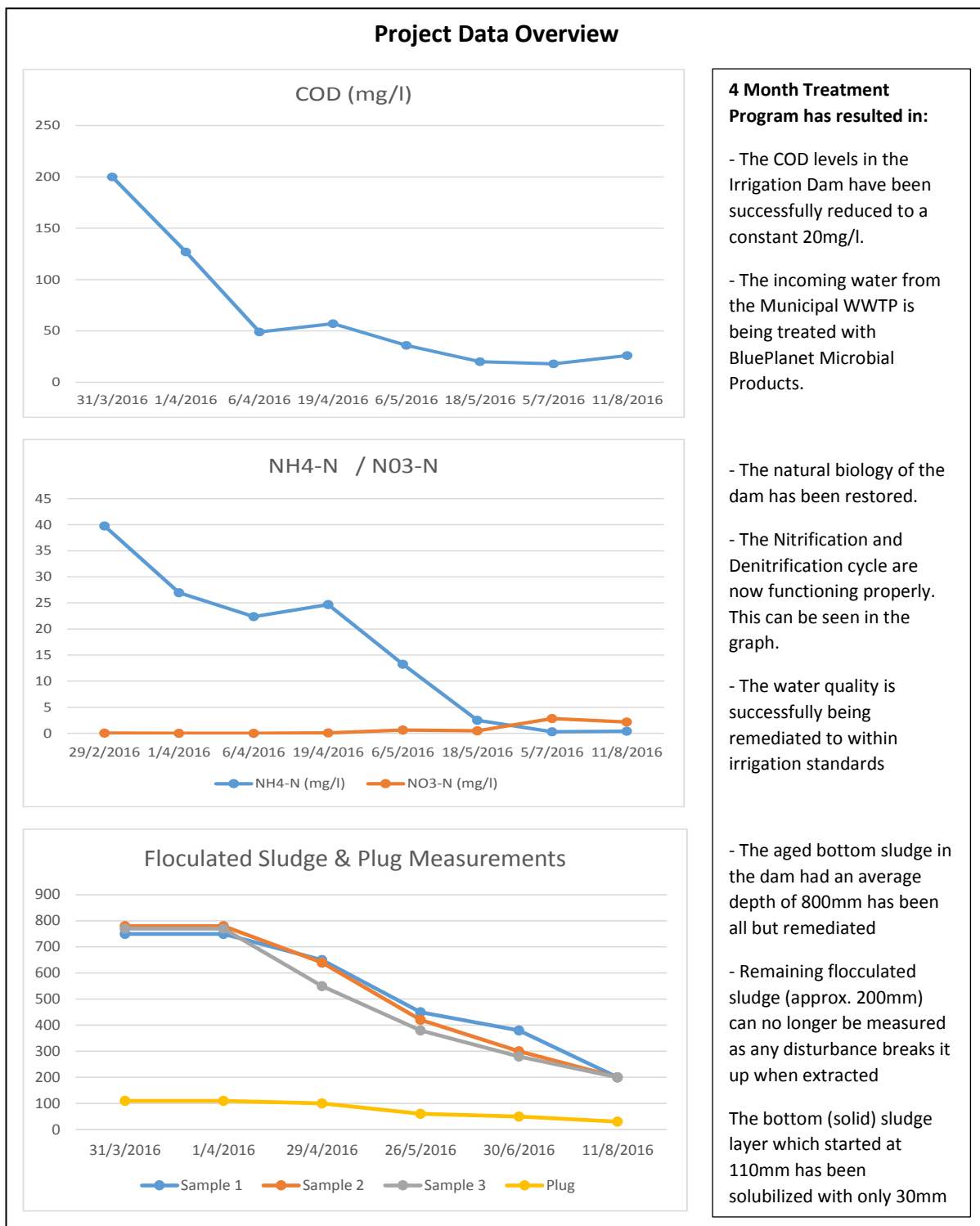




## Steenberg Golf Estate - FINAL Bio-Remediation Report

16/8/2016



16<sup>th</sup> August 2016

## Steenberg Estate Golf Club – Bioremediation Report

### Sludge & Water Treatment – (18<sup>th</sup> Hole) Irrigation Dam

**Foreword:**

The bio-remediation of sludge and treatment of incoming municipal wastewater (treated) has been successful.

All project parameters have been achieved, bottom sludge has been all but eliminated and the water parameters are well below the standard required for irrigation purposes.

The natural biology of the dam has been restored, COD levels, Suspended Solids, NH4-N and NO3-N are under control.

There is a visible increase in aquatic life due to the restored biology and the water body being circulated in the dam by means of aerators.

**Project parameters against results achieved:**

Measured Parameters	Target	Reduction Achieved	Comments	
Guaranteed Sludge Reduction	75mm / month	140mm (average)		
	300mm / 4 Months	560mm	last successful measurement - 200mm flocculated sludge remaining	
Bottom Sludge Reduction (110mm)	(not specified)	75mm	only 35mm solid sludge remaining	
Water Parameters	Start	Target	Achieved	
Ammonium NH4-N	26.76 mg/l	3 mg/l	0.28 mg/l	Stabilized
Nitrates NO3-N	0.00 mg/l	3 mg/l	2.83 mg/l	Stabilized
COD (Chemical Oxygen Demand)	127 mg/l	75 mg/l	18.00 mg/l	Stabilized

**Phase 1** - Bio-remediation Process has been successfully completed and Phase 2 has been commenced.

**Phase 2** – This eight month treatment program has been started at the beginning of August 2016. The eight month treatment plan has been implemented to treat the water from the municipal treatment works and to ensure that water parameters do not deteriorate again and to prevent bottom sludge build up.

There are a number of other downstream advantages that have been observed on site. These range from sludge reduction at the club house dam to odour control of the irrigation and dam water. There is also the added advantage on soil remediation and growth enhancement around the course due to the remediation bacteria being irrigated.

**Summary -**

- 1) A total sludge reduction of approximately **2500m<sup>3</sup>** of wet sludge volume has been remediated. The remediation process has proven to be an eco-friendly and very competitive alternative to dredging.
- 2) Water parameters have stabilized and are being controlled within irrigation standards.
- 3) Odour has been eliminated and nitrification cycle activated

## APPLICATION REPORT & PROJECT DATA

### Application Brief:

Steenberg Golf Club and Estate uses treated municipal wastewater for irrigation purposes. Up to 1 200m<sup>3</sup> are irrigated daily when no rainfall is being experienced. The irrigation dam located at the 18<sup>th</sup> hole is the primary irrigation dam for the course and estate.

The water being received is of a poor quality and has high COD, Suspended Solids and Ammonium NH<sub>4</sub>-N levels. In addition the water is being chlorinated at source to mask odour and to sterilize due to e-coli and other pathogens. The poor water quality is causing long term damage to the course and there is an evident odour in the irrigation water.

The chlorination of the incoming water has resulted in all bioactivity in the dam seizing. There is no nitrification taking place and this can be seen in the high NH<sub>4</sub>-N level whilst there is no NO<sub>3</sub>-N.

The dam has an average of 770mm bottom sludge with a solid compacted layer of 110mm. This sludge is contributing to a reduced holding capacity in the dam and also influenced the overall water quality through elevated COD and suspended solids.

Bio-Remediation of the water body was chosen above emptying and dredging of the dam. The brief was to eliminate bottom sludge and to improve the incoming and dam water quality to acceptable discharge standards.

### Irrigation Dam Technical Specification

Surface Area:	approximately 95 x 45m (4050m <sup>2</sup> )
Volume:	approximately 8 000m <sup>3</sup>
Max daily Irrigation Volume:	approximately 1400m <sup>3</sup>
Average sludge depth / volume	approximately 770mm / 2835m <sup>3</sup>
Retention time	varies depending take off and irrigation (8 days max)

Samples were taken at various depths and at different locations in the dam (data supplied by client)

Cl mg/l	HCO <sub>3</sub> -mg/l	SO <sub>4</sub> mg/l	P mg/l	NH <sub>4</sub> -N mg/l	TDS mg/l	COD mg/l	Suspended Sol mg/l
122.00	355.00	57.43	7.84	33.09	683.00	119.00	61.00
121.00	685.00	52.64	7.35	32.19	684.00	1040.00	414.00
152.00	709.00	58.56	17.50	55.78	976.00	2335.00	2373.00
131.00	615.00	41.57	18.24	45.53	786.00	5420.00	2474.00
125.00	467.00	51.62	10.89	39.09	777.00	745.00	671.00
137.00	694.00	54.17	8.18	33.02	721.00	725.00	334.00
<b>131.33</b>	<b>587.50</b>	<b>52.67</b>	<b>11.67</b>	<b>39.78</b>	<b>771.17</b>	<b>1730.67</b>	<b>1054.50</b>

- The above parameters indicate that there is a problem with the incoming wastewater, COD NH<sub>4</sub> and Suspended Solids being the biggest problem.
- The sludge analyses showed COD levels up to 32000 mg/l

## Approach

The following remediation approach was calculated based on the water analyses and data received:

### 4 Month Treatment Plan

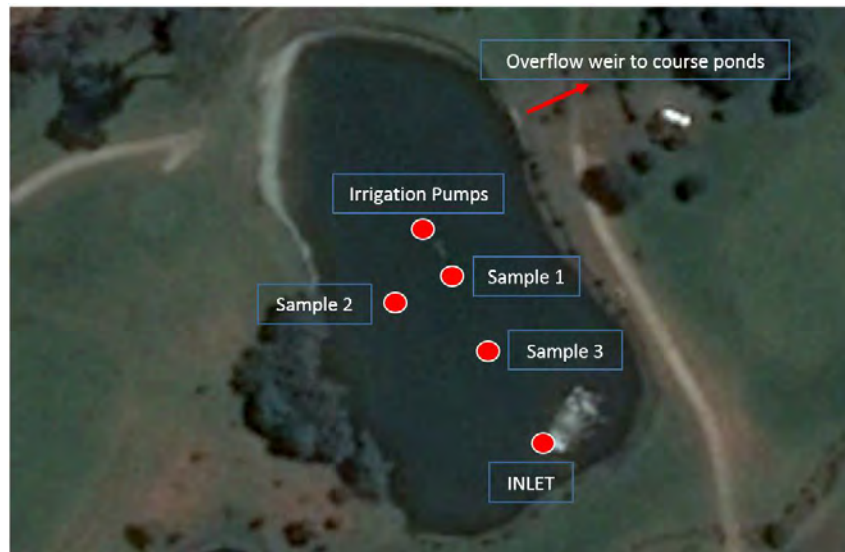
	BacBag Combo	ACF-32	ACF-SC
Week 1	12	12	12
Week 2		8	8
Week 3		8	8
Week 4		8	8
Week 5	12	6	4
Week 6		6	4
Week 7		6	4
Week 8		6	4
Week 9	12	6	4
Week 10		6	4
Week 11		6	4
Week 12		6	4
Week 13	12	6	4
Week 14		6	4
Week 15		6	4
Week 16		6	4
Week 17		6	4
	48	114	88

### Remarks

- A speedy result was required as the greens were being replanted, water quality had to be assured by time of work commencing.
- A guaranteed sludge reduction of 75mm / month was agreed to, this equated to 300mm over the first 4 months.
- The incoming and dam water quality needed to be improved to within irrigation standards of 75 mg/l COD and 3 mg/l NH4-N
- A retention time of 8 days was used for calculation purposes
- The dosage for phase 1 was increased threefold against the standard dosing which would be applied to open water bodies and for sludge reduction.
- The heavier phase 1 dosage results in higher rate of hydrolyses in the sludge layer and a short term recovery of the dam biology

- 1) BacBag Combos were selected as these release bacteria into the sludge layer over a period of 30 days, these are combined with ACF-SA wet spore products which enhance and establish the nitrification process.
- 2) Treatment commenced on the 1<sup>st</sup> April 2016 and new water samples were drawn for analyses. Monthly water samples were drawn at the inlet (incoming water from treatment works) and at the dam weir outflow (30cm under water surface)
- 3) It was agreed that sludge measurements would be taken at 3 points in the dam, these were taken on a monthly basis.
- 4) Sludge was measured using a sludge tool and was conducted in the presence of Steenberg Estate staff, measurements verified by photographs.
- 5) Water Analyses were conducted by ECA technologies as well as by Steenberg Estate. Bemlab are a SANAS approved laboratory who were used for analyses of water samples taken.
- 6) The treatment brief was to reduce the sludge layer by a minimum of 300mm over the Phase 1 period of 4 months.
- 7) Chlorine was switched off at source, no further chlorination will take place.
- 8) Aeration was added to the dam by means of two floating aerators also serve to move the water body and to increase the dissolved oxygen content of the dam.

## Sludge Measuring Points



## Sludge Measurements Taken

Date	Location	Sludge Depth	Compacted Sludge Depth	
24/3/2016	Sample 1	750mm	100mm	
	Sample 2	780mm	110mm	
	Sample 3	770mm	110mm	
Extraction of the sludge from the dam showed a compacted sludge layer of around 110mm whilst the remaining 650mm is made up of suspended sludge which is light in volume.				
29/4/2016	Sample 1	650mm	100mm	-100mm
	Sample 2	640mm	110mm	-140mm
	Sample 3	550mm	110mm	-220mm
26/5/2016	Sample 1	460mm	60mm	-290mm
30/6/2016	Sample 1	380mm	50mm	-370mm
	Sample 2	300mm	50mm	-480mm
	Sample 3	280mm	50mm	-490mm
12/8/2016	Sample 2	Estimated 200mm	35mm	-580mm
	Sample 3	Estimated 200mm	35mm	-570mm
Samples of the flocculated sludge can no longer be taken as this is nearly completely hydrolysed.				
Movement of the sludge layer results in the sludge breaking up and discolouring the water. This a clear sign that the sludge reduction process is nearly completed.				
The solid sludge layer is nearly completely solubilized, this is clear in the last of the measurement photos.				

**Sludge Measurement Process Used – Sludge tool with ball**



Compacted sludge serves as plug with rubber ball / Rope becomes visible at top showing sludge level

**Measurement Taken 24/3/2016 (Project Start)**

**Measurement Taken 29/4/2016**



Sample 2: 780mm / 110mm compacted sludge

Sample 1 - 650mm

Sample 2 – 640mm

Sample 3 – 550mm

**Measurement Taken 30/6/2016**

**Measurement Taken 12/8/2016**



Sample 1 - 380mm

Sample 2 – 300mm

Sample 3 – 280mm

Compacted Sludge Plug 50mm  
30/6/2016

Remaining 35mm Plug

Dissolved flocculated sludge  
discolouring the water when measuring

## Water Sampling

Monthly water samples were taken. The first sample drawn was taken 10 days after the project start, this was due to the low level of the dam due to ongoing irrigation.

This effectively means that 10 days of bioremediation had taken place prior to the starting sample being taken. Hence we have used the proposal analyses received as the starting point for the graphs.

### The first sample was taken on the 4<sup>th</sup> April 2016

#### Effluent Water Report

Date received: 04/04/2016

Date tested: 05/04/2016

Origin No.	Lab. No.	pH @25°C	EC @25°C mS/m	COD mg/l	Suspended solids (mg/l)	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	P mg/l	SAR	NH <sub>4</sub> -N mg/l	NO <sub>2</sub> -N mg/l	NO <sub>3</sub> -N mg/l	Cl <sub>2</sub> mg/l	PO <sub>4</sub> mg/l	F mg/l
Steenburg Inflow	3900	7.7	109.4	25	21	102.08	22.34	38.93	8.93	8.73	3.84	26.96	0.57	0.50	0.37	26.71	0.24
Steenburg Outflow	3901	7.4	141.5	127	23	169.66	22.21	36.74	8.80	7.54	6.53	26.76	0.04	0.00	0.31	23.07	0.22

Origin	Lab. No.	Total Bacteria /1 ml	Coliforms /100ml	E. coli /100ml	Faecal Coliforms /100ml	Date tested	Date sampled	Temperature °C
Steenburg Inflow	3900	>3000	>2420	186	194	04/04/16	Unknown	6.0
Steenburg Outflow	3901	>3000	>2420	88	88	04/04/16	Unknown	9.6

#### Water Analyses Report

Date received: 20/04/2016

Date tested: 21/04/2016

Reference No.	Lab. No.	Date Sampled	Temperature at reception (°C)	pH	COD mg/l	NH <sub>4</sub> -N mg/l	NO <sub>2</sub> -N mg/l	Suspended solids (mg/l)	TDS mg/l
Mon 18/4	4723	18/04/2016	8.900	7.18	53.00	25.48	0.09	17	666
Tues 19/4	4724	19/04/2016	7.600	7.13	57.00	24.69	0.07	21	684

#### Water Analyses Report

Date received: 06/05/2016

Date tested: 09/05/2016

Reference No.	Lab. No.	Date Sampled	Temperature at reception (°C)	COD mg/l	NH <sub>4</sub> -N mg/l	NO <sub>2</sub> -N mg/l	pH	TDS mg/l	Suspended solids (mg/l)
	5328	Unknown	15.300	36.00	13.23	0.61	7.02	550	27

#### Water Analyses 5/7/2016

Origin	Lab. Nr.	pH @ 25°C	NH <sub>4</sub> -N mg/l	NO <sub>2</sub> -N mg/l	COD mg/l	TDS mg/l	Date tested	Suspended solids (mg/l)	Temperature at reception (°C)
	7928	7.2	<0.28	2.83	16.00	414.0	Unknown	57	7.4
Method nr.	3136	3271	3271	3289					

#### 12/8/2016

Origin	Lab. Nr.	pH @ 25°C	NH <sub>4</sub> -N mg/l	NO <sub>2</sub> -N mg/l	COD mg/l	TDS mg/l	Date Sampled	Suspended solids (mg/l)	Temperature at reception (°C)
18th Dam	9570	6.9	0.39	2.16	26.00	434.0	11/08/2016	26	12.4

## Notes

Monthly progress reports were compiled and distributed to all stakeholders. These reports support the information contained herein.

## Conclusion

The bioremediation of this water body has been a success with the desired sludge reduction being achieved and surpassed, also the water parameters are under control and odour has been eliminated.

This application has proven remediation to be an eco-friendly and very competitive when compared to dredging which is a common practice.

This biology of this dam has effectively been rehabilitated and 2500m<sup>3</sup> of sludge has been solubilized within a four month period.

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