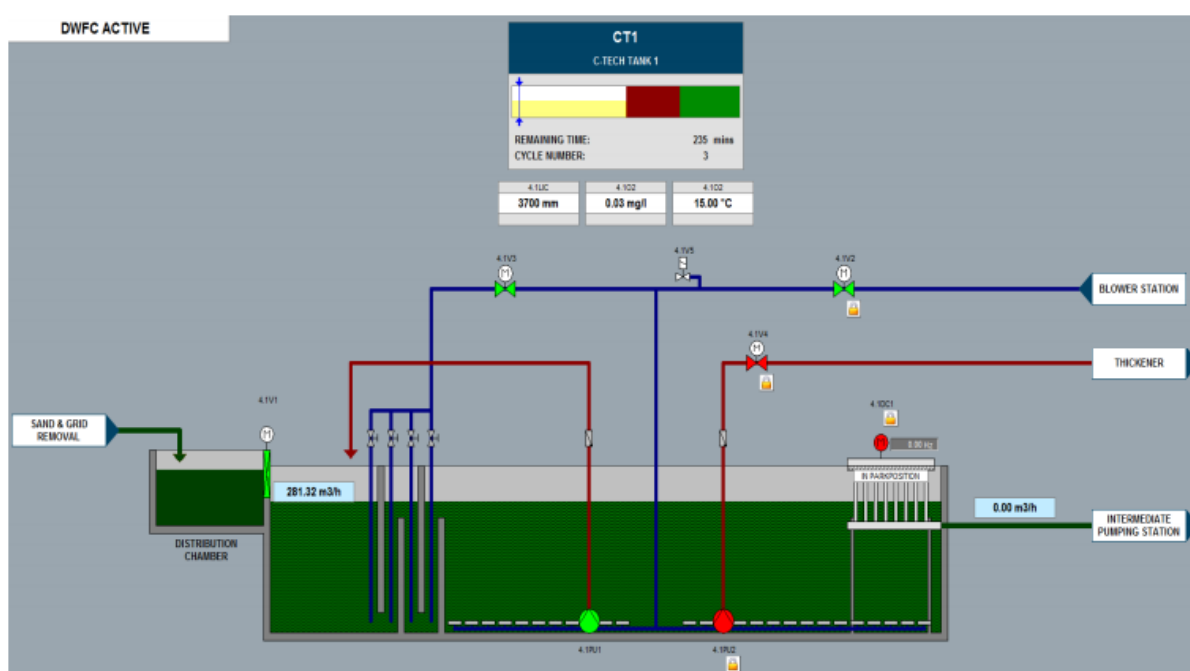
1.5 Operational Simplicity of the te-cyc™ Process

Plant control is fully automated, the entire equipment of the **te-cyc™** basins like decanters, pumps, valves, blowers etc. as well as the cycles are controlled by the PLC.

The cycle time functions of each basin are displayed on a monitor in the control room. Duration and intensity of the aeration are regulated by the **OUR** process control system via the same PLC. This means that optimum operation and performance are synonymous.

Varying loads and flows within a day can be handled via the PLC and therefore the system always works in an economic mode.

There are only a limited number of components and variables to be controlled by the PLC, the SCADA image below illustrates the simplicity of the **te-cyc™** control system.



1.6 Advantages of the te-cyc™ Process

1.6.1 Specific design advantages of te-cyc™ over other biological solutions

- **te-cyc™** tanks are simpler to construct than a combination of primary settling tanks, biological tanks and final settling tanks and will typically generate a 50% saving on footprint and civil construction costs.
- The **te-cyc™** operation itself favours the suppression of filamentous bacteria. In addition, the biological selector is particularly effective for suppressing any kind of filamentous microorganisms.
- **te-cyc™** provides simultaneous nitrification and denitrification, providing enhanced performance and resilience against future tightening discharge consents.
- The mechanical equipment in the system is reduced to a minimum.
- There are no exposed sludge collection and pumping stations, no separated re-cycle stations, no complicated collection and distribution channels and networks nor any mixers

1.6.2 Advantages over conventional SBR systems

In comparison to other conventional SBR (sequencing batch reactor) processes, the use of the **te-cyc™** process offers significant economies in capital cost, operation and maintenance costs and land area requirements. Its main advantages include:

- Effective oxygen demand/supply operational control delivered by the **OUR** process control system, in combination with the **Selector** design, achieves simultaneous nitrification and denitrification without the need for dedicated mixing tanks or equipment.
- The **OUR** process control reduces the aeration time during night-time automatically to accommodate reductions in flow and load during the night. This increases the lifetime of blowers and diffusers and reduces the energy demand.
- A clear water withdrawal system for high-rate decanting allows drawing off up to 2.5 m of solids free effluent without complex valving arrangements.
- “Dry Weather Flow” and “Wet Weather Flow” operating protocols are standard features, whereas conventional SBR systems typically have only one cycle with confusing adjustment possibilities for the operator.
- The SCADA makes provision for maintenance cycle settings.
- The **te-cyc™** does not require buffering capacity or equalization tanks.
- The incorporation of the selector in the **te-cyc™** design promotes enhanced biological P removal.
- Conventional SBR systems do not have an anaerobic selector. Hence, filamentous sludge bulking in conventional SBR systems can be a problem, which can typically only be avoided with additional equipment like equalization tanks and pumps.
- There are extensive **te-cyc™** reference plants ranging in capacity from small package plants and rural plants to large scale plants for major towns and cities.

1.6.3 Advantages over Conventional Activated Sludge Systems

In addition to the specific advantages detailed in 6.6.1, compared to conventional activated sludge systems **te-cyc™** has the following advantages:

- **te-cyc™** has variable volumes for biological treatment and sedimentation. It provides flexibility and resilience to accommodate variations in design flows or loadings and avoids sludge bulking.
- **te-cyc™** operates utilising the **OUR** process control, the design incorporates the measurement of the actual biological activity of the microorganisms. This results in reduced operation costs, increased treatment efficiency, and precise aeration of the activated sludge.
- **te-cyc™** is not sensitive to peak flows and loadings because the cycle times of **te-cyc™** can be adapted to flows and loads. Hence, peak flows have no influence on the performance of the **te-cyc™** system.
- Each **te-cyc™** basin has its own recirculation pump, which pumps the sludge back into the **Selector**. Therefore, high initial F/M loadings are achieved, and sludge bulking can be avoided.
- **te-cyc™** needs only little electro-mechanical equipment due to the **Selector** and simultaneous nitrification and denitrification. Hence, the whole **te-cyc™** process is simpler and therefore has low maintenance, repair, and replacement costs.
- **te-cyc™** detects toxicity at the beginning of the cycle and in such case does not allow other basins to be filled.
- There is no requirement for sedimentation tanks, hence no risk of sludge wash out or carry over.
- There is no requirement for a separate anoxic zone with mixers.

1.7 Operation & Maintenance

The **te-cyc™** process is a straightforward to operate, robust, and resilient process requiring only routine visual inspection and minimal operator training, intervention, and maintenance. The **te-cyc™** process is controlled by timers with standard DO and level instruments for aeration and decanter control only. The control system is managed and operated by your own plant operatives and does not require any external remote monitoring or licence agreement. The **te-cyc™** control system does however contain an optimisation feature, the Oxygen Uptake Rate (OUR) control mode to optimise blower control and reduce operational cost, initiated as a standard control feature by your own operator.

Routine operation activities are very similar to standard or conventional Activated Sludge processes typically including general process checks such as visual checks on aeration distribution, selector flow and checking for scum build up. Routine checks and maintenance such as cleaning of the level and DO probes, air blower checks, calibration and greasing activities can be carried out during and without interruption to normal operation.

Long term planned maintenance activities every 5 years include general servicing of air blowers, servicing of RAS and SAS pumps and decanter motors which again can generally be performed without interruption to normal operation. Significant planned maintenance such as replacement of fine bubble diffusers every 7 to 10 years would require access to the basins (unless retrievable diffuser assemblies are installed) but this would be done on individual basins whilst maintaining operation through the remaining basins.

1.8 Carbon Reduction

The **te-cyc™** process provides a positive contribution towards net zero and carbon reduction commitments in the following key areas.

1.8.1 Biological Wastewater Treatment

te-cyc™ is an enhanced biological nutrient removal process with the associated benefits of significantly reduced or zero demand for chemicals and associated carbon footprint for the supply, transportation, and storage.

1.8.2 Process Control

As previously described the **OUR** (Oxygen Uptake Rate) process control automatically regulates the duration of the aeration cycle and the rate of aeration.

This **OUR** process control provides a true in-basin method for the efficient use of energy providing significant carbon and energy cost savings.

1.8.3 DfMA

The modular and package **te-cyc™** arrangements minimise the embodied carbon of the treatment assets and reduce on site construction activities and durations.

1.8.4 N₂O Emissions

Nitrous oxide N₂O is approximately 300 times more potent than Carbon Dioxide at heating the atmosphere and has an atmospheric lifetime of typically 110 years.

The process that removes nitrous oxide from the atmosphere also depletes ozone. So nitrous oxide is not only a greenhouse gas, but also an ozone destroyer.

Whilst agriculture may be the most significant contributor to N₂O emissions,

unfortunately there are also always N₂O emissions in biological wastewater treatment. The level of emissions do however vary between different treatment technologies and can therefore be mitigated.

The **te-cyc™** process generates much lower N₂O emissions through the following design features:

- Long anaerobic retention time in the **te-cyc™** selector of over one hour help ensure that the remaining N₂O and nitrate in the return sludge is consumed to ensure that less N₂O is released to atmosphere in the main aeration zone.
- In the **te-cyc™** process the denitrification is almost complete, consequently most of N₂O produced in the main aeration zone is also consumed within the main aeration zone.
- Over and under aeration will promote N₂O, the **OUR** process control however ensures that this risk is mitigated.
- Shock loads of NH₄ may also have a detrimental impact on N₂O generation, the **te-cyc™** process however eliminates this risk.

Appendices



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APPENDIX A – REFERENCES

The **te-cyc™** process has been proposed for Broadholme WRC based upon proven performance as an effective biological treatment and nutrient removal process.

The **te-cyc™** process is well established with over 500 references worldwide in several different applications on municipal and industrial wastewaters, including well established references in the UK and schemes currently under construction to address growth drivers and Phosphorus removal.

We have summarised below examples of established reference plants where long-term performance data can be provided to demonstrate effective and consistent process performance for solids, N and P removal.

Additional references and long-term performance data can be provided, along with reference plant site visits as required.

The following sections contain summaries of the reference performance data for various operational sites. For the full performance data set, please refer to the spreadsheets attached to this proposal.

Grossarl – Austria



Population Equivalent – 18,000 PE

Flow – 3,440 m³ / Day

Reactor Volume – 5,200 m³

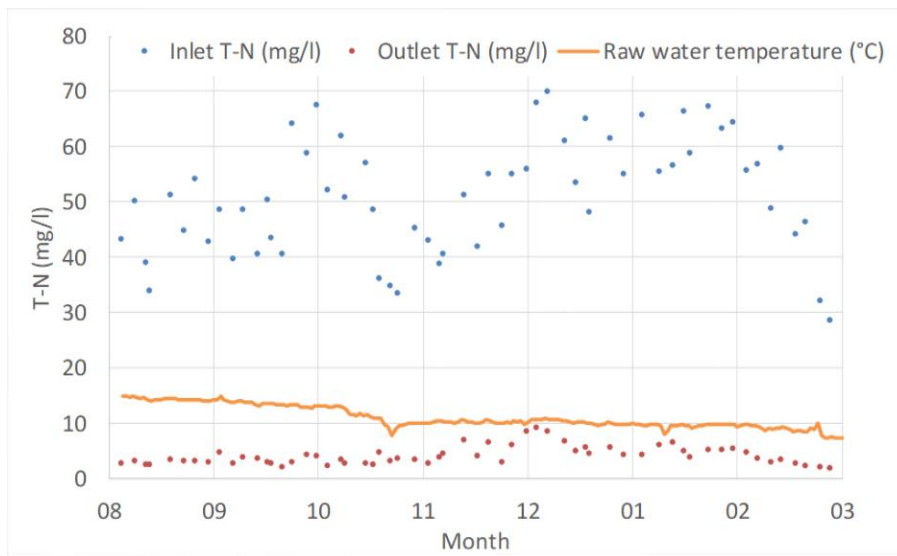
Completion – 2005

TN Removal Efficiency – 91.9%

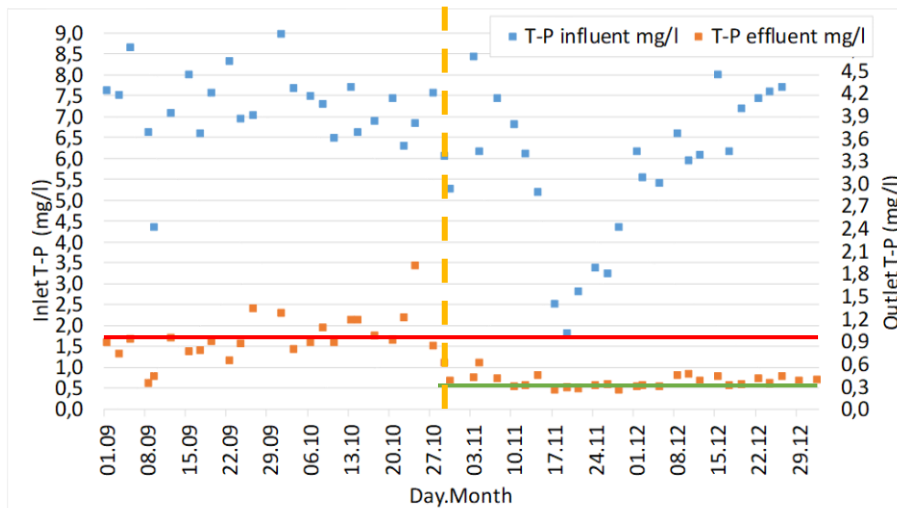
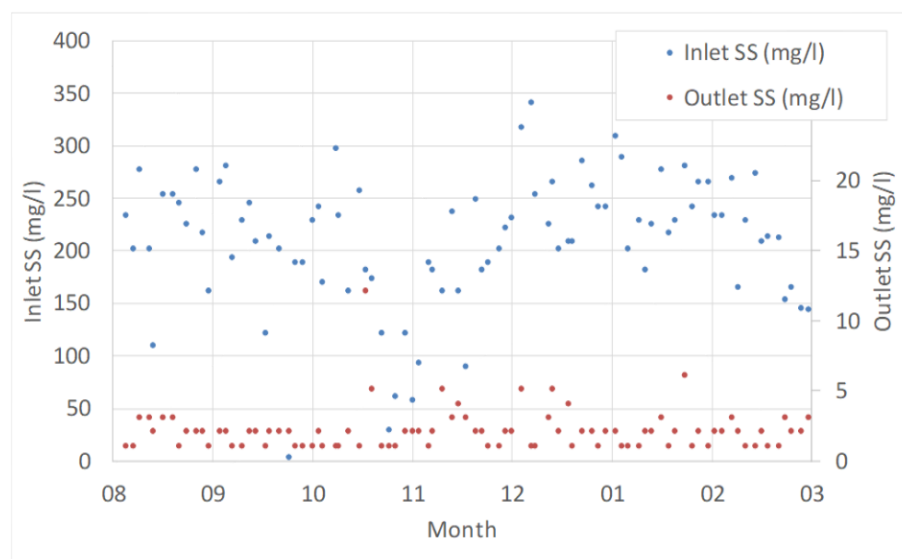
**TP Average Discharge – 0.3mg/l
(With chemical dosing)**

Performance Data Summary

		Influent	Effluent	Removal %
Temperature	°C	7 - 18		
BOD5	mg/l	321,8	7,3	97,7%
COD	mg/l	593,9	27,6	95,4%
SS	mg/l	206	2,0	99,0%
N-NH4	mg/l	27,3	1,1	96,1%
Ntotal	mg/l	50,4	4,1	91,9%
Ptotal	mg/l	7,1	0,7	89,6%



Simultaneous N/DN

TP 1.0 mg/l (annual average)
TP 0.3 mg/l with chemical dosing

Solids

Znojmo – Czech Republic

Population Equivalent – 130,000 PE

Average Flow – 21,500 m³ / Day

Reactor Volume – 34,160 m³

Completion – 2000

TN Removal Efficiency – 92.4%

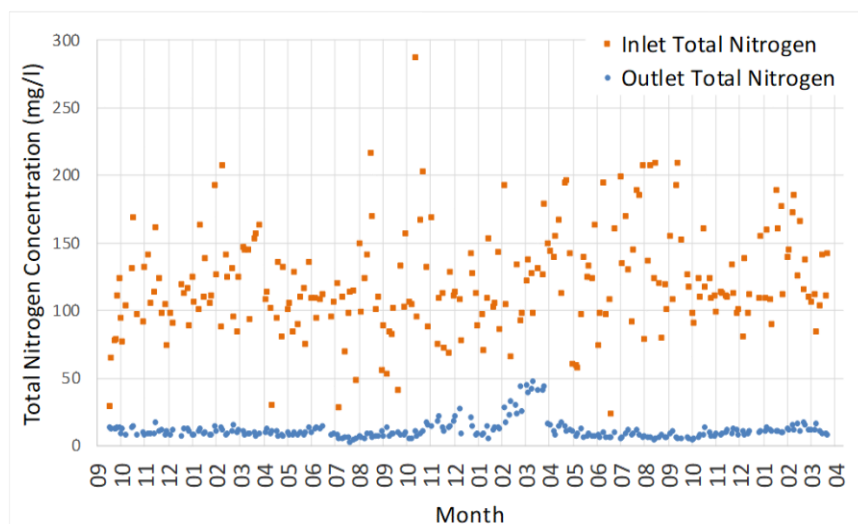
TP Average Discharge – 0.59mg/l
(Without chemical dosing)

TP Removal Efficiency – 96.7%

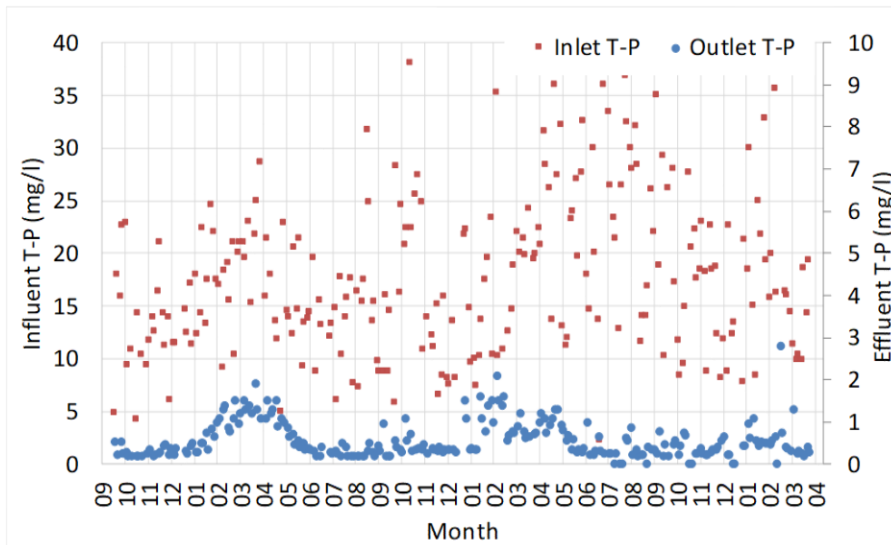


Performance Data Summary

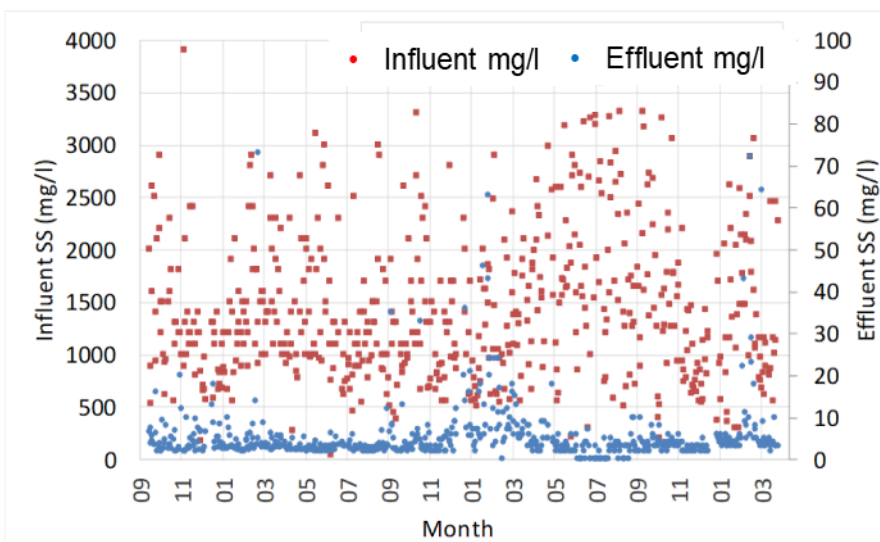
		Influent	Effluent	Removal %
Temperature	°C	7 - 22		
BOD5	mg/l	743	4,00	99,5%
COD	mg/l	1856	36,9	98,0%
N-NH4	mg/l	54,2	1,94	96,4%
N-NO2	mg/l	0,278	0,5	
N-NO3	mg/l	1,285	4,97	
Ntotal	mg/l	119,2	9,1	92,4%
Ptotal	mg/l	17,7	0,59	96,7%



Simultaneous N/DN



TP 1.0 mg/l (annual average)



Solids

Neubrandenburg – Germany



Population Equivalent – 140,000 PE

Average Flow – 21,000 m³ / Day

Reactor Volume – 30,000 m³

Completion – 1998

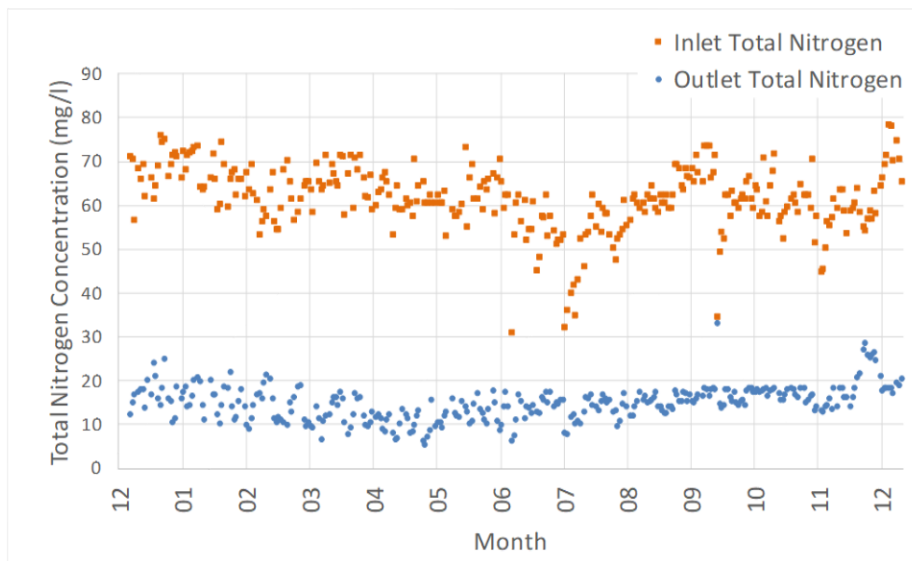
TN Removal Efficiency – 76.3%

TP Average Discharge – 0.32mg/l

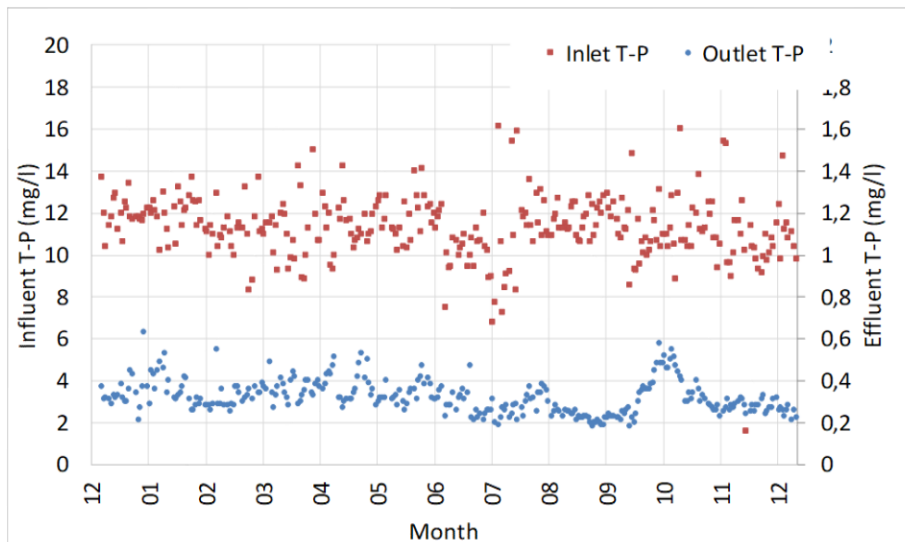
TP Removal Efficiency – 97.2%

Performance Data Summary

		Influent	Effluent	Removal %
Temperature	°C	10 - 20		
BOD5	mg/l	344	3,51	99,0%
COD	mg/l	939	29,2	96,9%
NH4-N	mg/l	61,0	2,81	95,4%
NO3-N	mg/l	0,385	11,5	
NO2-N	mg/l	0,038	0,22	
T-N	mg/l	61,3	14,6	76,3%
T-P	mg/l	11,7	0,32	97,2%



Simultaneous N/DN



TP 0.4 mg/l (annual average)

Hawkhurst WwTW – UK

Client – Southern Water

Population Equivalent – 2,285 PE

Average Flow – 504 m³ / Day

Reactor Volume – 966 m³

In Construction

TN Design Discharge – ≤ 6.0 mg/l

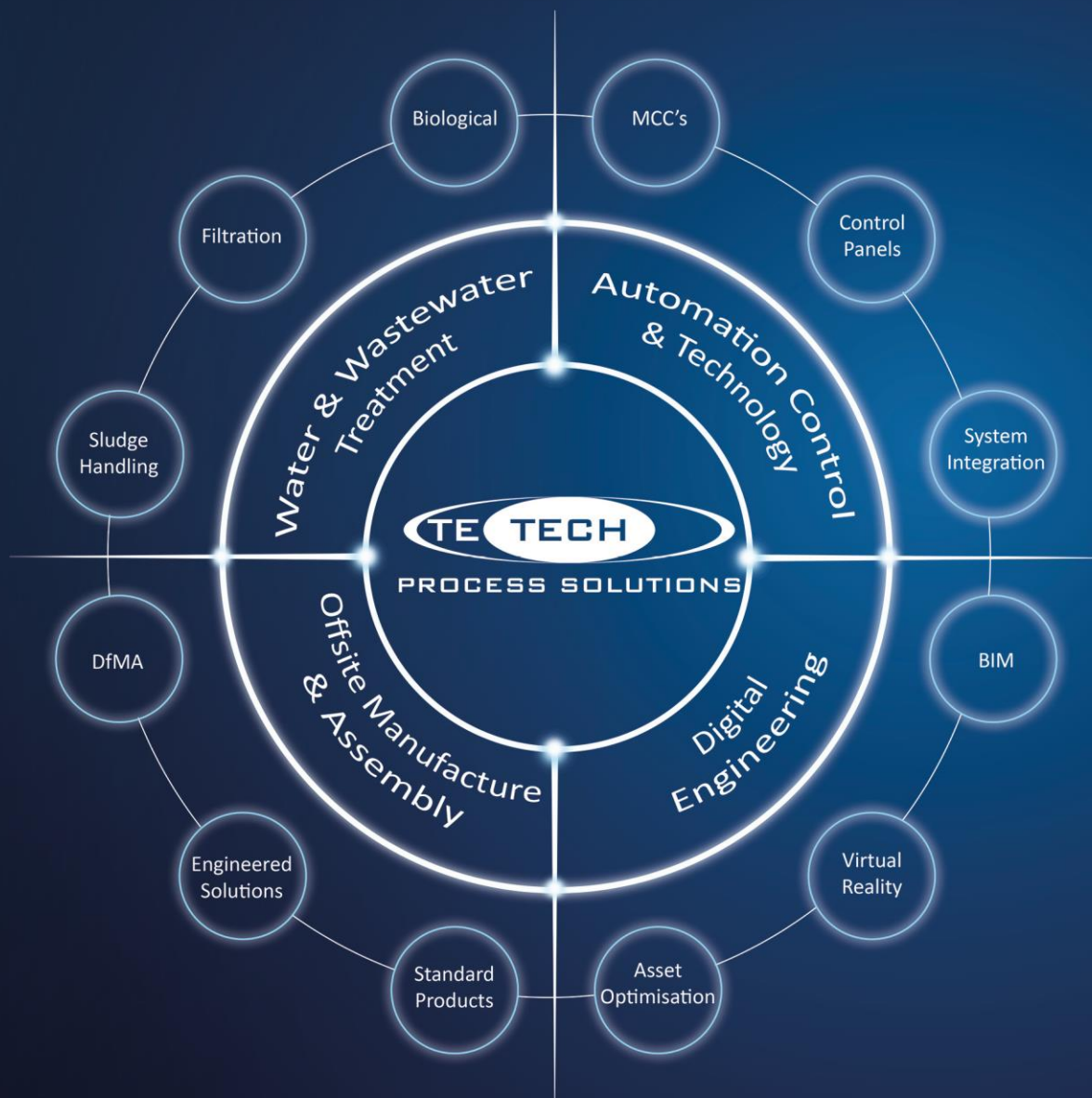
TP Design Discharge – ≤ 0.3 mg/l



Design Performance

Influent to te-cyc™ after PSTs				
Population Equivalent	2,285			
Minimum Hourly Flow, Q _{h_min}	6.5	m ³ /h		
Average Hourly Flow, Q _{h_avg}	21.0	m ³ /h		
Maximum Hourly Flow, Q _{h_max}	64.8	m ³ /h		
Peak Factor (Q _{h_max} / Q _{h_avg})	3.09	-		
Minimum Wastewater Temperature	7	°C		
Maximum Wastewater Temperature	20	°C		
BOD	212.1	mg/l	106.9	kg/d
COD	424.2	mg/l	213.8	kg/d
TSS	228.2	mg/l	115.0	kg/d
T-N	43.5	mg/l	21.9	kg/d
T-P	5.0	mg/l	2.52	kg/d

te-cyc™ Treated Effluent	Unit	Consent Average Spot Sample	Consent 95%ile Spot Sample	Additional te-cyc™ Benefit
COD	mg/l	-	-	≤50
BOD	mg/l	≤10	≤20	≤10
TSS	mg/l	≤5.0	≤10	≤5.0
NH ₄	mg/l	≤1.0	≤3.0	≤0.9
T-N	mg/l	-	-	≤6.0
T-P	mg/l	≤0.3	-	≤0.3



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