Report to the Bitou Municipality on the relative applicability of septic tanks and conservancy tanks in Natures Valley

Prepared for the Natures Valley Ratepayer's Association by Ian Palmer[1] in conjunction with representatives of the Ratepayers Association.

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1 Purpose of this report

Natures Valley (NV) sanitation policy has been under review for the past fifteen years primarily driven by concerns regarding the effectiveness of septic tanks (STs) and, more recently, conservancy tanks (CTs), the two traditional sanitation systems used in the Valley. There have been studies investigating sewered sanitation systems for NV but there has been no progress in implementing these options. The current policy of the Bitou Municipality requires the progressive replacement of septic tanks with conservancy tanks.

The Natures Valley Ratepayers Association (NVRA), acting on behalf of property owners, has grave concerns about the current policy favouring conservancy tanks for several reasons: high costs, environmental impact, increasing management responsibilities and administrative burden on property owners and the households living on these properties. Therefore, the NVRA has commissioned this report to investigate the situation and propose policy changes. (Refer to the attached "Proposed Assessment Procedure" document.)

The focus of this report remains on 'on site' sanitation. It does not deal with the applicability of the sanitation options in relation to lagoon location or the existence of soil with a clay content that prevents the functioning of a septic tank soakaway. Studies have been undertaken which indicate that soakaways on properties close to the lagoon and along most of Forest Drive are not favoured. This situation is accepted and therefore the focus of this report is on locations in NV where soil conditions are suitable for soakaways at septic tanks, applicable to some 80% of properties.

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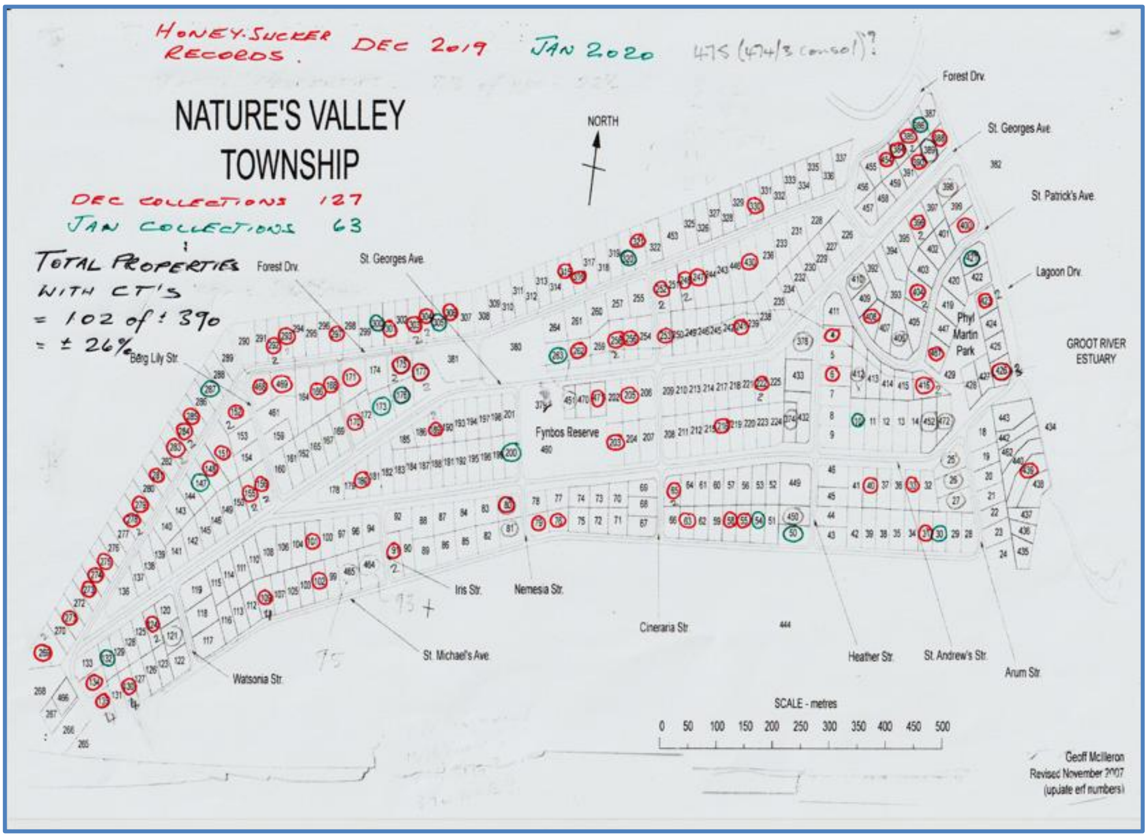
2 Current status with sanitation

There are 390 properties in Natures Valley. At the start of 2020 when most recent data is available, 102 have conservancy tanks (26%) with the balance using septic tanks (see map in figure below).



Over the period December 2019 to January 2020, 97 properties had their conservancy tanks emptied, with 167 tanker emptying trips.

3 Methodology

3.1 Static analysis

The static analysis compares the impact of each sanitation option for a single property at the current time.

A decision on the relative merits of conservancy and septic tanks needs to be based on multiple criteria:

1. Cost of providing sanitation system including capital cost of tanks and operating costs of tanker system.
2. Environmental impact - greenhouse gas emissions.
3. Environmental impact - stormwater pollution.
4. Environmental impact - groundwater pollution

5. Organisational impact - extent of municipal administration required.
6. Household administrative requirements - extent of household administration required.

In making decisions when there are multiple criteria the best practice is to apply the discipline of multiple criteria decision making (MCDA) which is covered extensively in the literature and has been widely applied to decisions associated with infrastructure or development initiatives more broadly. MCDA requires criteria to be identified and for each Intervention (the two tank options in this case) to be scored or rated. Then each criterion needs to be weighted in relation to each other. This weighting requires each criterion to be allocated a percentage in relation to its perceived importance, totalling 100%. This is typically undertaken by people knowledgeable in the field together with interested parties.

The approach to scoring for the NV sanitation systems is proposed as follows:

1. Capital costs: the capital cost discounted over the life of each tank option.
2. Operating cost: the cost of operating vacuum trucks and treating the wastewater (in the case of conservancy tanks) or sludge (in the case of septic tanks).
3. Greenhouse gas emissions:
    a. Quantity of methane emissions from tanks.
    b. Quantity of carbon dioxide emissions from vacuum trucks.
    c. Quantity of emissions associated with wastewater treatment (Methane, nitrous oxide and carbon dioxide)
4. Stormwater pollution: assessment of number of overflows per year combined with the relative organic content of the overflow water.
5. Groundwater pollution: Risk of pollutants reaching the lagoon, taking into consideration the type of pollutant.
6. Organisational impact on municipality: A relative rating on how much time is required by management and administration staff to manage each of the two tank options.
7. Household administrative requirements: A relative rating on the extent of administration required by a household to manage the tank system on their properties (call outs, payments etc).

3.2 Dynamic assessment

The assessment needs to look at likely trends in the future considering the change in impact of each of the tank options. Here the long-term need for additional investments (primarily vehicles but also wastewater treatment capacity) is a factor as is the need of increased management capability and household administration.

4 Technical assessment

This section deals with the hydraulic and organic load from each tank system considering a single property.

4.1 System load

The table below gives key parameters with yellow cells being inputs to the analysis:

Number of people on property		6
Time in residence	% of year	20%
Water per capita per day	l/cap/d	75
Return flow factor (% water entering sewer)		70%
Wastewater per capita per day	l/cap/d	52
Organic load concentration	mgCOD/l	1,500
Organic load per capita per day	g/cap/d	79

The figure of organic load of 79g/cap/d is relatively low in relation to figures in the literature of 100g/cap/d but is accepted for this analysis.

4.2 Septic tank load characteristics

Table below gives key parameters for septic tanks (yellow cells are inputs).

Sludge build-up in septic tank	l/cap/d	0.08
Build up per year - biological	litres/yr	35
Add for sand & other non-biodegradable		50%
Total sludge per year	litres/yr	53
Septic tank volume	litres	2,500
% full when emptying		50%
Years to emptying (theory)		21
Practical period between emptying	years	10
COD of digested sludge	mg/litre	45,000

Sludge build-up figure is taken from:

- GA Norris. c1995. "Sludge build-up in septic tanks, biological digesters and pit latrines in South Africa" WRC Report No. 544/1/00.

The concentration of organics in sludge from septic tanks, as measured by Chemical Oxygen Demand (COD) is taken from:

- Phandi. 2026. "Understanding Faecal Sludge & Septage and its Characteristics".
- Carlos M. Lopez-Vazquez et al. c2012. "Co-treatment of Faecal Sludge in Municipal Wastewater Treatment Plants".

The result, in terms of sludge load (sludge taken to WWTW) from a septic tank for one property (or household) is:

kg COD per year to be treated	**kgCOD/hh/yr**	**1.58**
Liquid volume per year to be treated	**kilolitres/yr**	**0.25**

4.3 Conservancy tank load analysis

Key parameters for conservancy tanks:

Tank volume	litres	4,500
Emptying cycle with full house	days	14.29

The theoretical emptying cycle is 14.2 days with a full house (6 people and return flow ratio of 70%). Actual records kept by the municipality show:

- In December 2013 there were 142 collections from 89 properties (1.59 per property per month).
- For December 2019: 105 collections from 78 properties (1.34 per property per month).
- For January 2020: 121 collections from 61 properties (1.98 per property per month).

Obviously in none of these cases will all the houses be full for the whole month. The January figures are probably most relevant as tank volume build up will have started in December and could represent a whole month with full house. Therefore, the theoretical figure of 14 day emptying cycle with a full house is reasonable and is used in the analysis.

The results of the analysis show that the load from conservancy tanks (at the WWTW) for a typical property (or household) is:

kg COD per year to be treated	**kgCOD/hh/yr**	**34.5**
Liquid volume per year to be treated	**kilolitres/yr**	**23.0**

4.4 Tanker transport analysis

The tanker truck analysis has the following inputs (yellow) with results for one property assuming 20% occupancy (2.4 months a year on average which factors in B&Bs):

Capacity of tanker truck	litres	4,500
Distance to Kurland WWTW	km	15
Number of trips per year - cons tank	**trips/yr**	**5**
Number of trips per year - septic tank	**trips/yr**	**0.10**

5 Cost analysis

5.1 Capital costs

Key figures assumed are given below (yellow inputs, bottom row results):

	Unit	Septic tank	Conservancy tank
Cost of tank and soakaway	Rands	49,000	60,000
Discounted cost factors			
Period	Years	15	20
Discount rate		5%	5%
Discounted cost per year	**R pa**	**4,721**	**4,815**

Capital costs for septic tank and soakaway based on an actual price in 2024. Conservancy tank costs are taken to be in the range of R50,000 to R100,000.

5.2 Operating costs

Operating cost parameters per property served are shown below (inputs in yellow; other cells calculated):

		Septic tank	Conservancy tank
Tanker cost			
Tanker operating costs pr km	R/km	15	15
Tanker costs per year	**R pa**	**45**	**2,300**
Treatment costs			
Treatment cost for organic load	R/kgCOD	5	5
Treatment cost for hydraulic load	R/kl	1.5	1.5
Treatment cost pa organic	R pa	8	172
Treatment cost pa hydraulic	R pa	0.38	34
Total treatment cost per year	**R pa**	**8**	**207**

The operating costs for tankers are calculated based on the distance travelled and a cost per kilometre of R15/km. It is clear that the operating costs for conservancy tanks are far higher than for septic tanks.

5.3 Cost summary

Adding discounted capital cost to operating costs gives the following summary of the cost analysis:

		Septic tank	**Conservancy tank**
Capital cost discounted	R pa	4,721	4,815
Tanker operating cost	R pa	45	2,300
Treatment cost	R pa	8	207
Total	**R pa**	**4,774**	**7,321**

6 Environmental impact analysis

6.1 Greenhouse gas emissions

The table below provides key parameters and results of GHG emission calculations with notes on sources below the table.

		Septic tank	Conservancy tank
Tank on site			
Emissions per capita per year	kg/cap/yr	126	0
Tank emissions per household (adjusted for occupancy)	**kg/hh/yr CO2eq**	**151**	**0**
Tanker transport			
Truck emissions per ton-km	gCO2/t-km	307	307
Truck tonnage		7	7
Truck emissions per trip	kg/trip	64	64
Truck emissions per capita	kg/cap/yr CO2eq	1.	54.9
Truck emissions per household	**kg/hh/yr CO2eq**	**1.3**	**65.9**
Emissions at WWTW			
Emissions from all processes	kg CO2eq/cap/yr	36.1	36.1
Assumed % for septic and cons tank		5%	100%
WWTW emissions per capita	kg CO2eq/cap/yr	1.6	36.1
WWTW emissions per household	**kg/hh/yr CO2eq**	**1.9**	**43.3**
SUMMARY			
On-site emissions at tank	kg/hh/yr CO2eq	151	0
Tanker transport	kg/hh/yr CO2eq	1.3	65.9
Treatment at WWTW	kg/hh/yr CO2eq	1.9	43.3
Total	**kg/hh/yr CO2eq**	**155**	**109**

Tank emissions are calculated based on figures from:

- Harold L. Leverenz et al. 2011. "Evaluation of Greenhouse Gas Emissions from Septic Systems".
- Loi Tan Huynh et al. 2021. "Greenhouse Gas Emissions from Blackwater Septic Systems"

Methane is the most significant gas emitted from the point of view of climate change.

Tanker transport emissions for trucks per ton-km are taken from trucking literature.

Wastewater treatment emissions are calculated based on:

- Parravicini et al. 2016. "Greenhouse gas emissions from wastewater treatment works".

The results show higher emissions for septic tank systems compared to conservancy tank systems.

6.2 Stormwater pollution

The key parameters governing stormwater pollution are given below (yellow cells are assumptions):

	Septic tank	Conservancy tank
Overflows into stormwater system		
Number of tanks	288	102
Number of events per year	1	5
Seriousness of event (1-10)	2	4
Overall risk indicator	**7**	**196**

There is insufficient data available on the number of spills per year, assuming a 'spill' means either raw sewage or septic tank soakaway effluent reaches the stormwater channels along the roads. Based on local knowledge it is estimated that there is about one spill per year from septic tanks and five per year from conservancy tanks. In the case of conservancy tanks this will be a raw sewage spill. For septic tanks this is likely to be mostly seepage from under-performing soakaways, but it is possible that there are occasional spills from the digester tanks. In balance is considered that conservancy tank spills have a greater impact on stormwater quality and hence on the quality of water in the lagoon.

The net impact is taken as the number of spills divided by number of tanks (average spill rate) times the rating of the seriousness of the spill. Conservancy tanks have a greater impact on the surface water environment.

6.3 Groundwater pollution

Groundwater pollution is assumed to occur only from septic tank soakaways as the treated effluent from digesters enters the soil surrounding the soakaway. The impact of septic tank systems on groundwater is well researched, for example:

- William Robertson. 2021. "Septic System Impacts on Groundwater Quality" The Groundwater Project.

The primary pollutants and their passage through the soil can be summarised as follows:

- Bacteria and viruses are either trapped by the soil (bacteria) or adsorbed onto soil particles due to their result of their net negative surface charge,
- Phosphorus, in the form of phosphates is adsorbed onto solid particles.
- Nitrogen is oxidised to nitrates which can flow though the soil.

This means the only significant impact on groundwater which may reach the lagoon is from nitrates. Nitrates at the concentration likely at the lagoon are not harmful to health. And, given the levels of salinity of water in the lagoon, the concentration of nitrates from the groundwater will be virtually undetectable. Nevertheless, the risks from septic tanks are marginally higher than for conservancy tanks.

A summary of groundwater impact parameters is given below (yellow cells are assumptions):

	Septic tank	Conservancy tank
Risk to health (1-10)	0	0
Risk to pollution of lagoon (1-10)	2	0
Average (1-10)	**1**	**0**

7 Organisational impact on municipality

The arrangement for emptying tanks requires management by Bitou Municipality staff which requires time from the head of technical services, wastewater treatment works operators, vehicle workshop staff and HR staff responsible for tanker crews. It also requires finance to purchase vehicles and maintain them. The service is required for both septic tank and conservancy tank emptying but the scale of management required for conservancy tanks is much higher.

The organisational impact cannot be measured and hence reliance needs to be made on a rating by the head of technical services. This is done on a scale of 1 to 10, with a score of 10 being the system requiring the most organisational obligation – conservancy tanks – and one being zero obligation. At this stage a score of 3 is allocated to septic tanks, pending comment by the head of technical services.

8 Household administrative requirements

Property owners (households) have administrative obligations including organising tanker call outs and paying for callouts. In the case of septic tank systems there is also the need to monitor tanks and soakaways and replace systems roughly once every twenty years. Again, it is not possible to measure the scale of these obligations and the rating by households is required. But here again this is difficult as a household (property owner) only experiences one type of sanitation system. Therefore, the view of the ratepayer's association committee is taken, with provisional scoring as follows (one is no administration and 10 is highest level of administration):

- Highest level of administration required is for conservancy tanks as this involves call-out and payments throughout the year. Score 10.
- Septic tanks typically only require attention every few years. Score 3.

9 Results of static analysis

The methodology for the multi-criteria decision analysis (MCDA) identifies six criteria with the septic and conservancy tank options to be scored for each criterion on a scale of one to ten. On order to get a final result each criterion needs to be weighted based on its level of importance. This weighting is normally done by knowledgeable people. For this report the NV Ratepayers Association has proposed an initial weighting but this is subject to the final decision to be taken by the Bitou Municipality.

The results are shown in the table below.

Criterion	Measure	Indicator		Score (zero is best, 10 is worst)		Weighting
		Septic tank	Cons' tank	Septic tank	Cons' tank	
Cost	Rands per annum	4,774	7,321	6.5	10	55%
GHG emissions	kg/hh/yr CO2eq	155	109	10	7.1	5%
Stormwater pollution	Overall risk indicator	7	196	0.4	10	15%
Groundwater pollution	Overall risk factor	1	-	10.0	-	5%
Municipal admininstration	Rating by tech head			3	10	8%
Household administration	Rating by households			3	10	12%
Final score				**5.2**	**9.4**	**100%**

The results show that septic tanks are clearly favoured assuming the soil conditions on the site are favourable.

With an MCDA it is also useful to undertake 'swing weighting' to assess how the weighting changes the results. As the scoring shows that septic tanks are more favoured on four of the six criteria this means the weighting for the other two criteria – Greenhouse gas (GHG) emissions and groundwater pollution - would have to raised to a very high proportion to change the result. For example, if the weighting for GHG emissions and groundwater pollution were increased to 30%, cost was 25% and other criteria at 5%, the septic tank option would be favoured. However, this weighting is unbalanced as it has been noted that the groundwater pollution from septic tanks is minimal and the GHG emissions from septic tanks are small in relation to all the other emissions in the area associated with private vehicles and electricity use.

10 Dynamic analysis

Under the dynamic analysis the extent to which the situation will change in the future is considered should the Bitou Municipality continue with the policy to require all properties to have conservancy tanks. The following projections are proposed:

1. Bitou Municipality will need to invest in new tanker vehicles to cope with the increased proportion of conservancy tanks. This will increase load on the Kurland WWTW. It will also increase management obligations of technical staff in the municipality.
2. Households (property owners) will be faced with significant costs to replace currently functional septic tank systems which will also increase their administrative obligations.
3. The number of CT's in NV at present is approximately 102 out of 390 homes (26%).

   If Bitou's current policy to convert all homes to CT's continues to be enforced, all the negative aspects of this option will be exacerbated, specifically; GHG Emissions of tankers, load on the Kurland WWTW and risk of overflows and lagoon pollution as a result of inability to deliver a timeous extraction service.

4. As the process of conversion proceeds to its ultimate conclusion, the demand for tankers during peak season will rise from the current requirement of around 200 trips over Dec/Jan to ultimately around 800 over the same period. Ie 13 trips per day (daylight hrs only). Assuming that each tanker takes at least 2 hours to make a round trip, there would be a demand for a minimum of two tankers to be on the road continuously each day (7 days per week) during the peak season. Any hiccup in this service would likely result in overflows requiring emergency attention from other municipal departments and a seriously bad reaction from ratepayers and visitors to the area. There would be no room for error by Bitou Municipality in delivering the honeysucker service.
5. Although a number of studies have been done by Bitou Municipality, there doesn't appear to be any viable water borne sewerage option for NV on the horizon, for practical and cost reasons, so the insistence on conversion to CT's should not be regarded as a temporary solution. The practicality and safe and effective operation of septic tanks should be regarded as the best medium to long term solution, provided these are safely located, well-constructed and the densification of the township is avoided, as supported by the Bitou Municipality SDF.

Taking a long-term view, septic tanks are clearly favoured.

11 Conclusion

Given the sizes of properties in Natures Valley and the sandy soils which exist over most of the valley, septic tanks have proven to be a successful sanitation option over the past sixty years. However, it is accepted that where these tanks are adjacent to the lagoon or have soakaways on soil with a high clay content there have been adverse environmental impacts. But such environmental concerns do not apply to the balance of some 80% of properties in the Valley. The analysis presented in this report both from a static and dynamic point of view show clearly that for this roughly 80% of properties septic tanks are by far the better option.

The policy of Bitou Municipality to require conservancy tanks for all properties in Natures Valley (tied to the approval of building plans) is unnecessarily increasing financial and management obligations of the municipality and substantially increasing costs and administrative obligations faced by households in Natures Valley without, in balance, any environmental gains. Therefore, it is incumbent on the Bitou Municipality to review this policy.
