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20/08/2019 08:38

The Director
Conserv Security
PO Box 163
Paardekraal 1751

Attention: Mr Trevor Roberts

Dear Sir:

**Comments on Water quality survey of streams in the Cradle of Humankind,
conducted on 08/08/2019**

African Environmental Development (AED) was requested to provide a professional opinion on the issue with poor effluent being discharged from the Percy Stuart Sewage Works into the Blougatspruit. The analyses report of the 12 water samples collected by staff from DD Science on 08 August 2019 and analysed by the same laboratory, has relevance. The survey was prompted by an issue with poor quality sewage effluent being released by the Percy Stuart Sewage works into the Blougatspruit. Please find our professional comments below.

Background

The issue of polluted water (untreated or poorly treated sewage effluent) flowing in the Blougatspruit/Rietspruit/Bloubankspruit was first brought to our attention on 11 July 2019, when **Photo 1** was taken.



Photo 1: A photo of the Bloubankspruit taken on 11 July 2019 in the Kromdraai area indicating that something is seriously wrong with the water flowing in this stream (Photo: Bob Fulton)

Members: E. M. Krige

Water is our business, protecting the environment our aim



An investigation by members of the community confirmed that the source of pollution was the effluent from the Mogale City's Percy Stuart Sewage Works.

General Hydrology downstream for the Percy Stuart Sewage Works

The Blougatspruit is a tributary of the Rietspruit. The Rietspruit rises at Riebeeck Lake in Randfontein. The Blougatspruit drains a significant part of Krugersdorp, rising immediately downstream from Factoria in Krugersdorp. It initially flows in a more-or-less natural watercourse until it flows through a culvert under the R28 roadway, from where it is channelled in a concrete canal for several kilometres (3.2 Km), up to a point immediately northeast of Krugersdorp West, whereafter it again flows in a natural watercourse. The Percy Stuart Sewage Works discharges treated sewage effluent into this stream.

After flowing into the Rietspruit at the southern tip of Sterkfontein Country Estates, the combined stream continues southwards to its confluence with the Bloubankspruit. The Bloubankspruit rises on dolomite at the farm Slookoppie 167 IQ, from where it is a mostly dry watercourse up to the confluence with the Rietspruit, due to the underlying dolomite. Surface water simply recharges into the underlying dolomitic aquifers rather than flowing in the stream channel, unless it rains really heavily. The same is true for the Rietspruit from just outside Randfontein. From here it also flows on dolomite and would have been a mostly dry stream, had it not been for the sewage effluent discharged into this stream from Randfontein as well as the water being discharged from the gold mines into the Tweelopiespruit, a tributary of the Rietspruit upstream from the Rietspruit's confluence with the Blougatspruit. As it stands, the Rietspruit/Bloubankspruit up to a short distance downstream from the Sterkfontein Caves is a losing stream, i.e. it loses most of its flow into the underlying dolomitic aquifer.

After passing the Sterkfontein Caves, the Bloubankspruit becomes a gaining stream, as its streambed intersects the groundwater table, which produces several springs in the reach of the stream from about the Sterkfontein Caves to the Nirox Exhibition area. Thereafter it leaves the dolomite and flows in a less permeable streambed.

After passing the Zwartkop hill area, the Bloubankspruit flows into the Muldersdrift se Loop. This is also the official start of the Crocodile River, flowing towards the Hartbeespoort Dam and beyond. There is a sewage works on the banks of the Muldersdrift se Loop, which discharges effluent into this stream.

Due to the underlying dolomitic aquifers within the Cradle of Humankind World Heritage Site that are recharged rapidly from surface streams, pollution of the surface streams will also impact on the underlying groundwater aquifers.

Comments on the analyses results of the samples collected on 08/08/2019

Very generally speaking, there are two primary polluters of the streams discussed in this report. The first is acid mine drainage (AMD), being discharged from a point source into the Tweelopiespruit, while the other is sewage effluent discharged by three sewage plants, of which the Percy Stuart Sewage Works is the one under scrutiny in this report. The two types of pollution are very different and can easily be distinguished from one another.

A total of 12 samples were collected and analysed by DD Science. Due to budgetary constraints, only a selected number of determinants were analysed, which would indicate the impact from the water discharged by the Percy Stuart Sewage Works and which would differentiate it from the AMD flowing in the Tweelopiespruit/Rietspruit. The following determinants were done:

- pH
- Electrical Conductivity



- Suspended Solids
- Turbidity
- Nitrates
- Free & Saline Ammonia
- Chemical Oxygen Demand (COD) and
- Sulphate
- Microbiological count

The latter three determinants (together with some of the other determinants) would differentiate between sewage water and AMD. The analyses results are reported in **Appendix 1**, the analyses report by DD Science Laboratory.

To make the chemistry simpler for a layperson to understand, AED produced maps, indicating the sampling points shown in the Google Earth file in **Appendix 1**, as well as the concentrations of some selected determinants from the DD Science Analyses Report. Please refer to **Figures 1 to 5** below.

Chemical Oxygen Demand (COD)

COD is a measure of the amount of biodegradable organic matter dissolved in water. COD can have several natural origins, but is primarily associated with sewage and the effluent of sewage treatment works. It is not known whether Mogale City Local Municipality has a water use licence for the Percy Stuart Sewage Works. Thus it is not known whether there are certain conditions we are not aware of in this water use licence. For this reason, the General Effluent Standards (GES) in terms of Regulation 991 of 18 May 1984 as published in Government Gazette No 991 of 18 May 1994, as amended by G.N.R.1930 of 31 August 1984, G.N.R.1864 of 15 November 1996, was used to evaluate the water in the samples.

In terms of the GES, COD in sewage effluent should not exceed 75 mg/l. The same regulation has a Special Effluent Standard, which has the COD at 30 mg/l. As far as AED is aware, the Percy Stuart Sewage Works locates in the areas covered by the GES and not the Special Standard. Thus the plant must consistently produce an effluent with a COD concentration of ≤ 75 mg/l.

Referring to **Figure 1**, it is obvious that the COD discharged from the sewage works into the Blougatspruit exceeds the GES limit by a significant margin. The COD in the effluent discharged from the plant was 261 mg/l, while at the same time the water in the Blougatspruit upstream from the point of discharge was 24 mg/l. When the two streams mixed, the COD reduced to a still unacceptable 176 mg/l. At 140 mg/l at the point where the Blougatspruit flows under the N14 (Sample incorrectly named *Bloubankspruit @ N14* - it should have read *Blougatspruit @ N14*), the COD was still well over the GES limit. After flowing past an oil factory at the N14, the COD increased to 633 mg/l, the highest of all the CODs recorded during this exercise. This could implicate the oil factory as a polluter, however, prior to this incident, the water in the Rietspruit downstream from the oil factory did not show any reason to implicate this oil factory. It is recommended that the Mogale City Local Municipality investigate this issue, however.

The COD improved from exceeding the GES levels to reaching concentrations between the Special Standards limit and the GES limit at the next two sampling points in the Bloubankspruit (yellow markers). Interestingly, the water entering the Bloubankspruit from the Honingklipspruit also had elevated COD concentrations, likely implicating the other sewage plant shown in **Figure 1**.

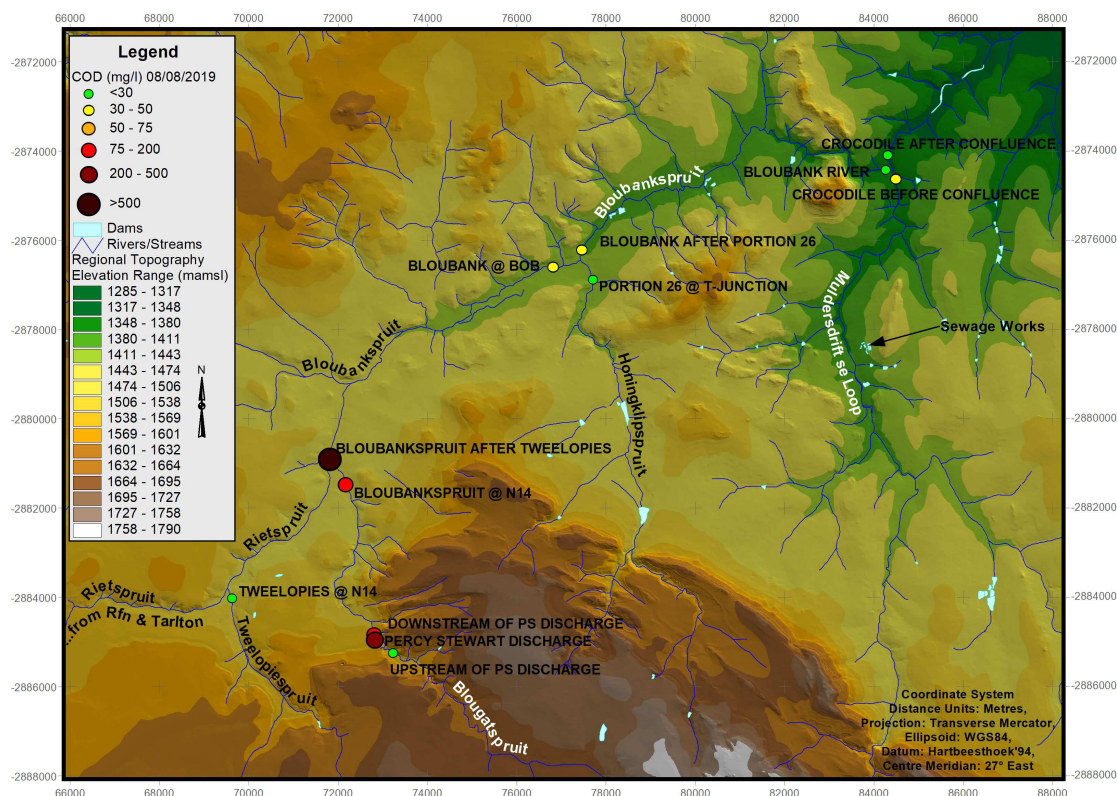


Figure 1: The COD in the streams up- and downstream from the Percy Stuart Sewage Works

Sulphate

Sulphate was added to the determinants being analysed to show the impact from Gold Mining and the decanting water flowing from a point source in the Tweelopiespruit.

Due to issues at the AMD treatment plant, the Rietspruit was not flowing at the time when the sampling was done, thus the only point where a sample could be collected from the mine water was just before the Tweelopiespruit joined the Rietspruit. Thereafter the water simply disappeared into the ground, but under normal circumstances it flows year round with AMD water.

The sulphate concentration at this point was 1 050 mg/l, far exceeding the SANS 241 drinking water standard of 500 mg/l. The effect of this pollution could still be detected at sampling point, *Bloubankspruit @ Bob* (yellow marker) and even as far as the last two sampling points (*Bloubank River* and *Crocodile after confluence*).

For obvious reasons, the sulphate concentration in the Blougatspruit up and downstream from the Percy Stuart discharge point was low, even though some sulphate was detected in levels higher than what would be expected. The Percy Stuart effluent had a sulphate concentration of 175 mg/l, which is quite unexpected.

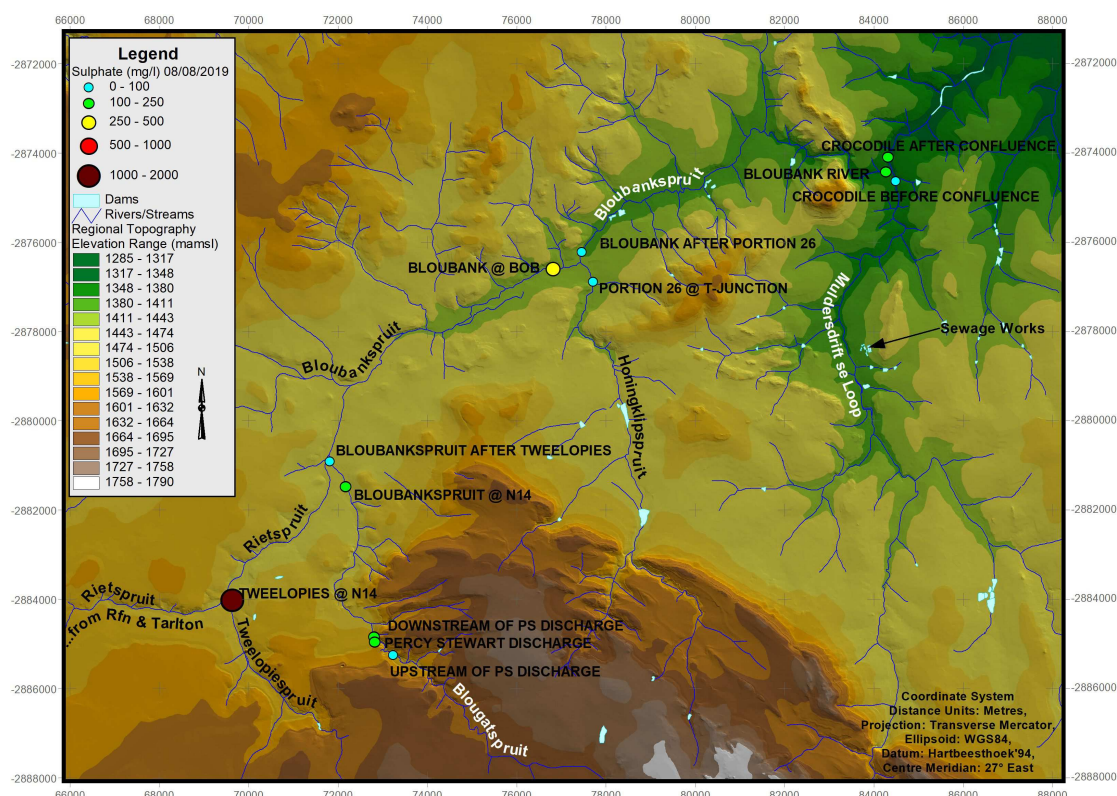


Figure 2: The sulphate concentration at the sampling points. Elevated sulphate will implicate mining and is not usually associated with sewage effluent

Ammonia (Free and Saline Ammonia)

During the sewage treatment process, organic matter is broken down and one of the by-products is nitrogen, initially in the form of a fairly toxic (to aquatic organisms) ammonia, and after undergoing additional treatment, nitrate, which is much less toxic to aquatic organisms. If ammonia is detected in sewage effluent in concentrations higher than the GES standard of 1 mg/l, this means that the treatment process is defective. As can be observed in **Figure 3**, the ammonia in the water from Percy Stuart was high (24 mg/l), while the sample downstream from the discharge point was even higher at 27-mg/l. This suggests that water, released by Percy Stuart a short while before the stream was sampled, had an even higher ammonia concentration than what was recorded from the sewage effluent at the time of sampling.

Ammonia is a plant nutrient and will rapidly be assimilated by aquatic vegetation downstream from a pollution source. What does show in **Figure 3** is that even several kilometres downstream, the ammonia concentration is still very high, implying that raw, or close to raw sewage is flowing in this stream, as the treatment process (breaking down of organic matter) is still occurring downstream, releasing ammonia.

In a well-operated sewage plant, ammonia will be converted to nitrate and then a further process will remove this nitrate. Thus, high ammonia implies poor treatment in general, low ammonia and high nitrate implies good treatment by a plant not designed to remove nitrate, while low ammonia and low nitrate implies a plant that is effectively removing both determinants.

From the high ammonia concentration in the Percy Stuart effluent it is clear that the plant is not performing as it should be doing.

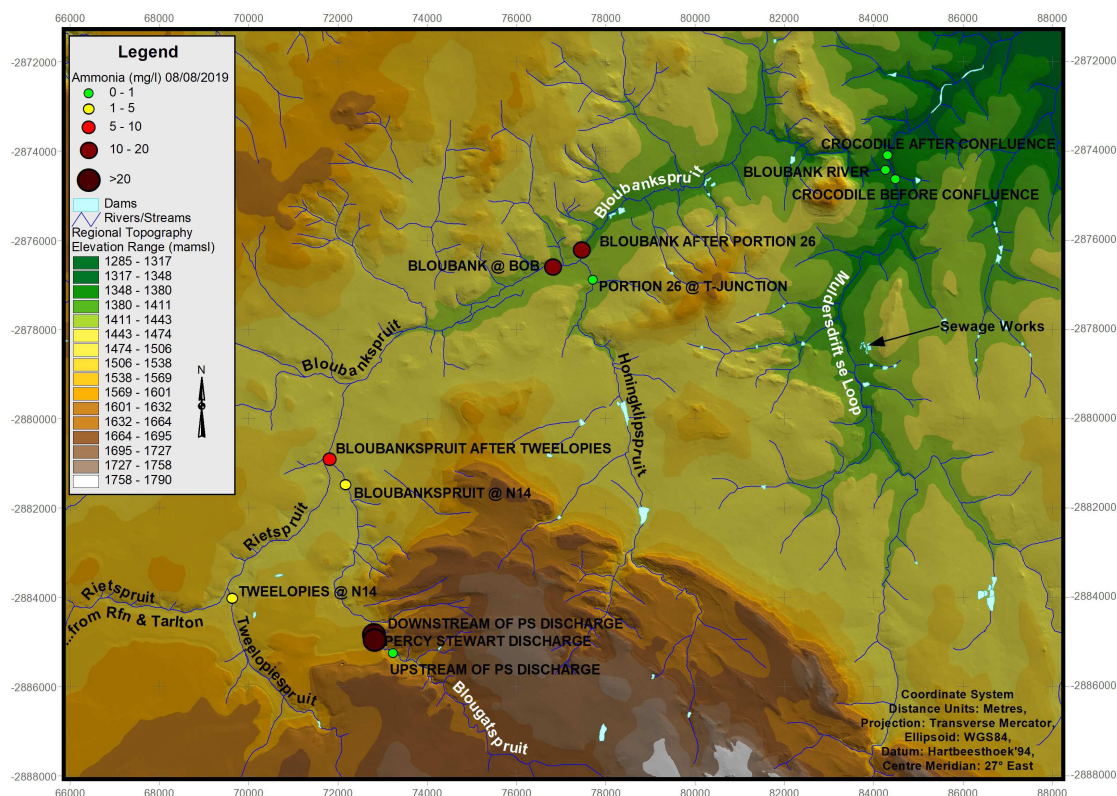


Figure 3: The ammonia concentration of the streams at, and downstream from, the Percy Stuart Sewage Works. From the large dark red markers, it is clear this plant is not performing and that a poor effluent is being released. The effect of poorly treated sewage flowing in the streams is detected as far as the confluence of the Honingklipspruit with the Bloubankspruit

Nitrate

As explained in the previous paragraphs, nitrate is a product formed when a sewage plant is operating well. The GES does not sets a limit for nitrate, but the SA drinking water standard, SANS 241 does. The limit is 11 mg/l, whereafter water with higher concentrations could be fatal to babies under the age of 6 months. Nitrate is a plant nutrient and it should disappear fairly quickly from the water in a stream, as it is taken up by aquatic vegetation. It is also a fertiliser, and a high nitrate concentration in the absence of faecal pollution is mostly caused by fertilisers flowing off agricultural land into a stream. The fact that a very high nitrate concentration (45 mg/l) was observed in the Bloubankspruit (Sample, *Bloubank River*) just upstream from its confluence with the Crocodile River, suggests agricultural pollution, rather than the Percy Stuart Sewage Works.

In general, the nitrate concentration of the water leaving the Percy Stuart Sewage Works is comparatively low, while the ammonia concentration is high, suggesting that the nitrification process at the has not occurred and that most of the nitrogen is still in the form of organic matter or in the form of ammonia. The nitrate concentration in the water leaving the sewage plant was 7.1 mg/l.

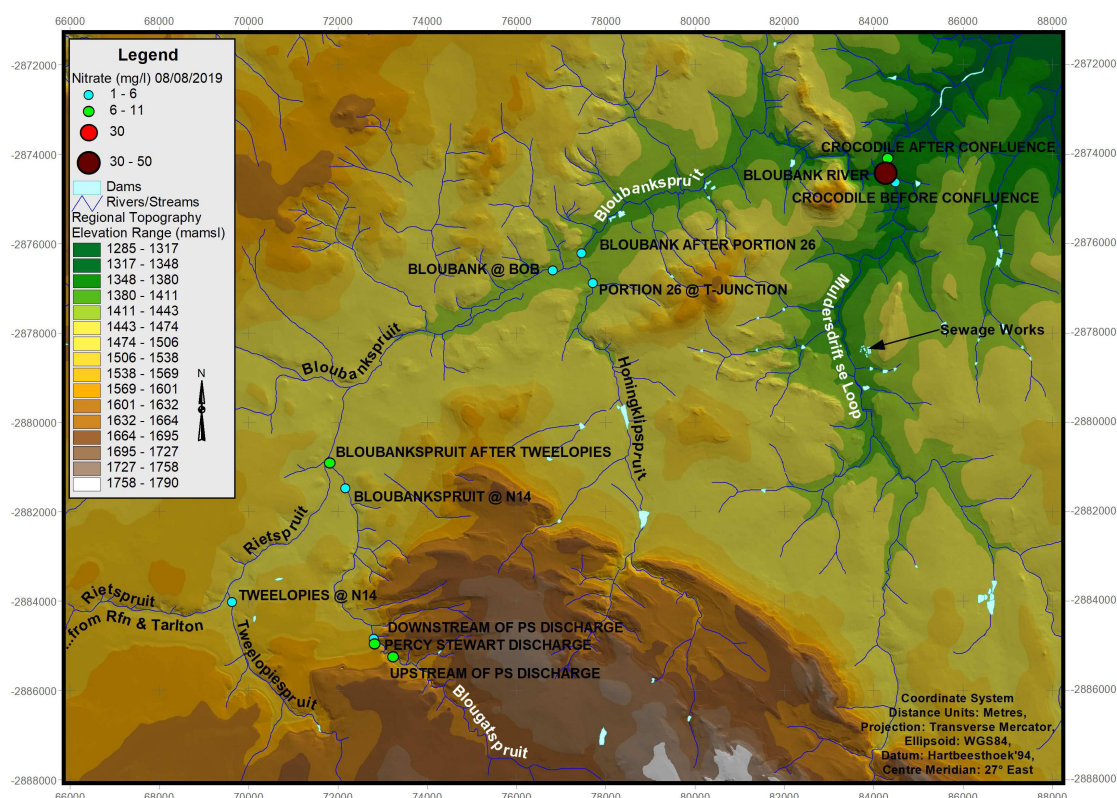


Figure 4: The nitrate concentrations at the sampling points. The comparatively low concentration in the sewage effluent suggests that the nitrification process at the sewage plant has not occurred successfully. The high nitrate concentration (45 mg/l) in the Bloebankspruit just before its confluence with the Crocodile River suggests some other form of pollution, likely from an agricultural source (fertiliser)

Faecal Coliforms

Faecal coliforms bacteria refer to a group of bacteria found in the intestinal tracts of vertebrates (in their colons, hence the name, "coliform" - referring to "colon"), including humans. These bacterial forms are not exclusively associated with humans and to distinguish between human faecal pollution and animal (farm and wild animals) pollution, it is necessary to count both the faecal coliforms and faecal streptococci. The ratio between the two would indicate whether the pollution is from human or other animal origin. However, water in sewage effluent is certainly almost exclusively from human origin and thus does not have to be typed.

A sewage plant should not have any viable (living) faecal coliforms in its effluent. That is why sewage effluent is chlorinated before it is released into the environment. The high faecal coliform count in the sewage effluent suggests that the chlorination process is either not working at all, or that it is being overwhelmed by the high organic load (COD) in the effluent. It is likely the latter.

The effluent had a count of 220 000 faecal coliform bacteria per 100 ml. This count diminished to 25 00 downstream from the point of effluent release and then further decreased to 320 at the N14 bridge. Then it increased again at the Rietspruit/Blougatspruit confluence, implicating the oil factory and not necessarily the sewage works. Faecal coliforms cannot survive out of a mammal's intestinal tract for prolonged periods, and thus, in a stream they will disappear rapidly. Thus the increase after passing the oil factory suggests this factory (or someone else in the vicinity of the oil factory) is releasing sewage into the stream.

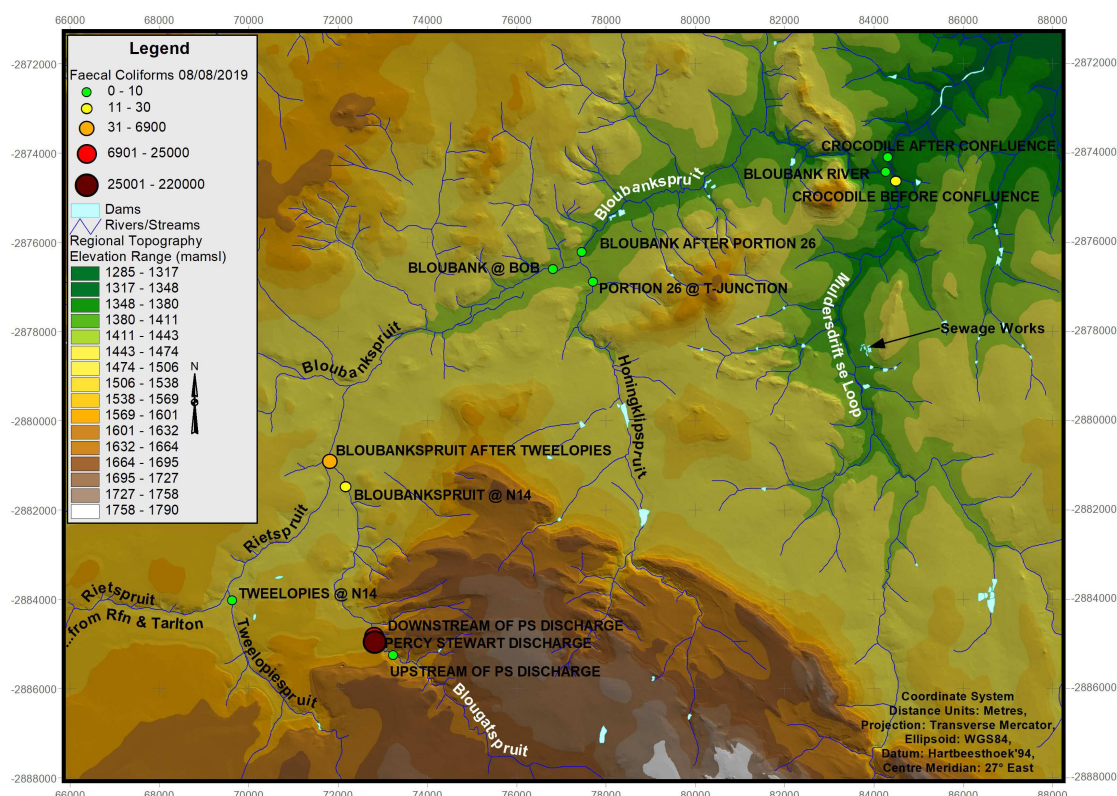


Figure 5:

Conclusions

From the above discussion it is obvious that the Percy Stuart Sewage Works has serious issues with its treatment process. This is a fact. What is not understood is the exact cause of the poorly treated water, and it was not the intention of this exercise to identify the cause. However, the author wishes to add the following notes:

There is a condition in the activated sludge treatment process referred to as "bulking sludge" that can cause similar symptoms (carry-over of solids in the effluent) as is observed at the Percy Stuart Sewage Treatment Works. Although this is not necessary the cause of the problem at Percy Stuart, the author is of the belief that the odds are in favour this it being the problem. It is explained hereunder.

In the activated sludge treatment process certain aerobic bacteria groups are cultivated to process the organic matter in sewage. These bacteria convert the organic matter in the sewage to by-products, mostly into carbon dioxide, to methane and to "body mass" of the bacteria. These bacterial groups are selectively cultivated for their ability to convert organic matter to these other, less offensive, by-products, but also for their properties to separate from the water in which they exist, by gravity. This is done in a sludge-separating tank (settler). The clarified effluent flows over the brim of the separating tank, while the heavier bacteria sink to the bottom of the tank and are then pumped back to the head of works to do their work over again. In order keep the numbers of bacteria in equilibrium with the amount of organic material received by the sewage plant, a certain volume of bacteria is removed from the system, either daily or on a continuous basis. If this is not done, the ratio between the bacteria and their food (organic matter) goes out of balance, essentially meaning that there are too many bacteria for the amount of food available. If this (the wasting of bacteria) is not done carefully, it will promote the colonisation of a different type of bacteria that will out-compete the "good" bacteria. These bacteria usually have filamentous forms, the filaments increasing their surface areas and thus their ability to "catch" food. Thus, in a plant where there are too many bacteria, these filamentous bacteria will take over the plant. The problem with them is



that, due to their filamentous shapes, they do not readily sink to the bottom of a separating tank, but rather remain in suspension and therefore this type of sludge is called a "bulking sludge" i.e. the bacteria are carried over the edge of the separating tank into the effluent.

Once established, these bacteria are very difficult to get out of the system and as long as they remain in the plant, the plant loses almost all of its bacterial mass, thus leaving insufficient bacteria to process the organic matter. The "good" bacteria are lost first and the filamentous bacteria continue to propagate.

From first-hand experience by the author, it is extremely difficult to re-establish the correct bacterial types. One method that produces good results is to chlorinate the return activated sludge (the bacteria being pumped back to the head of works). As the filamentous bacteria has a larger surface area to body mass ratio, this also means that they are more susceptible to the effects of low doses of chlorine in the water. Thus, if the return activated sludge is carefully chlorinated in such a way that the "good" bacteria are not killed then, within a few days, the plant can be stabilised.

AED does not necessarily recommend this method, as it addresses a specific problem, but if this is indeed the issue with the Percy Stuart Sewage Works, then it should be tried.

Irrespective of the above, it can be confirmed that the water leaving the Percy Stuart Sewage Works is a health hazard to both humans and farm animals, it will kill (or already has) all aquatic vertebrates such as fish, frogs, etc. and invertebrates such as insect larvae, freshwater shrimps, etc. and will generally degrade the streams in which it flows severely.

Sincerely,

Garfield Krige *Pr.Sci.Nat. (Aquatic Science)*
Director: Technical Services

Appendix 1

Laboratory Report

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Google Earth file