AN INDEPENDENT INVESTIGATION AND ADVISORY ON THE ROLE OF WATER, SANITATION AND HYGIENE IN THE 2023 CHOLERA OUTBREAK IN HAMMANSKRAAL, SOUTH AFRICA

WORK PACKAGE 4: WATER AND SANITATION SAFETY ASSESSMENT AND ENVIRONMENTAL MONITORING

Part 4: Assessment and Monitoring of Solid Waste and Sewer Overflows

Final Report to the
Water Research Commission

by

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RESEARCH
COMMISSION

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EXECUTIVE SUMMARY

BACKGROUND

This report is “Report number IV – Assessment and monitoring of solid waste and sewer overflows” and form part of “Work Package Four – Water and Sanitation Safety Assessment and Environmental Monitoring. The potential of illegal dumping of municipal solid waste as well as dysfunctional sewer systems on the potential spread of cholera is investigated.

AIMS

The main the aims of the project are shown below:

1. To identify potential sources of contamination caused by untreated sewerage or municipal solid waste dumped illegally.
2. Determine which of the identified areas poses a potential risk and obtain samples where sewerage and or waste comes into contact with water sources.

METHODOLOGY

Google earth was used to identify it as an illegal dump site as well as an uncontrolled sewer discharge. Each Source (S) was evaluated to determine if there is a Partway (P) to a Receptor (R), i.e. river, stream, pond or dam.

RESULTS AND DISCUSSION

Identification of sources

One hundred potential sources of contamination were identified with 16 targeted due to being identified as a risk level 4. The 16 high risk potential sources were linked to receptors such as rivers, streams, ponds or dams.

A team discussion determined the risk level for each site or area based on the table below.

Risk Level			
None	Low	Medium	High
1	2	3	4

Site sampling

The sites and areas identified as a high-risk level was targeted for sampling of pathways and/or receptors. Where possible, water samples were collected from these pathways or receptors and analysed in terms of microbiological and chemical constituents.

CONCLUSIONS

The microbiological and chemical analysis did not yield any positive results for cholera although several sites showed definite contamination from sewerage, including targeted pathogens. The illegal dump sites also have the potential to spread *V. cholerae* should it be present due to soiled nappies being disposed here.

RECOMMENDATIONS

The sewer system needs to be repaired and maintained and illegal dumps cleared whilst an adequate waste collection system should be implemented to curb illegal dumping.

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ACRONYMS & ABBREVIATIONS

Abbreviation	Meaning
P	Pathway
R	Receptor
S	Source

ACKNOWLEDGEMENTS

The project team thanks the following people for their contributions to the project.

Name	Affiliation
Cholera Advisory Panel	Various Institutions
Dr Eunice Ubomba-Jaswa (Research Manager)	Water Research Commission
Community Members	Hammanskraal

GLOSSARY

Illegal dump. An area where a community disposes of waste in a non-environmentally sound manner.

Pathway. A non-perennial stream of erosion gully that allows water to flow from a source to a receptor.

Receptor. Waterbody such as a dam or pond or a large perennial stream.

Source. For the purposes of this report the source is defined as an illegal dump site or sewer manhole overflowing.

CHAPTER 1: BACKGROUND

1.1 INTRODUCTION

This report investigates the potential of illegal dumping of domestic solid waste as well as dysfunctional sewer systems that may aid in the spread of cholera, or other similar diseases.

1.2 PROJECT AIM

Assess the functionality of waste management systems (including but not limited to solid waste and sewerage) within the designated outbreak areas.

1.3 SCOPE LIMITATIONS AND METHODOLOGY

The scope for the “Assessment and monitoring of waste and sewer overflows” was left to the project team to determine how best to achieve the desired outcome.

Due to the area that had to be covered, “Google Earth” was used to identify uncontrolled sewer discharge as well as illegal dump sites. Each Source (S) was evaluated to determine if there is a Partway (P) to a Receptor (R), i.e. river, stream, pond or dam.

Where sources were connected to receptors, the potential for contamination was assessed based on allocated risk levels. Sites were identified where samples were taken for analysis.

1. Obtain samples where sewerage and or waste comes into contact with water sources to specify the risk.

CHAPTER 2: IDENTIFICATION OF POSSIBLE CONTAMINATION SOURCES

2.1 INTRODUCTION

An extensive search was conducted on Google Earth to identify illegal dump sites and sewer overflows. This was done by searching the study area in a grid pattern, whereby illegal dumpsite can be easily identified since it is usually located on open areas within residential areas or on the outskirts of residential areas. Sewer overflows are easily identified when images taken during the winter month are viewed since overflows typically shows as green vegetation in an otherwise dry environment.

2.2 RESULTS FROM SEARCH

Figure 1 shows the 100 sites identified. Some of the sites are a combination of illegal dump site and sewer overflows and a number were marked as unknown for field verification.

2.3 CRITERIA FOR EVALUATION OF SITES IDENTIFIED

Once the potential Sources were identified, a team discussion determined the risk level for each site or area. Four risk levels ranging from none to high risk were considered for the evaluation of sites.

The following were considered for determining the risk level for each site:

- The likelihood of illegal waste dumps being infected with cholera is remote since these dumps contain very little organic matter that can act as a hibernating ground for the bacteria. These dumps mainly contain plastic; paper, metal cans, glass and cardboard and are mostly not conducive to the growth of bacteria. However, disposal of soiled nappies at these sites has the potential spreading disease.
- The possibility of such a dump being a place of growth medium for the pathogenic bacteria can increase during the rainy season but these dumps usually dry out quickly after a rain event. Hence, the most likely chance of spreading the bacteria is if an infected dump site has a pathway such as natural runoff ways, i.e. small non-perennial streams or erosion gullies down to a mainstream or river which flows to a dam or pond where water is being extracted.
- Other vectors that could contribute to the spread disease include inspects (typically flies), birds (often ibises) and rodents.
- Site where waste was dumped on street corners did mostly not have pathways.
- Some dumps are in old quarries that is filled with water during the rainy season which has the potential to spread the bacteria, should the waste dump be contaminated.
- Several illegal dumps are on the outskirts of residential areas and some of the sites are linked to a receptor stream or dam via a pathway erosion gully or non-perennial stream.
- A few street vendors have illegal dumps site at the back of their stalls and although these may be more conducive for bacterial growth due to potential increase of growth medium (spoiled food, offcuts etc.) These are potential high-risk areas, due to chances of transmission via unwashed hands or contaminated food. Due to the intrusive nature of sampling here, these sites were not considered.
- There are also several illegal dumps situated on or adjacent to school properties, these have also been classified as a medium risk.

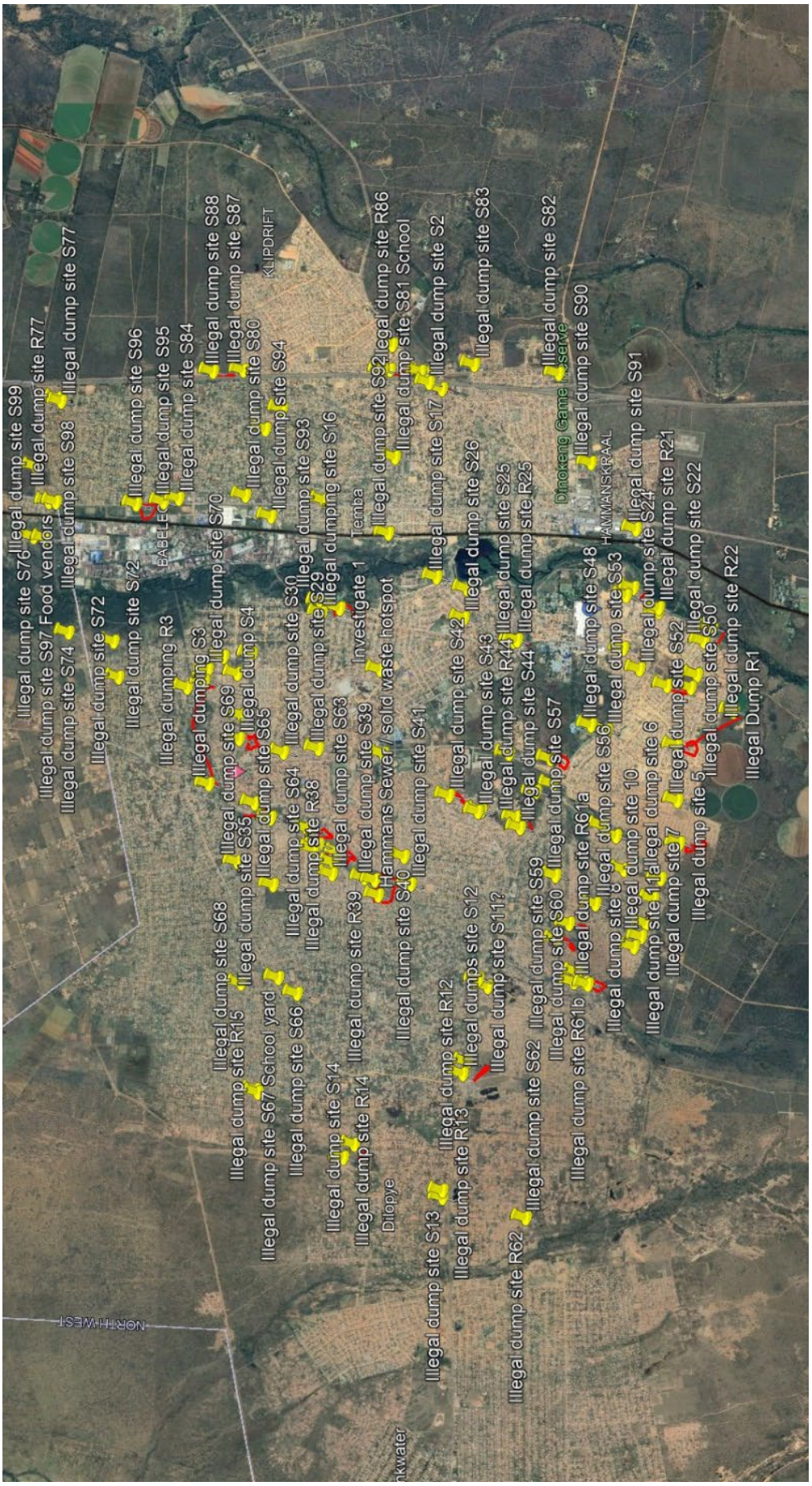

Figure 1: Map showing sewer overflows and illegal dump sites

2.4 SITE EVALUATION

The table below shows the sites that were identified for site investigation. A detailed table is shown in Appendix A of the report.

Table 1: Site identified for field investigation

Risk Level					
None	Low	Medium	High		
1	2	3	4		
Site	Source	Pathway	Receptor	Comment	Investigate
3	X	X	X	All purple sites linked	x
13	X	X	X		x
16	X	X	X		x
17	X			Adjacent to larger receptor	x
Inv	X			Adjacent to larger receptor	X
18	X			Adjacent to larger receptor	x
34	X	X	x	All purple sites linked	x
35	X	X	x	All purple sites linked	x
36	X	X	x	All purple sites linked	x
37	X	X	x	All purple sites linked	x
38	X	X	x	All purple sites linked	x
39	X	X	x	All purple sites linked	x
64	X	X	x	All purple sites linked	x
85	X	X	X		x
86	X	X	X		x
100	X	X	X	Sewer overflow	x

CHAPTER 3: SITE INVESTIGATION

3.1 SITE INVESTIGATION AND SAMPLING

The sites and areas identified as a high risk as shown in Table 1 in the previous section, were targeted for sampling of pathways or receptors. Where possible, water samples were collected from these pathways or receptors.

3.2 RESULTS FROM INVESTIGATION

Set out below are photographs showing the sites where field investigations were conducted as well as the microbiology and chemical test results of the samples taken for each site.

Site 13

Figure 2: Site 13 – Locality

Figure 3: Site 13 – Illegal dump site

Figure 4: Site 13 – Receptor

Test results for the samples received

MICROBIOLOGY TEST RESULTS			CHEMISTRY TEST RESULTS		
DETERMINANT	**UoM**	**R13**	**DETERMINANT**	**UoM**	**R13**
Total coliforms	MPN.100ml^{-1}	488000	Chemical oxygen demand (COD)	mg.L^{-1}	40.0
Escherichia coli	MPN.100ml^{-1}	17000	Electrical conductivity	mS.m^{-1}	*113.0*
Heterotrophic plate count	CFU.1ml^{-1}	68000	Ammonia-nitrogen (NH_3)	mg.L^{-1}	0.4
Salmonella enterica	Positive/Negative	Negative	pH		*7.9*
Shigella species and/or EIEC	Positive/Negative	Negative	Comment: Results acceptable No cholera		
Toxigenic *Vibrio cholerae* (*ctxAB*+)	Positive/Negative	Negative			

Site 16 and Site for investigation

Figure 5: Site 16 – Locality

Figure 6: Site 16

Figure 7: Site for investigation

Test results for the samples received

MICROBIOLOGY TEST RESULTS				CHEMISTRY TEST RESULTS			
DETERMINANT	**UoM**	**R16**	**INV1**	**DETERMINANT**	**UoM**	**R16**	**INV1**
Total coliforms	MPN.100ml^{-1}	>24 200	>2 420 000	Chemical oxygen demand (COD)	mg.L^{-0}	26.0	44.0
Escherichia coli	MPN.100ml^{-1}	*24200*	276000	Electrical conductivity	mS.m^{-0}	118.0	86.0
Heterotrophic plate count	CFU.1ml^{-1}	184000	2 350 000	Ammonia-nitrogen (NH_3)	mg.L^{-0}	0.5	**10.9**
Salmonella enterica	Positive/Negative	***Positive***	Negative	pH		8.4	7.3
Shigella species and/or EIEC	Positive/Negative	*Negative*	***Positive***	Comment: Both microbiology (Salmonella and Shigella) and Chemistry results (INV NH_3) are indicative of sewerage contamination. *V. cholerae* negative.			
Toxigenic *Vibrio cholerae* (*ctxAB*+)	Positive/Negative	Negative	Negative				

Site 85 and 86

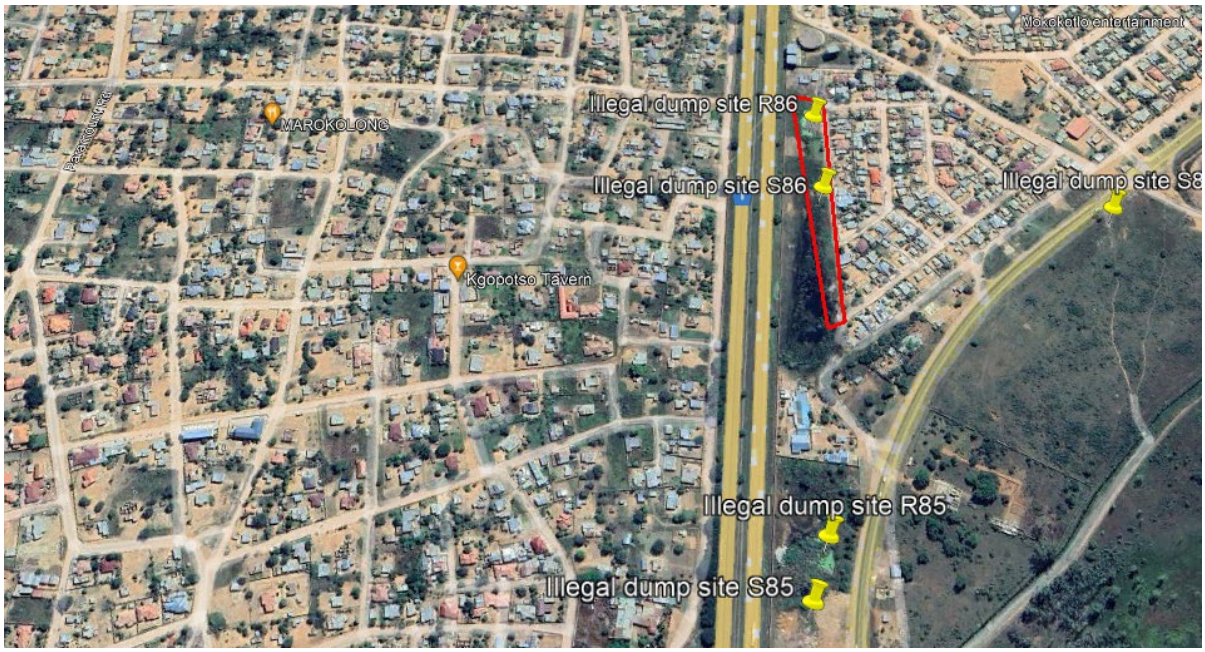

Figure 8: Site 85 & 86 – Locality

Figure 9: Site 85

Figure 10: Site 86

Test results for the samples received

MICROBIOLOGY TEST RESULTS				CHEMISTRY TEST RESULTS			
DETERMINANT	**UoM**	**R85**	**R86**	**DETERMINANT**	**UoM**	**R85**	**R86**
Total coliforms	MPN.100ml^{-1}	>2 420	10460	Chemical oxygen demand (COD)	mg.L^{-0}	38.0	35.0
Escherichia coli	MPN.100ml^{-1}	18	400	Electrical conductivity	mS.m^{-0}	181.0	*134.0*
Heterotrophic plate count	CFU.1ml^{-1}	40000	58000	Ammonia-nitrogen (NH_3)	mg.L^{-0}	0.5	4.1
Salmonella enterica	Positive/Negative	Negative	Negative	pH		8.2	*8.3*
Shigella species and/or EIEC	Positive/Negative	Negative	Negative	Comment: Chemistry results of R86 (NH_3) indicative of potential sewerage contamination. *V. cholerae* negative.			
Toxigenic *Vibrio cholerae* (*ctxAB*+)	Positive/Negative	Negative	Negative				

Linked sites – 3, 34, 35, 36, 37, 38, 39, 64, 100 (Solid waste hot spot)

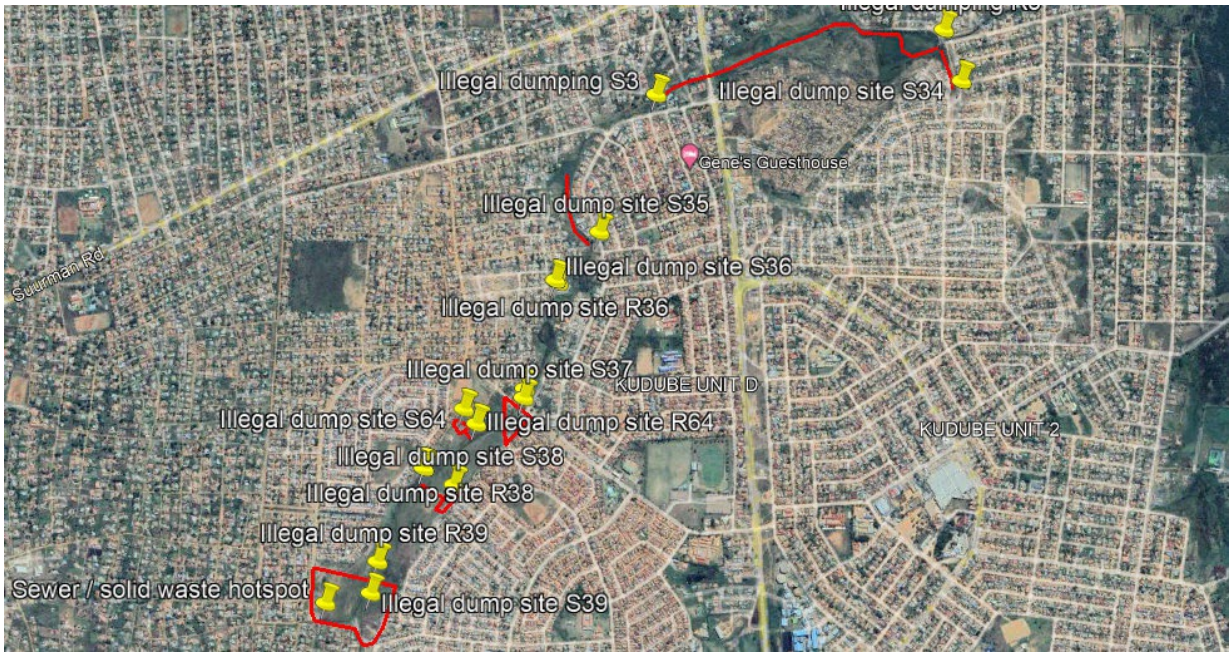

Figure 11: Site 85 & 86 – Locality

Figure 12: Site 3

Figure 13: Site 3

Figure 14: Site 36

Comment: Illegal dump site S39 at the source of a natural stormwater stream links a number of other identified sites downstream to S3. Samples along this linkage was composited and analysed as for the other sites.

MICROBIOLOGY TEST RESULTS			CHEMISTRY TEST RESULTS		
DETERMINANT	**UoM**	**R7, S3 & R39**	**DETERMINANT**	**UoM**	**R7, S3 & R39**
Total coliforms	MPN.100ml^{-1}	21400	Chemical oxygen demand (COD)	mg.L^{-1}	<10.0
Escherichia coli	MPN.100ml^{-1}	5900	Electrical conductivity	mS.m^{-1}	*82.0*
Heterotrophic plate count	CFU.1ml^{-1}	105000	Ammonia-nitrogen (NH_3)	mg.L^{-1}	0.2
Salmonella enterica	Positive/Negative	Negative	pH		*8.2*
Shigella species and/or EIEC	Positive/Negative	Negative	Comment: Results acceptable *V. cholerae* negative.		
Toxigenic *Vibrio cholerae* (*ctxAB*+)	Positive/Negative	Negative			

3.3 GENERAL COMMENTS

The following should be noted regarding monitoring of Sites 17 and 18.

- Site 17 already monitored at receptor – down stream of Dam
- Site 18 already monitored at receptor – Sample taken before inflow into dam, the dam was also sampled.

CHAPTER 4: CONCLUSIONS & RECOMMENDATIONS

4.1 CONCLUSIONS

The following can be concluded from the site investigation and sampling.

Table 2: Conclusions

Site	Conclusion
Site 13	No evidence of microbial contamination or the presence of *V. cholerae*.
Site 16 and Site for Investigation	Both microbiology (Salmonella and Shigella – Site 16 and INV) and chemistry results (NH_3 – INV) are indicative of sewerage contamination. *V. cholerae* was not detected.
Site 85 & 86	Chemistry results of R86 relating to NH_3 is indicative of potential sewerage contamination. *V. cholerae* was not detected.
Linked sites	No evidence of microbial contamination or the presence of *V. cholerae*.

Based on the sampling and analysis conducted*, V. cholerae* was not found at any of the respective monitoring points.

There is however evidence of chronic sewerage contamination caused by leaking sewerage lines or manholes. These could potentially serve as a pathway for cholera. Other pathogens that cause gastro-intestinal disease, including salmonella and shigella were in fact detected.

Nappies are disposed of at several of the illegal dump sites. If contaminated nappies are disposed of at these sites, it could lead to the spread of diseases when conditions are favourable.

4.2 RECOMMENDATIONS

A concerted effort should be made to maintain sewerage infrastructure to avoid a potential pathway for the spreading of diseases. A proper waste collection system should also be implemented to avoid illegal dumping of municipal solid waste.

APPENDIX 1: LIST OF SAMLING POINTS

Risk Level						
None	Low	Medium	High			
1	2	3	4			
Site	Source	Pathway	Receptor	Linked	Comment	Investigate
1	x	x	x			
2	x	x	x			
3	x	x	x		All purple sites linked	
4	x		x			
5	x					
6	x					
7	x					
8	x					
9	x					
10	x					
11a	x					
11	x	x	x			
12	x	x	x			
13	x	x	x			x
14	x	x	x			
15	x	x	x			
16	x	x	x			x
17	x				Adjacent to larger receptor	x
Inv	x				Adjacent to larger receptor	x
18	x				Adjacent to larger receptor	x
19	x					
20	x	x	x			
21	x	x	x			
22	x	x	x			
23	x					
24	x					
25	x	x	x			
26	x					
27	x					
28	x					
29	x					
30	x					
31	x					
32	x					
33	x					
34	x	x	x		All purple sites linked	
35	x	x	x		All purple sites linked	
36	x	x	x		All purple sites linked	
37	x	x	x		All purple sites linked	
38	x	x	x		All purple sites linked	
39	x	x	x		All purple sites linked	
40	x					
41	x					
42	x					
43	x		x			
44	x	x	x			
45	x					
46	x					
47	x					
48	x					
49	x					
50	x					
51	x					
52	x					
53	x					
54	x					
55	x					
56	x					
57	x					
58	x					
59	x					
60	x					
61	x	x	x			
62	x	x	x			
63	x					
64	x	x	x		All purple sites linked	
65	x					
66	x					
67	x				In school yard	
68	x					
69	x					
70	x					
71	x					
72	x					
73	x					
74	x					
75	x					
76	x					
77	x	x	x			
78	x					
79	x					
80	x					
81	x				In school yard	
82	x					
83	x					
84	x				Street vendor	
85	x	x	x			
86	x	x	x			x
87	x					
88	x					
89	x					
90	x					
91	x					
92	x					
93	x					
94	x					
95	x					
96	x					
97	x				Street vendor	
98	x					
99	x					
100	x	x	x		Sewer overflow	x

APPENDIX 2: LABORATORY RESULTS

Company: Virtual Consulting Engineers
Address: 57 George Storrar Drive,Groenkloof
Pretoria
0181
Tel No: (012) 452 0444

Project No: VIRTUAL_CONSU-20230629

Date Sample Received: 2023/06/29
Certificate Date: 2023/07/06

CHEMICAL ANALYSIS

Date Analysed:		2023/07/03 - 2023/07/05					
Sample Number:		1	2	3	4	5	6
Sample Name:		R13	R16	SB3	SB6	SB8	ENV1
Sample Date and Time:		2023/06/29	2023/06/29	2023/06/29	2023/06/29	2023/06/29	2023/06/29
Lab Number:		2388777	2388779	2388781	2388783	2388785	2388787
Sample Description:		Water	Water	Water	Water	Water	Water
Sample Container:		500ml plastic bottle	500ml plastic bottle	500ml plastic bottle	500ml plastic bottle	500ml plastic bottle	500ml plastic bottle
Determinant (unit)	Method Number						
Ammonia Nitrogen (mg/L N)	EL268	0.4	0.5	0.5	4.1	21.6	10.9
Chemical Oxygen Demand (mg/L O2)	EL 18	40	26	38	35	60	44
Conductivity (mS/m @ 25°C)	EL 1	113	118	181	134	127	86
pH	EL4	7.9	8.4	8.2	8.3	7.9	7.5

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0181
Tel No: (012) 452 0444

Project No: VIRTUAL_CONSU-20230629

Date Sample Received: 2023/06/29
Certificate Date: 2023/07/05

CHEMICAL ANALYSIS

Date Analysed:		2023/07/03 - 2023/07/05
Sample Number:		7
Sample Name:		R3,R3 and R59 (combined)
Sample Date and Time:		2023/06/29
Lab Number:		2385789
Sample Description:		Water
Sample Container:		2L plastic bottle
Determinant (units)	Method Number	
Ammonia Nitrogen (mg/L N):	EL269	0.2
Chemical Oxygen Demand (mg/L O2):	EL 18	<10
Conductivity (mS/m @ 25°C):	EL 1	82
pH	EL4	8.3

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Project No: VIRTUAL_CONSU-20230629

Date Sample Received: 2023/06/29
Certificate Date: 2023/07/06

MICROBIOLOGICAL ANALYSIS

Date Analysed:		2023/06/29 - 2023/07/02					
Sample Number:		1	2	3	4	5	6
Sample Name:		R13	R16	R85	R86	S18	INV1
Sample Date and Time:		2023/06/29	2023/06/29	2023/06/29	2023/06/29	2023/06/29	2023/06/29
Lab Number:		2388777	2388779	2388781	2388783	2388785	2388787
Sample Description:		Water	Water	Water	Water	Water	Water
Sample Container:		500ml plastic bottle	500ml plastic bottle	500ml plastic bottle	500ml plastic bottle	500ml plastic bottle	500ml plastic bottle
Determinant (units)	Method Number						
E.coli (MPN/100mL)	EM 9	17000	24200	18	400	1046000	276000
Heterotrophic Plate Count (cfu/1mL)	EM 3	68000	184000	40000	98000	1880000	2330000
Total Coliforms (MPN/100mL)	EM 9	488000	>24200	>2420	10460	>2420000	>2420000

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Project No: VIRTUAL_CONSU-20230629

Date Sample Received: 2023/06/29
Certificate Date: 2023/07/06

MICROBIOLOGICAL ANALYSIS

Date Analysed:		2023/06/29 - 2023/07/02
Sample Number:		7
Sample Name:		R3,S3 and R39 (combined)
Sample Date and Time:		2023/06/29
Lab Number:		2386739
Sample Description:		Water
Sample Container:		2L plastic bottle
Determinant (units)	Method Number	
E.coli (MPN/100mL)	EM 9	5900
Heterotrophic Plate Count (cfu/1mL)	EM 3	101000
Total Coliforms (MPN/100mL)	EM 9	21400

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Tel No: (012) 452 0444

Project No: VIRTUAL_CONSU-20230629

Date Sample Received: 2023/06/29
Certificate Date: 2023/07/06

PCR ANALYSIS

Date Analysed:		2023/06/29 - 2023/06/30					
Sample Number:		1	2	3	4	5	6
Sample Name:		RL3	RL6	RS5	RS6	SI5	INV1
Sample Date and Time:		2023/06/29	2023/06/29	2023/06/29	2023/06/29	2023/06/29	2023/06/29
Lab Number:		2388777	2388779	2388781	2388783	2388785	2388787
Sample Description:		Water	Water	Water	Water	Water	Water
Sample Container:		100ml plastic bottle	100ml plastic bottle	100ml plastic bottle	500ml plastic bottle	100ml plastic bottle	500ml plastic bottle
Determinant (units)	Method Number						
Salmonella enterica	PCR 1	Negative	Positive	Negative	Negative	Negative	Negative
Shigella species and/or Enteroinvasive E. coli	PCR 3	Negative	Negative	Negative	Negative	Positive	Positive
Toxigenic Vibrio cholerae	PCR 2	Negative	Negative	Negative	Negative	Negative	Negative

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Project No: VIRTUAL_CONSU-20230629

Date Sample Received: 2023/06/29
Certificate Date: 2023/07/06

PCR ANALYSIS

Date Analysed:		2023/06/29- 2023/06/30
Sample Number:		7
Sample Name:		R3,33 and R39 (combined)
Sample Date and Time:		2023/06/29
Lab Number:		2338789
Sample Description:		Water
Sample Container:		1L plastic bottle
Determinant (Units)	Method Number	
Salmonella species	PCR 1	Negative
Shigella species and/or Enteroinvasive E. coli	PCR 3	Negative
Toxigenic Vibrio cholerae	PCR 2	Negative

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