3 Findings and recommendations

3.1 Objectives of pilot projects

The objectives of pilot projects are described as below table.

Table 3-1: The objectives of pilot projects

PP site	Objective	Detail
Kurunegala MC	■ Verify the outcome of STREPS as the appropriate technics for proper management of final disposal site.	■ Filter the ground water by using Permeable Reactive Barrie (PRB)
Rathnapura MC	■ Verify the method of 3Rs promotion	■ Improvement of source reduction, separate discharge, separate collection transportation, and public awareness.
Katharagama PS	■ Verify the outcome of STREPS as the appropriate technics for proper management of final disposal site. ■ Verify the method of 3Rs promotion	■ Expansive clay liner system as local available material. ■ Improvement of source reduction, separate discharge, separate collection transportation, and public awareness.

3.2 Findings and recommendations

The details of findings and recommendations at each pilot project are discussed in the below table.

Table 3-2: details of findings and recommendations at each pilot project

	Findings	Recommendation
Kurunegala MC (PRB)	✓ PRB seems to contribute to improve the water quality of some parameters. ✓ There are not so many borrow pits of Bangadeniya soil material. ✓ No heavy metal at up stream and down stream monitoring wells is detected before and after installation of PRB	Design stage ✓ Check the availability of clay soil during the design stage. ✓ Consider material alternative. Operation stage ✓ Replacement of PRB material is not required before 6years. But in case heavy metal is detected, PRB material should be replaced
Kataragama PS (Clay liner)	✓ Construction of clay liner system is easier than HDPE liner system. ✓ There are not so many borrow pits of expansive clay ✓ Bentonite cost causes rising of total construction cost ✓ Clay liner is eroded by storm water	Design stage ✓ Check the availability and distance of expansive clay material. ✓ Cost comparison between clay liner and HDPE liner system Construction stage ✓ Top soil or protection sheet should cover liner system to avoid erosion

	Findings	Recommendation
Kataragama PS (3Rs)	✓ Starting with simple 2-category separation of bio-degradable and non-biodegradable wastes was easy to be accepted, with proving ample information ✓ Starting with separation of bio-degradable waste made it easier to further separate other recyclables at the recycling facility as well as at the discharging points. ✓ For bio-degradable waste separation, distribution of separation bins which are in appropriate size and quality for both dischargers and collection workers, was an encouraging element.	✓ Collection crew's strong commitment to keeping the rules during operation is necessary, being the first counter face with dischargers. ✓ Allocation of field staffs, while maintaining close communication with the official in charge of SWM of the local government, to monitor the collection service and discharging practice is essential especially in the early stage of implementation when people need to understand and get used to the details of the rules.
Rathnapura MC (3Rs)	✓ Starting with bio-degradable waste and 5-category separation of bio-degradable and non-biodegradable wastes has been accepted, with proving ample information and equipment such as bio-degradable separation bin, poly sack bag and three wheeler. ✓ Some data at Kanadra compost plant is not so accurate because of some human error. ✓ Malfunction of skid loader gives serious negative impact to compost plant operation for long time. ✓ According to public opinion survey, the knowledge interesting and intention of SWM cooperation are increased.	✓ The capacity of compost treatment should be developed for increasing the amount of separated bio-degradable waste. ✓ The weigh bridge should be installed to get accurate data of in-coming amount of waste. ✓ Several monitoring such as separation of recyclable waste, home compost, collection schedule should regularly be conducted. ✓ The final disposal site should be established as soon as possible.

4 General recommendations

General recommendations based on the project are summarized as below;

(1) Imposing bylaws and all relevant parties extend their support to enforcement of laws and by-laws related to SWM is required.

(2) Strong supporting hand to LA by PC, CEA and government in terms of disposal site technical knowhow, budget and monitoring is essential. To make clear the duty, role of stakeholders, budget and schedule, SWM Master Plan project of national and provincial level is expected.

(3) Updating of action plan of solid waste management for short term to make clear targets, roles and duty of each stakeholder is necessary.

(4) 3 Category (Biodegradable, recyclables and others) separation is essential at first step of 3Rs .

(5) Enhancement of capacity of compost plant with developed technology is essential to facilitate 3Rs.

(6)Development the current recycling system in terms of society and business field is important to facilitate 3Rs. Not only to facilitate 3Rs but also to establish material cycle society, development of recycling system project is expected.

5 Others

5.1 Study tour at Shibushi city and Fukuoka city in Japan

The counterpart of CEA, Kurunegala MC and Kataragama PS visited Shibushi City and Fukuoka City in a self-funded trip to observe Solid Waste Management from 29January2018 to 3February2018.

5.1.1 Participant

The participant list is shown in the table below.

Table 5-1 : Participant list of the study tour

No.	Name	Title
Central Environmental Authority: CEA (Group 1)		
1	Pathiranage Buddhika Hemantha JAYASINGHE	Director General: DG
2	Upali Indrarathna JAYASEKARA MUDALIGE	Deputy Director General (DDG), Waste management
Kurunegala Municipal Council: KMC (Group 2)		
3	Pradeep Nishantha Tilakaratne NUWARA PAKSHAGE	Commissioner
4	Ratnayake Mudiyanselage Shishirodha RATNAYAKE	Medical Officer of Health: MOH
5	Lal Ranjith WETHTHASINGHE	Health Supervisor
6	Dayarathna Rajapakse RAJAPAKSE DEWAGE	Public Health Inspector: PHI
7	Nalaka Arjuna Bandara RANAMUKA ARACHCHILLAGE	Engineer
Kataragama Pradeshiya Sabhas: KPS (Group 2)		
8	Lal Jayathilaka KODITUWAKKU LIYANARACHCHI	Secretory
9	Sarath Bandula KARUNASINGHE DEVALAGE	Development officer
EX Research Institute Ltd.		
10	G S Nayana Kanthi Madhugeethika Jagath SAMARAWEERA	Consultant
11	Layan Sampath WICKRAMARATHNA GUNASEKARA	Consultant
12	Naofumi SATO	Senior consultant
13	Chiharu Iida	Consultant

5.1.2 Schedule

The schedule of study tour is shown in the below table.

Table 5-2: Schedule of the study tour

No	Date	Detail	Person no.	Stay
1	27 Jan(Sat)	Group 1 UL454	1,2	-
2	28 Jan (Sun)	Group1 Arrive. Narita	1,2	Shinjuku
		Group2 UL454	3-11	-
3	29 Jan(Mon)	Group 2 Arrive Narita, Travel Narita-Haneda	3-11	-
	a.m.	Group 1 Courtesy call MoE, JICA	1,2,12	-
	p.m.	Group 1 meets Group2 Travel Haneda-Kagoshima Travel Kagoshima- Shibushi	1-13	Shibushi
4	30 Jan(Tue)	Briefing of SWM at Shibushi city Site visit at “SO” recycling centre Site visit at final disposal site	1-13	Shibushi
5	31 Jan(Wed)	Site visit at collection place for kitchen waste, other waste Observe “Environmental Patrol” activity Site visit at Compost plant Wrap up meeting	1-13	Shibushi
6	1 Feb (Thru)	Move : Shibushi-Kagoshima JR station	1-13	
		Move ： Kagoshima JR station – JR Fukuoka station	1-13	Fukuoka
7	2 Feb(Fri) a.m.	Site visit at Waste to Energy facility Site visit at sanitary landfill site	1-13	-
	p.m.	Move: Fukuoka-Haneda-Narita	1-13	Narita (No.1-12)
8	3 Feb(Sat)	Travel: UL455	1-11	-

5.1.3 Courtesy call to Ministry of Environment Japan（29Jan. 2018）

Pathiranage Buddhika Hemantha JAYASINGHE (Director General）, Upali Indrarathna JAYASEKARA MUDALIGE（Deputy Director General）and Naofumi Sato (Chief consultant) visited the Ministry of Environment Japan as a courtesy call. Main topic during discussion is as follows;

(1) Individual Recycling Law of Japan (English version)

There is no “Individual Recycling Law of Japan (English version)”, but English summary of it can be shared.

(2) Method of monitoring of proper municipal solid waste management in Japan

The current status of operation and maintenance of waste treatment facility must be announced officially in accordance with Waste Management Law Chapter 8, Clause 3. In case that waste treatment facility is not operated well in accordance with Waste Management Law Chapter 9, Clause 2. Province orders the execution body of waste treatment to improve it. The operation and maintenance of municipal waste treatment facility is monitored under the Ministry of Environment, Provincial government and Local government.

5.1.4 Briefing of solid waste management of Shibushi city (30Jan. 2018)

Main topic of the presentation and discussion were as follows;

- 25% of collected waste is discharged at final disposal site, while 75% of it becomes recyclable material
- The volume of discharged waste was drastically reduced since the separation of kitchen waste started in 2004.
- Role and duty of health committee
- At the beginning, separation of waste was requested
- Role of environmental committee
- Annual monitoring form submitting to Ministry of Environment Japan

Briefing

Group photos in front of Shibushi city office

5.1.5 “SOH” recycling centre (30th Jan. 2018)

Main topic of discussion were as follows;

- Machine of volume reduction of styrene foam
- Buyer and selling price of recycling company

- Bio diesel system
- Population of waste generation, amount of recyclable waste, number of staff working there, consumption of electricity, capacity and price of sorting machine

Site visit at “SO” recycling centre

5.1.6 Final disposal site and leachate treatment facility (30th Jan. 2018)

Main topic of discussion were as follows;

- Amount and types of waste discharging (Discharge of ash from incinerator is strictly prohibited according to category of registration.）
- Liner sheet material
- Storm water drain and gas removal facility
- Relationship between annual precipitation and size of leachate treatment facility

Sanitary Landfill Site and Leachate treatment facility

5.1.7 Collection place and collection rule for the discharged kitchen waste and others （31st Jan. 2018)

Main topic of observation and discussion are described as below;

- Frequency of collection: kitchen waste 3 days per week, other waste 1day per week, and recyclable waste 1day per month
- Subcontracting company collects waste and manage (1) collection route (2) schedule at collection place
- No limitation of discharge time
- Collected kitchen waste bucket is replaced to empty bucket
- Name of discharger is written in the other waste plastic bag.
- The cost of making calendar which mentions collection schedule is supported by commercial advertisement, and it is distributed to citizens free of charge
- Sticker for illegal discharging
- Role of health committee
  - ➢ Only health committee member can discharge
  - ➢ Management of collection place
  - ➢ Instruction of discharge rule, etc.

Observation of kitchen waste and other waste collection

Observation of environmental patrol activities

5.1.8 Compost plant (31st Jan. 2018)

Main topic of observation and discussion are described as below;

- Process: receiving bio-degradable waste->chopping->composting->packing
- Weight ratio between kitchen waste and garden waste = 1:1, volume = 1:3~4

  mixing after chopping both
- Temperature 80C during decomposition period
- Turning of compost pile starts after 4-5 days after receiving waste. Mechanical aeration operates for 24hrs
- Purpose of adding Lactic acid bacteria is to deodorize

Observation of compost plant

5.1.9 Wrap up meeting at Shibushi LA (31st Jan. 2018)

Discussion and comment at wrap up meeting are described as below;

Name	Comment
Mr. Jayasinghe, DG, CEA	(1) There is a big gap of citizen's behaviour between Japan and Sri Lanka. Community engagement in Sri Lanka is still poor. (2) Capacity development of SWM sector of Provincial level and LAs level is essential (3) The progress of 3Rs promotion is not enough in Sri Lanka (4) The SWM business, particularly recycling market, is established well in Japan. Since the establishment of systematic recycling market is necessary and urgent in Sri Lanka, the Shibushi LA is kindly requested to support the establishment of it. (5) The target of SWM in Sri Lanka is to achieve recycling society for sustainable development.
Mr. Indrarathna, DDG, CEA	(1) Compere to Japanese SWM, there are still many issues of optimization of SWM, such as collection of waste, operation of compost plant and so on in Sri Lanka. (2) Enforcement for SWM for all stakeholders in Japan functions well.

Name	Comment
	(3) Since the basic infrastructure for SWM is not enough in Sri Lanka, it must be developed within the 5 years. (4) Accountability for citizens and participation of citizens are functioning well in Japan.
Mr. Pradeep, Commissioner, KMC	Based on this study tour experience, I would like to formulate proper SWM policy expected by Sri Lankan citizens.
Dr. Ratnayake, MOH, Kurunegala MC	(1)The collection coverage ratio in MCK does not yet reach 100%. (2)Because of lack of equipment and facility of SWM, lot of labourer are needed. (3)Most Japanese citizens are honest, cooperative for participation of 3Rs activity.
Mr. Lal Jayathilaka, Secretary, Kataragama PS	The improvement and development of SWM in KPS is quite essential. Same Shibushi model must be introduced and established in KPS as well.
Mr.Nishikawa Director of Environement Department	• It is difficult to separate 29 category wastes same as Shibushi LA from the beginning. <There two important considerations> 1. To achieve 100% collection coverage ratio, it means that to provide collection service to all citizens is first priority. 2. To separate kitchen waste is the second priority other than separation of other recyclable material after achievement of 100% collection <Request> 1. Your experience in Shibushi LA is requested to share with your colleagues. 2. The establishment of even small scale of Shibushi model in Sri Lanka is requested to share its idea to many stakeholders.

5.1.10 Waste to Energy facility and sanitary landfill site of Fukuoka city（2 Feb. 2018）

Counterpart visited Waste to Energy facility and sanitary landfill site of Fukuoka city

Observation of Waste to Energy facility and sanitary landfill site of Fukuoka city

5.2 Study tour in Shibushi Cityn and Nerima Ward, Japan

5.2.1 Participants

The participant list is shown in the table below.

Table 5-3: Participant list of the 2nd study tour

No.	Name	Title
Uva Provincial Council		
1	Mangala Mihilal WIJENAYAKE	Commissioner of Local Government (Uva)
2	Nandasiri Dissanayake DISSANAYAKE MUDIYANSELAGE	Assistant Commissioner of Local Government
Kataragama Pradeshiya Sabhas (KPS)		
3	Puhul Walla Gamage CHANAKA AMIL RANGANA	Chairman
4	Bhathiya Madhusanka GALLE WATHTHAGE	Member of Council
Sabaragamuwa Provincial Council		
5	Bamunu Arachchige Chamara Premanath BAMUNU ARACHCHI	Commissioner of Local Government (CLG)
Rathnapura Municipal Council (RMC)		
6	Tiron Hirantha Attanayake ATTANAYAKE MOHOTTALALAGE	Mayor
7	Aruna Sanjeewa Jayanadha GODELLAWATHTHA	Commissioner
8	Gamini NIVITIGALA BOWATTALAGE	Medical Officer of Health (MOH)
9	Nuwan Prasanna Chandrasena MAGAMMANAGE	Engineer
10	Anura Piyarathna LIYANA ARACHCHILLAGE	Chief Public Health Inspector (CPHI)
Rathnapura Municipal Council (RMC)		
11	Thushara Sanjeewa VITHARANA	Mayor
12	Sumith Kumara UDAWASALAGE	Deputy Mayor
13	Aruna Shantha Sumedha BORUPPAGE DON	Member of Council
14	Thiyagarajah KRISHNAPALAN	Member of Council
15	Ehalagaha Waththe Gedara Rohana Priyantha SAMARAKOON	Additional Medical Officer of Health (AMOH)
EX Research Institute Ltd.		
16	G S Nayana Kanthi Madhugeethika Jagath SAMARAWEERA	Consultant
17	Naofumi SATO	Senior consultant
18	Chiaki Nishi	Consultant
19	Kazuki Kobayashi	Ph D. student, Intern

5.2.2 Schedule

The schedule of study tour is shown in the below table.

Table 5-4: Schedule of the 2nd study tour

No.	Date		Schedule
1	30-Jul-18	Mon	Arrive Narita airport JICA curtesy call
2	31-Jul-18	Tue	Study tour: collection system, 3Rs and Incineration in Nerima Ward in Tokyo
3	1-Aug-18	Wed	Move: Haneda airport- Kagoshima airport-Shibushi Meeting at Shibushi city hall
4	2-Aug-18	Thu	Study tour: SWM Shibushi
5	3-Aug-18	Fri	Study tour: SWM Shibushi wrap up meeting
6	4-Aug-18	Sat	Move: Shibushi-Kagoshima airport-Haneda

5.2.3 Briefing of solid waste management of Nerima Ward, Nerima Incineration Plant and Hikarigaoka apartment complex (31 July 2018)

The officer of Nerima Ku explained the outline of SWM in Nerima, particularly the public participation from Hikarigaoka apartment complex was highlighted.

Lecture of SWM

Practice of separation

Hikarigaoka apartment complex

Incinerator

5.2.4 Collection Station, Recycling centre and compost plant in Shibushi city (2-3 Aug. 2018)

Main topic of observation and discussion at recycling center:

- Machine for volume reduction of styrene foam
- Buying and selling price of recycling company
- Bio diesel system
- Population of waste generation, amount of recyclable waste, number of staff working there, consumption of electricity, capacity and price of sorting machine

Main topic of observation and discussion at final disposal site:

- Amount and types of waste discharging at disposal site
- Liner sheet material
- Storm water drain and gas removal facility
- Relationship between annual precipitation and size of leachate treatment facility


Discharging manner of mixed waste


Collection of kitchen waste


Recycling centre


Recycling centre


Compost plant


Recyclable waste station


Final disposal site


Final disposal site


Leachate treatment

5.2.5 Wrap up meeting at Shibushi city (3 Aug 2018)

(Question 1) Are there penalties for illegal dumping etc?

(Answer 1) Yes. Although it is a prison sentence of less than 3 years, or 10 million yen, most applications are for industrial waste.

(Question 2) What is the response when a person from outside temporarily discards their garbage inappropriately?

(Answer 2) Three environmental patrols are monitoring the town.

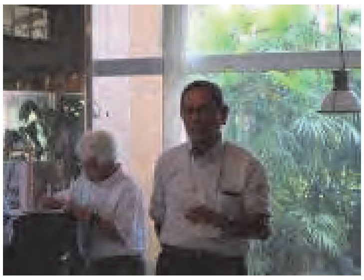
(Question 3) Outsourcing: do you select suppliers by bidding? I understand there was a profit made from the sale of valuables back from the outsourcer, but what is the surplus or loss of the total waste as a whole?

(Answer 3) Initially it is a general bidding, after that it is a voluntary contract. Even if the profit on sale is returned, it is totally in deficit as a whole.

(Sri Lanka side comment) In this training, it was very meaningful to be able to visit the waste business activities of both Nerima Ward with incineration facilities in an urban area, and Shibushi, which is a small-scale in rural area. It is a great surprise that the communities are solid with both local governments and that the right to consolidate with local governments is close.

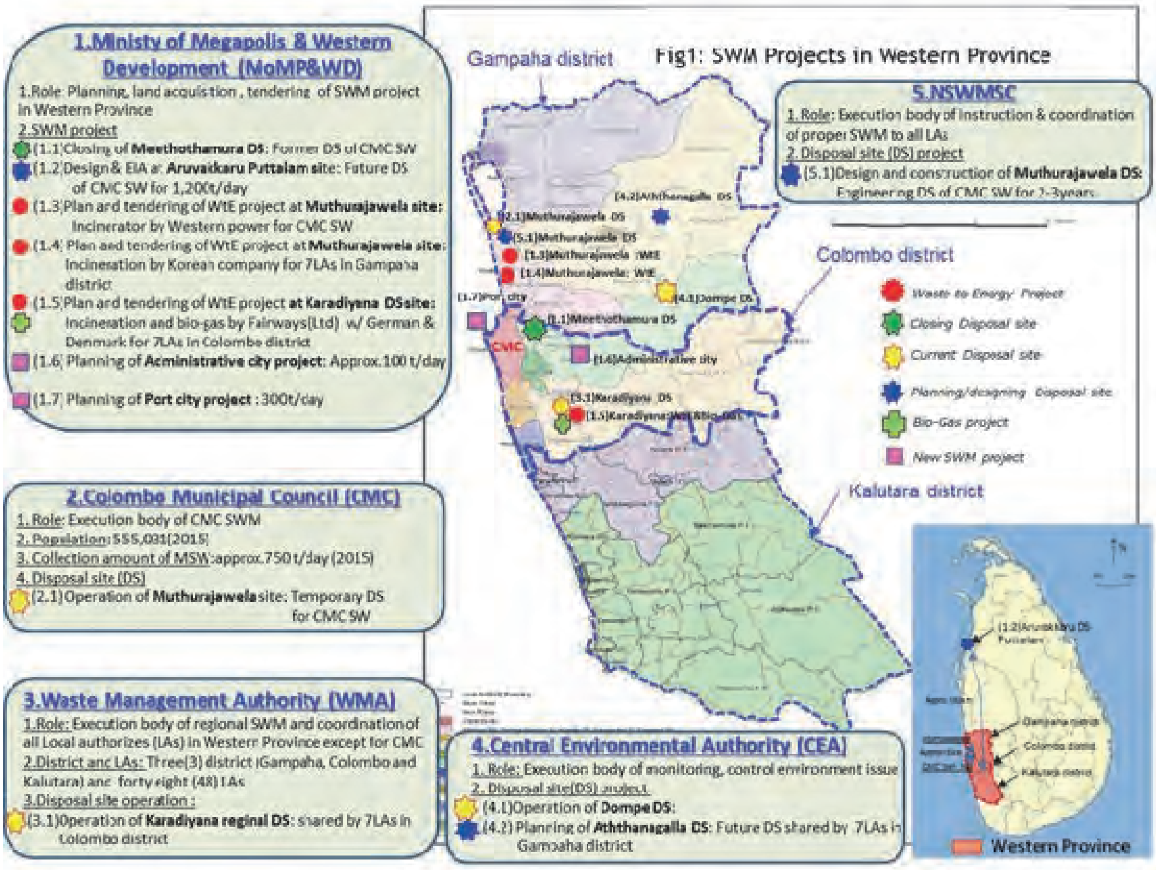
I was convinced that the ideal image of local government waste business in Sri Lanka is the Shibushi model, but since we cannot immediately implement all of the Shibushi model, we want to implement about 10% for the time being.

(Shibushi City comment) Not limited to Shibushi, the local governments’ waste business in Japan is a series of repeated trial and error, and they have overcome these issues after overcoming many difficulties. I would like Sri Lanka, which is rapidly developing in the future, to refer to Japan's experience. Please understand that the most important thing is to gain the cooperation of citizens.



5.3 Current condition of incinerator plan and final disposal sites in Western province including Colombo Municipal Council

Japanese government dispatched Disaster Relief Expert Team to Sri Lanka from 19 April 2017 to 25 April 2017 for the landslide disaster caused by heavy rain on 14 April 2017 at the final disposal site of Colombo Municipal Council. The incinerator to reduce the amount of collected waste is discussed in Sri Lanka because of the landslide disaster and some incinerator projects are planned in a couple of years. The latest incineration projects is studied in Western Province and Colombo Municipal Council as follows.



1.Ministy of Megapolis & Western Development (MoMP&WD)
1.Role: Planning, land acquisition, tendering of SWM project in Western Province
2.SWM project
(1.1)Closing of **Meethothamura DS**: Former DS of CMC SW
(1.2)Design & EIA at **Aruvakkaru Puttalam site**: Future DS of CMC SW for 1,200t/day
(1.3)Plan and tendering of WtE project at **Muthurajawela site:** Incinerator by Western power for CMC SW
(1.4) Plan and tendering of WtE project at **Muthurajawela site:** Incineration by Korean company for 7LAs in Gampaha district
(1.5)Plan and tendering of WtE project **at Karadiyana DSsite:** Incineration and bio-gas by Fairways(Ltd) w/ German & Denmark for 7LAs in Colombo district
(1.6) Planning of **Administrative city project**: Approx.100 t/day
(1.7) Planning of **Port city project** : 300t/day

2.Colombo Municipal Council (CMC)
1. Role: Execution body of CMC SWM
2. Population: 555,031(2015)
3. Collection amount of MSW: approx.750 t/day (2015)
4. Disposal site (DS)
(2.1)Operation of **Muthurajawela** site: Temporary DS for CMC SW

3.Waste Management Authority (WMA)
1.Role: Execution body of regional SWM and coordination of all Local authorizes (LAs) in Western Province except for CMC
2.District and LAs: Three(3) district (Gampaha, Colombo and Kalutara) and forty eight (48) LAs
3.Disposal site operation :
(3.1)Operation of **Karadiyana reginal DS**: shared by 7LAs in Colombo district

4.Central Environmental Authority (CEA)
1. Role: Execution body of monitoring, control environment issue
2. Disposal site(DS) project
(4.1)Operation of **Dompe DS**:
(4.2) Planning of **Aththanagalla DS**: Future DS shared by 7LAs in Gampaha district

5.NSWMSC
1. Role: Execution body of Instruction & coordination of proper SWM to all LAs
2. Disposal site (DS) project
(5.1)Design and construction of **Muthurajawela DS**: Engineering DS of CMC SW for 2-3years

Figure 5-1: Current condition of incinerator plan and final disposal sites in Western province including Colombo Municipal Council

Table 5-5: Current condition of incinerator plan and final disposal sites in the Western province including Colombo Municipal Council

	No	Title	Outline	Current status
Ministry of Megapolis and Western Development(MoMP&WD)	1.1	Closing of Meethothamura DS	The landslide at the disposal site (which has been operating since 2009) happened on 14 April 2017. MoMP & WD planned to close the disposal site in six months.	The construction of gentle slope and 3 stage terrace, the installation of vinyl sheet, the diversion of rainfall, and monitoring are implemented to protect the slope.
	1.2	Design & EIA at Aruvakkaru Puttalam site	The feasibility study of sanitary landfill site for the discharging of waste from CMC is ongoing by MoMP&WD. The residue of ash or non-burnable waste are planned to be transported to the disposal site at Kelaniya transfer station.	The facility planning and EAI at abandoned quarry are implemented by Korean consultant Kunhwa. The target year and start year of construction are not clear.
	1.3	WtE project at Muthurajawela site for CMC SW	The project consists of the establishment of an incinerator for approximately 700 ton/day of CMC MSW based on the contract between CMC and private company Western Power. The candidate site in Muthurajawela approximately 10 acres (4ha) and acquired by SLLRDC.	EIA was implemented in November 2016. If the project is not started by 2019, the contract between CMC and Western power is cancelled.
	1.4	WtE project at Muthurajawela site for 7LAs in Gampaha district	The project consists of the establishment of incinerator for approximately 400 ton/day of MSW of 7 LAs in Gampaha district based on the contract between WMA and private Korean company. The candidate site in Muthurajawela is approximately 10 acr (4ha) and acquired by SLLRDC.	Korean KCHT Lanka Jang(Pvt) Ltd made contract with WMA based on the tender in January 2016. The fluidized bed types of the incinerator is planned.
	1.5	WtE project at Karadiyana DS site for 7LAs in Colombo district	The project consists of the WtE of incinerator and bio-gas for approximately 500 ton/day of MSW of LAs in Colombo at Karadiyana disposal site. The plan of project and tender was carried out by MoMP&WD.	The tender was held in January 2016 and Sri Lankan Fairways Ltd, German and Denmark joint venture was selected as EPC for the project.
	1.6	Planning of Administrative city project	The project targeting approx. 100 tons/day MSW from Administrative city is planned by MoMP&WD.	The MP including target year and population is not formulated.
	1.7	Planning of Port city project	The project targeting approx. 300 tons/day MSW from Port city is planned by MoMP&WD.	The MP including target year and population is not formulated.
CMC	2.1	Operation of Muthurajawela temporary DS for CMC MSW	CMC is discharging the MSW at the marshy land in Muthurajawela as a temporary site after closing disposal site where landslide occurred.	The MSW from CMC is being discharged to the site without any environmental mitigation facility.
WMA	3.1	Operation of Karadiyana reginal DS: shared by 7LAs in Colombo district	The project consists of the landfill site, compost plant and material recovery facility at Karadiyana. The receiving amount of waste is approximately 500 ton/day of MSW of LAs in Colombo.	The disposal site is operated fairly well, although it is not a sanitary landfill site. The WtE project is ongoing in accordance with the above mention 1.5.
CEA	4.1	Operation of Dompe DS:	The first sanitary landfill site in Sri Lanka granted 450 million Rs by KOICA in 2014.The actual receiving amount of waste is approx.10ton/day of MSW from Dompe PS and the lifetime is approx. 10years.	The original amount planned or receiving waste is 90 ton/day, however only 10 ton/day MSW is being received due to strong projection from residence in Dompe PS.
	4.2	Planning of Aththanagalla DS	The planned final disposal site for MSW from Gampaha district is different from 1.4.	The topographic survey is ongoing.
NSW MC	5.1	Design and construction of Muthurajawela DS	The temporary disposal site for a couple of years will be at Muthurajawela for CMC MSW after closing Meethotramura disposal site due to landslide disaster.	Just open dumping without any environmental mitigation facility since April 2017.

5.4 Inspection of pilot project site at Kurunegala MC and Kataragama PS by Prof. Kawamoto of Saitama University

5.4.1 Improvement of Kurunegala final disposal site

Professor Kawamoto of Saitama University visited to inspect the progress of pilot project of improvement of Kurunegala final disposal site on 11th March 2018 after the brief meeting at Kurunegala MC. The comments of Professor Kawamoto are given as below;

- The excess amount of coliform is detected at existing wells in the residential area. What reason is assumed?
  - → Answer: Due to no lid on the existing well and it opens, it is assumed that drops from birds or animals easily mix to well water.
- During rehabilitation of current disposal site, the collected waste should be temporally discharged at the old disposal site.
- The landfill mining survey is important to study the expansion of lifespan of current disposal site.
- Since the discharging of heavy metal at the disposal site must be avoided, the separation of waste which contains heavy metal at source generation is important.

Site visiting at final disposal site at KC

Checking PRB material

Demonstration of PRB construction

Group photo

5.4.2 Improvement of Kataragama final disposal site

Professor Kawamoto of Saitama University visited to inspect the progress of the pilot project for improving the Kataragama final disposal site on 16th March2018. After the brief meeting at Kataragama PS, the comments of Professor Kawamoto are given as below;

- The proper drainage surrounding the planned disposal site for diversion of storm water should be constructed and regularly maintained well since quite a large amount of storm water must come from the hill behind to the final disposal site.
- Total selling price of Progress of 3Rs activity can be evaluated not only by percentage of recycling but also by the trend of total selling price of recycling.

5.5 Hand over equipment

Table 5-6: List of handover equipment

No.	Items	Model	Qty.	Location
1	Three wheeler	Piagio pick-up model 2016	1	RMC
2	Chopping machine	Jinasena Agricultural Machinery (PVT) Ltd. Multi Chopper Couple 15HP Motor	1	KPS

Appendix

Approval letter for Work Plan

මධ්‍යම පරිසර අධිකාරිය
மத்திய சுற்றாடல் அதிகாரசபை
Central Environmental Authority
[illegible]
"Parisara Piyasa", 104, Denzil Kobbekaduwa Mawatha, Battaramulla, Sri Lanka.

08/WM/JB/2015

7-4-2017

Ms Yuko OSUMA
(Head of the JICA Expert team)
Dr Naoharu SATO
Senior consultant
Ex Research Institute Ltd
Japan

Dear Sir/Madam,

Approval of the Draft Work Plan for Pollution Control and Reduction of Environmental Burden in Solid Waste Management

Central Environmental Authority carefully reviewed the work plan and in principle, this Authority agreed to proposed work plan given in March 2017 document.
However, CEA would like to request for amending the work plan, if necessary, according to the compelling requirements of the stake holders with the consensus of JICA and Project Expert team.
On behalf of CEA and other stake holders, I thank you and all the members of the project consultant team for your extensive effort and technical advices.
I also would like to express our gratitude especially to JICA, for their kind support for developing the waste management sector in Sri Lanka.
Thank you.

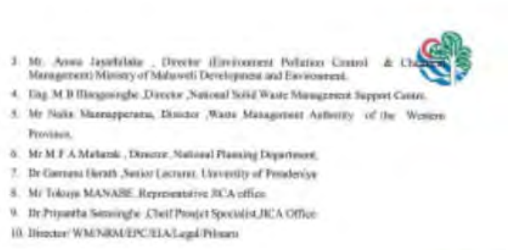
Yours sincerely,

K.H.Muthukudaarachchi
Director General
Central Environmental Authority (CEA)

Copies

1. Mr. S.D.A.B. Boralessa, Additional Secretary, Ministry of Local Government and Provincial Councils
2. Director General, Urban Development Authority

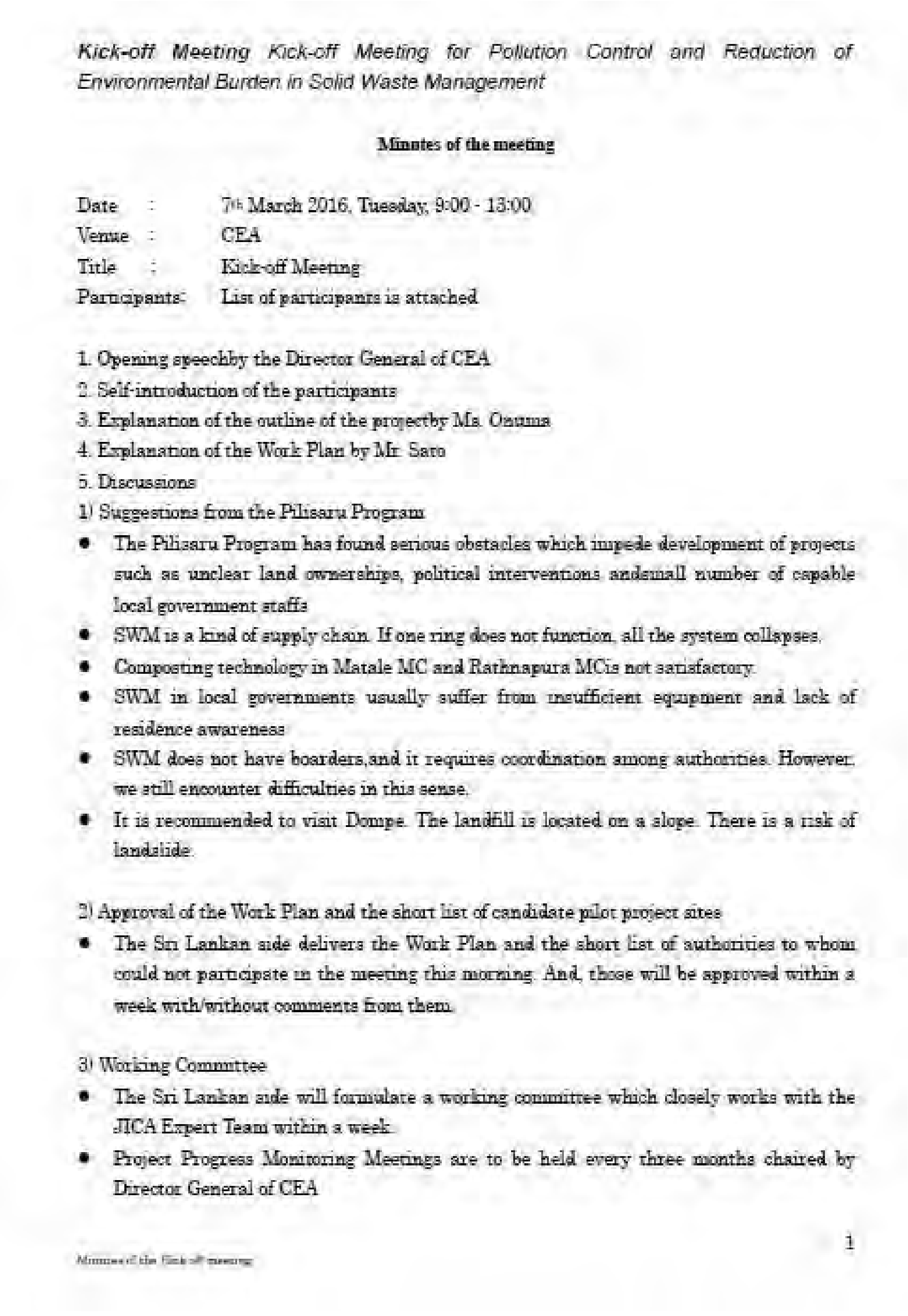
   Attn: Mr.Mahinda Withanachchi, Director of Projects, Urban Development Authority



3. Mr. Anura Jayatilake, Director (Environment Pollution Control & Ch Management) Ministry of Mahaweli Development and Environment.
4. Eng. M B Illangasinghe, Director, National Solid Waste Management Support Centre.
5. Mr Nalin Mannapperuma, Director, Waste Management Authority of the Western Province.
6. Mr M F A Mubarak, Director, National Planning Department.
7. Dr Gemunu Herath, Senior Lecturer, University of Peradeniya
8. Mr Tokuya MANABE, Representative JICA office
9. Dr Priyantha Senasinghe, Chief Project Specialist, JICA Office
10. Director/ WM/NRM/EPC/EIA/Legal/Pilisaru

3. Mr. Anura Jayatilake, Director (Environment Pollution Control & Ch Management) Ministry of Mahaweli Development and Environment.
4. Eng. M B Illangasinghe, Director, National Solid Waste Management Support Centre.
5. Mr Nalin Mannapperuma, Director, Waste Management Authority of the Western Province.
6. Mr M F A Mubarak, Director, National Planning Department.
7. Dr Gemunu Herath, Senior Lecturer, University of Peradeniya
8. Mr Tokuya MANABE, Representative JICA office
9. Dr Priyantha Senasinghe, Chief Project Specialist, JICA Office
10. Director/ WM/NRM/EPC/EIA/Legal/Pilisaru

Minutes of meeting for kickoff meeting



Kick-off Meeting Kick-off Meeting for Pollution Control and Reduction of Environmental Burden in Solid Waste Management

Minutes of the meeting

Date : 7th March 2016, Tuesday, 9:00 - 13:00
Venue : CEA
Title : Kick-off Meeting
Participants: List of participants is attached

1. Opening speechby the Director General of CEA
2. Self-introduction of the participants
3. Explanation of the outline of the projectby Ms. Onuma
4. Explanation of the Work Plan by Mr. Sato
5. Discussions

1) Suggestions from the Pilisaru Program

- The Pilisaru Program has found serious obstacles which impede development of projects such as unclear land ownerships, political interventions andsmall number of capable local government staffs
- SWM is a kind of supply chain. If one ring does not function, all the system collapses.
- Composting technology in Matale MC and Rathnapura MCis not satisfactory.
- SWM in local governments usually suffer from insufficient equipment and lack of residence awareness
- SWM does not have boarders,and it requires coordination among authorities. However, we still encounter difficulties in this sense.
- It is recommended to visit Dompe. The landfill is located on a slope. There is a risk of landslide.

2) Approval of the Work Plan and the short list of candidate pilot project sites

- The Sri Lankan side delivers the Work Plan and the short list of authorities to whom could not participate in the meeting this morning. And, those will be approved within a week with/without comments from them.

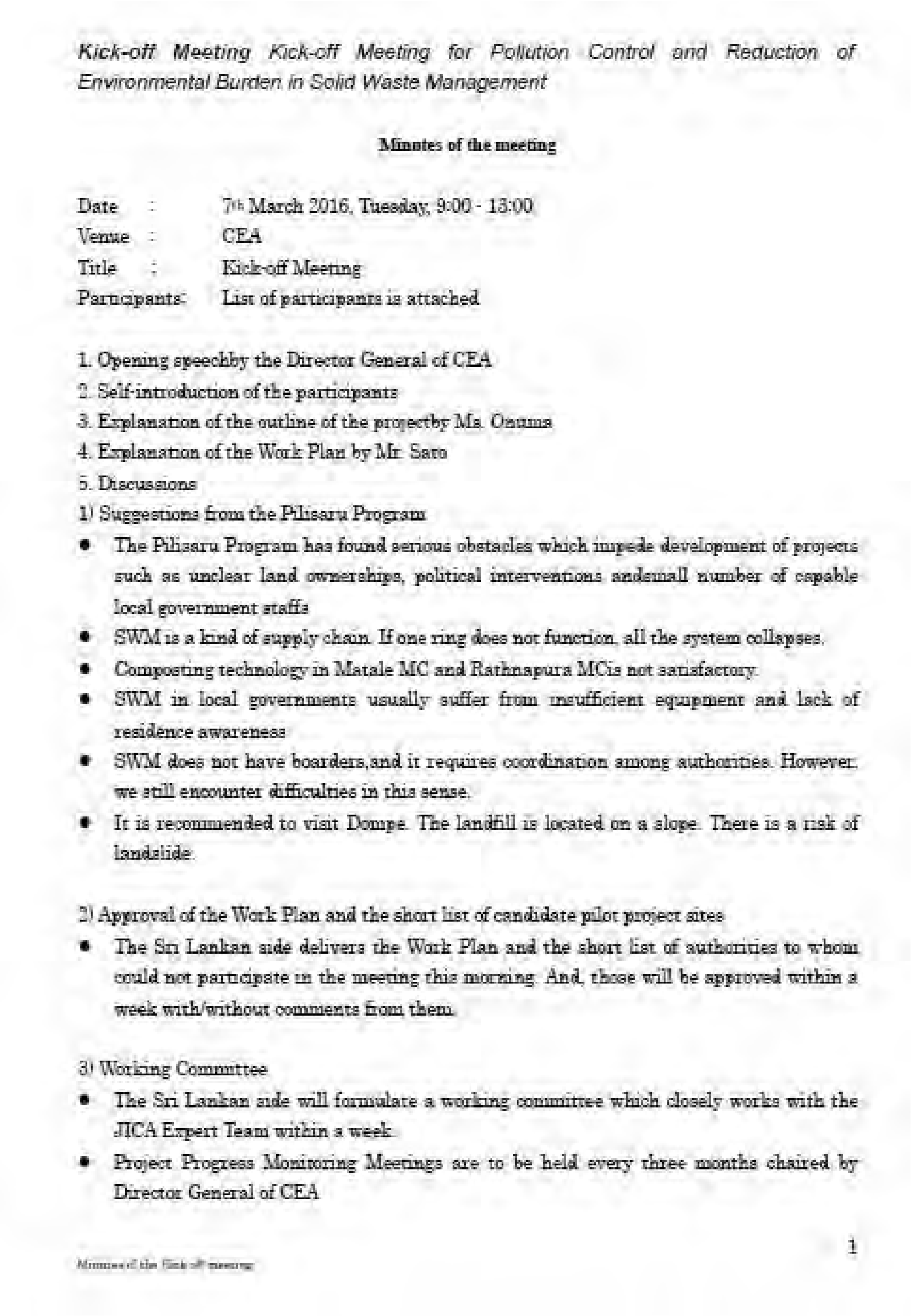
3) Working Committee

- The Sri Lankan side will formulate a working committee which closely works with the JICA Expert Team within a week.
- Project Progress Monitoring Meetings are to be held every three months chaired by Director General of CEA

1

Minutes of the Kick-off meeting

Minutes of meeting for kickoff meeting



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1

Minutes of the Kick-off meeting

1st stakeholder meeting

Meeting: **Finalization of (Draft) SATREPS Guide and 1stStakeholder Meeting for Pollution Control and Reduction of Environmental Burden in Solid Waste Management**

Date: *Tuesday, June 13, 2017*

Venue : *Conference room, Central Environmental Authority*

Minutes of the meeting

1. Explanation of the progress of pilot project by Dr Sato
2. Explanation of the outline of the SATREPS Guide by Dr Gamunu
3. Discussion

1) Comments from Dr Gamunu
    - SATREPS guide is to convert open dumps in to Sanitary landfills to reduce pollution. Unforeseen delays in the process of preparation.
    - In addition to the technical matters issue, gaps and challenges was the limitations for the study.
    - Chapter 6.2 should be amended since the study is still ongoing, probably end of this year.
    - For the study of the liner used Moragahakanda and Buttala Soils. For Hambantota field study used Buttala soil with 10% Bentonite . Permeability is $10\text{-}^{9}ms^{-1}$
    - It will be difficult to locate Bangadeniya soil. It is advisable to get the support of Dr. Chandana and Ruhuna University in this regard.
    - Several factors should be concerned in construction i.e. level of compaction, permeability, moisture content etc,
    - Prefer to handover the guide to a foreign consultant to review the document.
    - 3 Detailed action plans were prepared and handed over to the respective LAs namely, Kandy MC, Gampola UC and Udapalatha PS

2) Dr Nadeej explained in dry zones cracks will appear in the clay liner and mixing with coir fiber dust will minimize/prevent it.

For the final cover soil with Olick acid were tested. Also slope stability were studied.

3) Comments from Director Pilisaru
   - Instead of 3Rs Pilisaru promotes 5Rs i.e. Reject and Respect
   - Wild life will not support for elephant fence in Katharagama so better to go for natural barriers (live fence). Amapara district implements “Aliyata Kithul” project uses plants (such as Gajamadara, Giricedia) that produce aromatic compounds which prevent elephant attack.
   - In relation to identification of required soil types in different locations “Sri Lanka Canada soil study” could be used.
   - Permission would be a problem for sand mining
   - In the guide 2.6 not only legal and social frame work but also political frame work should be included since the political influences is inevitable in SWM.
   - Similar as forest and wildlife reserve a buffer zone should be introduced in SWM facilities.
   - MOPCLG will organize a workshop On June 23and 24th to prepare National Action Plan for SWM. SATREPS team can contribute the forum through the research output.

4) General comments
   - Find the possibility of preparing a technical guide for composting and Biogas.
   - Geomembrane will cost Rs.10 million for 1 hectare. But condition such as Muthurajawela there is a possibility to damage the layer due to the high level of peat.

Decisions

- Hardcopy of the Guide should be circulated among the 22 experts of the SATRREPS Guide consulting committee and all the other relevant parties including Ministry of Megapolis.
- CEA will circulate the hard copy of the document among stakeholders.
- One last meeting will be held in July to finalize the document.
- Pilot projects could be implement using the draft Guide.

Appendix 3-2

2nd stakeholder meeting

Minutes of Meeting

Meeting: 2nd Stakeholder Meeting for Pollution Control & Reduction of Environmental Burden in SWM

Date: 25th October 2017

Time: 3.00 pm

Venue: CEA Conference Room

Participants:

Stake Holders	Prof Lal Dharmasiri	Chairman, CEA
	Mr. W. T. D. Disanayake	DG, CEA
	Mr Upali Indarathna	DDG, CEA
	D A Ruwan Pathirana	AD Legal division
	K Pirapaharan	SEA,CEA
	R W S M N Manoratne	AD/ IR
JICA SWM team	Dr. Yoko Onuma	Long term expert
	Dr. Naofumi Sato	Consultant expert
	Ms Chiharu Iida	Consultant expert
	Ms. Nayana Samaraweera	Project Coordinator

① The Chairman of CEA chaired the meeting and made the welcome speech and opening remarks.

- Dr Onuma explained about the ReEB waste project progress, outline of the SATREPS Project, proposed 3 years technical cooperation project background, objective, stakeholders and schedule.
- Dr Onuma explained about the progress of the ongoing surveys of Method of SWM annual budget making and utilizing collection and disposal data in LA and SWM labour satisfaction survey in Rathnapura.
- Also informed about the Seminar scheduled on November 23 on SWM data collection, analysis and dissemination.
- Dr Sato made a detail presentation on the progress of pilot projects including the process of site selection, site surveys, basics of improvement plan, site specific field surveys and SWM action plan.

② Discussion

- There is an issue of administrative system of this project. MOU should be signed between JICA and ERD. In kind no for the project should be obtained as soon as possible. ARFR format should obtain from Audit section.

- Check the Recommendation for elephant fence from the wild life department.
- Operation mechanism for Katharagama disposal site should be prepared.
- Also, operation standards and guideline for the dumpsite should be prepared.

③ Confirmations

- SATREPS Guide will be amended with Prof. Kawamoto comments by Dr Sato and forward to Dr Gamunu.
- By the end of this year SATREPS guide will be finalized.
- Administrative problems of the project (reporting financial progress) should be resolved as soon as possible.

3rd stakeholder meeting

Minutes of Meeting

Meeting: 3rd Stakeholder Meeting for Pollution Control & Reduction of Environmental Burden in SWM

Date: 24th January 2018

Time: 2.30 pm

Venue: Board Room of CEA

Participants:

Stake Holders	Prof Lal Dharmasiri	Chairman, CEA
	Mr Upali Indarathna	DDG, CEA
	Mr. Nalin Mannapperuma	Director, WMA
	Dr Young	Korean Expert, WMA MoE
	Mr. K Pirapaharan	SEA,CEA
	Mr. R W S M N Manoratne	AD/ IR
JICA Office	Mr. Tilak Nawaratne	Planning Officer
	Hiroki HASHIMOTO	Representative
JICA SWM team	Dr. Yoko Onuma	Long term expert
	Dr. Naofumi Sato	Consultant expert
	Ms Chiaki Nishi	Consultant expert
	Mr. Akira Haseyama	Consultant expert
	Ms. Nayana Samaraweera	Project Coordinator

④

- The Chairman of CEA chaired the meeting and made the welcome speech and opening remarks.
- Dr Sato made a detail presentation on the progress of pilot projects including kick off seminar, basics of improvement plan, condition of tendering, Progress of activities in pilot project areas of Kurunegala and Rathanapura .
- Ms Nishi explained the progress and limitations of Katharagama PS pilot project.
- Dr Sato explained about the amendment and preparation of the final version of SATREPS Guide.
- Also informed about the future schedule.

- Dr Onuma explained about the progress of receiving in kind number for the project, results of the surveys of Method of SWM annual budget making and utilizing collection and disposal data in LA and SWM labour satisfaction survey in Rathnapura
- Informed about the Seminar held in November.
- Dr Onuma explained about the progress of proposed 3 years technical cooperation project and Planned Recycling survey and schedule as well.
- DDG informed there is a slight delay in the tender process due to the election and recent incident in Katharagama.
- Also mentioned politicians involvement from February will influence final outcome, specially KMC . There is strong community protest in KMC.

① Discussion

- Chairman requested to get review from the seminar participants with short questions to check the effectiveness. JICA team agreed to do it in the next seminars organized in August and December.
- Importance of continuous monitoring of Sundarapola site was stressed.
- Chairman suggested to introduce bio fence in addition to the electric fence in Katharagama.
- Also mentioned about involvement of human resources in Ruhuna university including awareness.
- Questioned about the Life time of the KPS site and Dr Sato mentioned target is 10 years but it is highly depend on the practices of PS, if they increase composting life time can be increased.
- DDG informed landfill site operation practices are poor in general, he visited eastern province recently and operation is not up to the standard. Further stated that "NEP" which is under preparation is address this issue.
- Dr. Sato said that construction of a landfill site is easy, and operation is the difficult task. KPS lack required human resources and external support is essential.
- Chairman said that the political leaders will expedite the process and address the issues.
- Director WMA mentioned that LAs can collect and transport, it is better to handle collected waste by a separate Authority. Presently western province practices it. Also, it's better to investigate the possibility of having SPC to run the facilities as joint venture.
- DDG mentioned in future stakeholder level meeting to discuss specific areas up to the point will be organized in national level.

- The Korean expert Dr Young appreciated JICA approach and stated that the outcome is highly depend on policy and policy tools. At present no charging system (almost free) and voluntary system will not last if there are no policy tools to make it happen. So, he questioned from the CEA what is the plan for sustain and maintain the introduced systems.
- DDG mentioned that National Policy on waste management is under preparation will finalize very soon address all the serious issues.
- Also, Dr Young questioned are there any regular discussion flatform, CEA to share experiences of best practices of LAs, success and failures, drives and barriers, coherence with policy and strategies.
- DDG mentioned there are practical problems; there are only 3 LAs with more than 100T/d collection, few middle level and majority are less than 10T/d collection. In the common forums LAs always discuss only the negative factors they face (e.g.: no labour, no machine and no land). Therefore, have to address specific way i.e. high, middle and less than 10T/d categories. District base cluster meetings with participation of LAs, CLG, CEA regional office, District secretariat and relevant stake holders are organized by Pilisaru yearly is another table to discuss. On the other hand, CEA is a regulatory body but depend on the need CEA supported to construct about 150 compost yards and in now concentrate on recycling and value-added materials. Dedicated authority is required since CEA is enforcement agency and covers many aspects: MSW, Hazardous and medical waste etc.
- Director WMA stated that planning should be done in national level execution should be done by provincial level as the system practice in western province.
- Dr Young stated that connectivity and feedback system is very much important, and it should reflect in the policy. Realizing the connection is vital. Overarching institution cannot be observed. Comprehensive planning, review and coordinating and commitment is essential.
- MOLGPC could be the coordinating body.
- Director WMA stated that WP badly needed waste transportation plan.
- DDG stated that under the new policy tipping fee, master plan etc. address and CEA will provide fullest cooperation for the required elements.

② Confirmations

- Landfill operation Mechanism is required.
- MOLGP is essential for the process.
- SATREPS guide will be finalized soon.

4th stakeholder meeting

Meeting: 4th Stakeholder Meeting for Pollution Control & Reduction of Environmental Burden in SWM
Date: 22nd March 2018
Time: 2.00 pm
Venue: Board Room, CEA

Participants

Stake Holders		
	Mr Upali Indarathna	DDG, CEA
	R W S M N Manoratne	AD/ IR
JICA Office	Ms. Tomita	Representative
	Dr Serasinhe	Senior consultant
JICA SWM team	Dr. Yoko Onuma	Long term expert
	Dr, N. Sato	Expert Consultant
	Ms. Nayana Samaraweera	Project Coordinator

① DDG Waste Management of CEA chaired the meeting and made the welcome speech and opening remarks.

☐ Dr Onuma explained about the Financial Progress of the project, WMA Roundtable Meeting, Ratnapura Survey Result and Way forward, Contents of Waste Flow and Recycling Industry Survey and the JICA Public Relations Activities (“Mundi” Interview)

☐ Dr Sato made a detail presentation on the progress of pilot projects including the process collection improvement, 3R initiatives, tender process, progress of construction, improvement schedule, SATREPS Guide and Shibushi study tour.

① Discussion

☐ Simple GPS units has been introduced to Rathnapura MC and Katharagamma PS baseline data will be collected and collection improvement will be planned accordingly.

☐ 3R pilot project will be very useful experience and it should be recorded in a systematic manner (Eg Flow Chart) to share with stakeholders.

☐ Experience of the pilot project should go to the CEA regional office staff. Therefore maximum involvement of them is important.

☐ Its good to add awareness component in to SATRPES Guide.

☐ Recently CEA established a dedicated unit on MSW and better to get their involvement too.

☐ Its better to have district level SWM data base and NSWMSC could manage the data base with discussion of stakeholders about parameters, what form of data and software etc.

② Confirmations

- CEA will arrange the message from Secretary and Current DG for SATREPS Guide.
- JICA Project team will design an attractive cover for the book
- SATREPS Guide will be handover to the president on 5th June.

5th stakeholder meeting

Meeting: 5th Stakeholder Meeting for Pollution Control & Reduction of Environmental Burden in SWM

Date: 29th June 2018

Time: 10.00 am

Venue: Conference Room, CEA

Participants

Stake Holders		
	Mr. Upali Indarathna	DDG, CEA
	Ms. Sarojinie Jayasekara	Director, SWM, CEA
	Mr. S.M. Madawalagama	Director, NSWMSC
	Ms. Sujeewa Fernando	AD, MoMD&E
	Ms. Sepali De Silva	AD/ Policy Planning, MoMD&E
	Mr. R W S M N Manoratne	AD/ BOI, CEA
	Mr. Tilak Nawaratne	Planning Officer, CEA
JICA Office	Ms. Rie Tomita	Representative
	Dr. Serasinhe	Senior Consultant
	Mr. Shinya Inoue	JICA Volunteer
JICA SWM team	Dr. Yoko Onuma	Long term expert
	Dr. N. Sato	Expert Consultant
	Ms. Nayana Samaraweera	Project Coordinator
	Mr. A. Siriwardana	Survey Assistant

1. DDG Waste Management of CEA chaired the meeting and made the welcome speech and opening remarks.
    - Dr Onuma explained about the
        - Financial Progress of the ReEB Waste project
        - As JICA Public Relations Activities JICA publish a monthly Japanese magazine named “Mundi”, May issue of the magazine describes about ReEB Waste Project activities as one of the excellent SWM project implement by JICA
        - WMA Roundtable Meeting progress
        - JICA SWM New project- WP SWM Master Plan Formulation Project Progress
        - Demonstration of Takakura Composting system
        - Waste Flow and Recycling Industry Survey progress
        - Finalization of SATREPS Guide
    - Dr Sato summarized the schedule of ReEB waste project and made a detail

presentation on the progress of pilot projects including the progress of construction, Progress of 3R initiatives, Planned intermediate evaluation in June/July and the future schedule of project activities.

2. Discussion

- Master plan project period is 3 years and Master Plan will be prepared within 1 1/2 years and Pilot project will be implemented and out puts will be amended.
- NSWMSC director explained that NPD approval has been granted for the new project and after finalizing it will be forward for cabinet approval.

- After completion of ReEB waste project 2 manuals will be prepared (3R and compost promotion, landfill operation).

- New deputy minister of MoMD&E advised to promote household composting

- MoPC&LG initiated Takakura composting project. Mixing is a problem.

- DDG explained in 2017, 13 exporters collected 8000MT of E waste and PC, mobile phone batteries are the items that exported.

- Asia recyclers stopped operation due to machine failure. Their mercury collection amount is too small (10MT) to ship. CEA stress them to start operation again. Spare parts provider of the machine (Sweden) is bankrupted. Possible option is Japan and ReEB waste will facilitate the communication.

- CFL and florescent market is shrinking because of LED. Government has to facilitate until CFL and florescent phase out.

3. Confirmations

- As next step ReEB waste project will conduct RMC labourers satisfaction survey.

4. Recommendations

- Preparation of Smart registry of Recyclers.
- All the recyclers need government support because the recycle market is shrinking down.

6th stakeholder meeting

Meeting : 6th Stakeholder Meeting for Pollution Control & Reduction of Environmental Burden in SWM
Date : 23rd October 2018
Time : 3:00 pm
Venue : Conference Room, CEA

Participants

Stake Holders	Eng:. Upali Indarathna	DDG, CEA
	Ms. Sarojinie Jayasekara	Director, SWM, CEA
	Ms Wasantha Wijesekara	Director,CEA Laboratory
	Ms. Sujeewa Fernando	AD, MoMD&E
	Ms.V Hewawasam	AD/ Policy Planning, MoMD&E
	Mr. R W S M N Manorathne	AD/ BOI, CEA (coordinator from CEA)
	Ms. E R H S Yomukubura	SEO (R&D)
	Mr. K.Pirapaharan	SEO, CEA
	Ms Sewwandi Wickramasinghe	SEO, CEA
	Ms Chandi Wijayasinghe	Director, Planning
	Ms Nadeeka Karunarathne	AD/Legal /CEA
	Ms R. Shanmugapriya	AD (Technical) / WMA
JICA Office	Dr. Yoko Onuma	Long term Expert
	Dr. Naofumi Sato	Expert Consultant
	Ms. Nayana Samaraweera	Project Coordinator
	Mr. A. Siriwardana	Survey Assistant

DDG Waste Management of CEA chaired the meeting and made the welcome speech and opening remarks

☐ Dr Onuma explained about the

☐ Financial Progress of the ReEB Waste project

☐ Findings of working hour utilization survey in Rathnapura

☐ Progress of Waste Flow and Recycling Industry Survey

☐ A Seminar has been organized on 13th December to share the findings of both surveys as well the experience of So Recycle Company, Japan

☐ Dr Sato made a detailed presentation on the progress of pilot projects including the progress of construction, Progress of 3R initiatives, planned final evaluation in November and the proposed. Monitoring committee structure and the check list.

① Discussion

☐ Time and motion study is very useful for local authorities in decision making. Though the LAs always complains about inadequacy of vehicles the study explicit 50% drivers absent, denotes vehicles idling.

☐ The possibility of replicating this study to other LAs by NSWMSC should be considered. MCs could be the starting point. Using these studies if can provide a guideline based on population and waste amount necessary minimum human/physical resource requirement for SWM activities it will be very useful to LAs.

☐ Project activities will be completed by the end of January, Manuals and reports will be prepared including the experiences of Pilot projects.

② Confirmations

- Waste Flow & Recycle Industry Survey and Results Dissemination Seminar will be held in December 13th.
- Final ReEB waste project seminar will be held in January.

③ Recommendations

- Lessons learned and way forward is very important. This project could be a bench mark in SWM and the reports should include recommendations for SWM policy, as well as recommendations to Ministry of Environment and Presidential Environment unit and NPD.

7th stakeholder meeting

Meeting : Final Stakeholder Meeting for Pollution Control & Reduction of Environmental Burden in SWM
Date : 29th January 2019
Time : 10.30 am
Venue : Conference Room, CEA

Participants

Stake Holders	Eng:. Upali Indarathna	DDG, CEA
	Mr. M.J.J.Fernando	DDG, CEA
	Ms. Sarojinie Jayasekara	Director, SWM, CEA
	Ms. Wasantha Wijesekara	Director,CEA Laboratory
	Ms. Chandi Wijayasinghe	Director, Planning
	Ms. Hewawasam	AD/ Policy Planning, MoMD&E
	Mr. R W S M N Manorathne	AD/ BOI, CEA
	Ms. C M Kottawaththa	Commissioner RMC
	Mr. M. N. Kumaraperperuma	Legal officer-CEA
	Mr. W S Jayathissa	SEO, CEA
	Ms. G M T S Fernando	EO- CEA
JICA Office	Ms. Moe Negishi	Representative
	Dr P Serasinhge	Project Specialist
	Dr. Yoko Onuma	Long term Expert
	Dr. Naofumi Sato	Expert Consultant
	Ms Misako Takatama	JICA Expert
	Mr Shunichiro Honda	JICA Expert
	Ms. Nayana Samaraweera	Project Coordinator
	Mr. A. Siriwardana	Survey Assistant

DDG Waste Management of CEA chaired the meeting and made the welcome speech and stated that the project successfully completed, publishing 3 manuals as the output of the implementation of pilot projects (including SATREPS Guide). Also thanked to JICA for training opportunities and for the ReEB waste project. Requested the support in future as well. Also appreciated the support extended by the project experts for out of their scope SWM activities and issues such as Gampaha, Batticaloa etc.

Ms Negishi of JICA Sri Lanka office made the opening remarks.

☐ Dr Onuma explained about the
☐ Financial Progress of the ReEB Waste project
☐ Seminar held on 13th December to share the findings of surveys
☐ Findings of Waste Flow and Recycling Industry Survey
☐ Technical Guidance given by the President of So Recycling Company in Shibushi to 3 Pilot Project LAs
☐ January JICA study tour

☐ Director MSW, Ms Sarojini made a presentation about the Japan Study Tour. She explained the legal system in Japan for smooth SWM and the necessity of streamlining the law in Sri Lanka for better SWM. Also requested the support of JICA to prepare comprehensive legal system as a future project
☐ Dr Sato explained the progress of pilot projects of
Kurunegala MC – PRB construction
Rathnapura MC – 3R Promotion
Katharagama PS – Landfill rehabilitation and 3R promotion
including the "Monitoring committee "meeting at Katharagama.

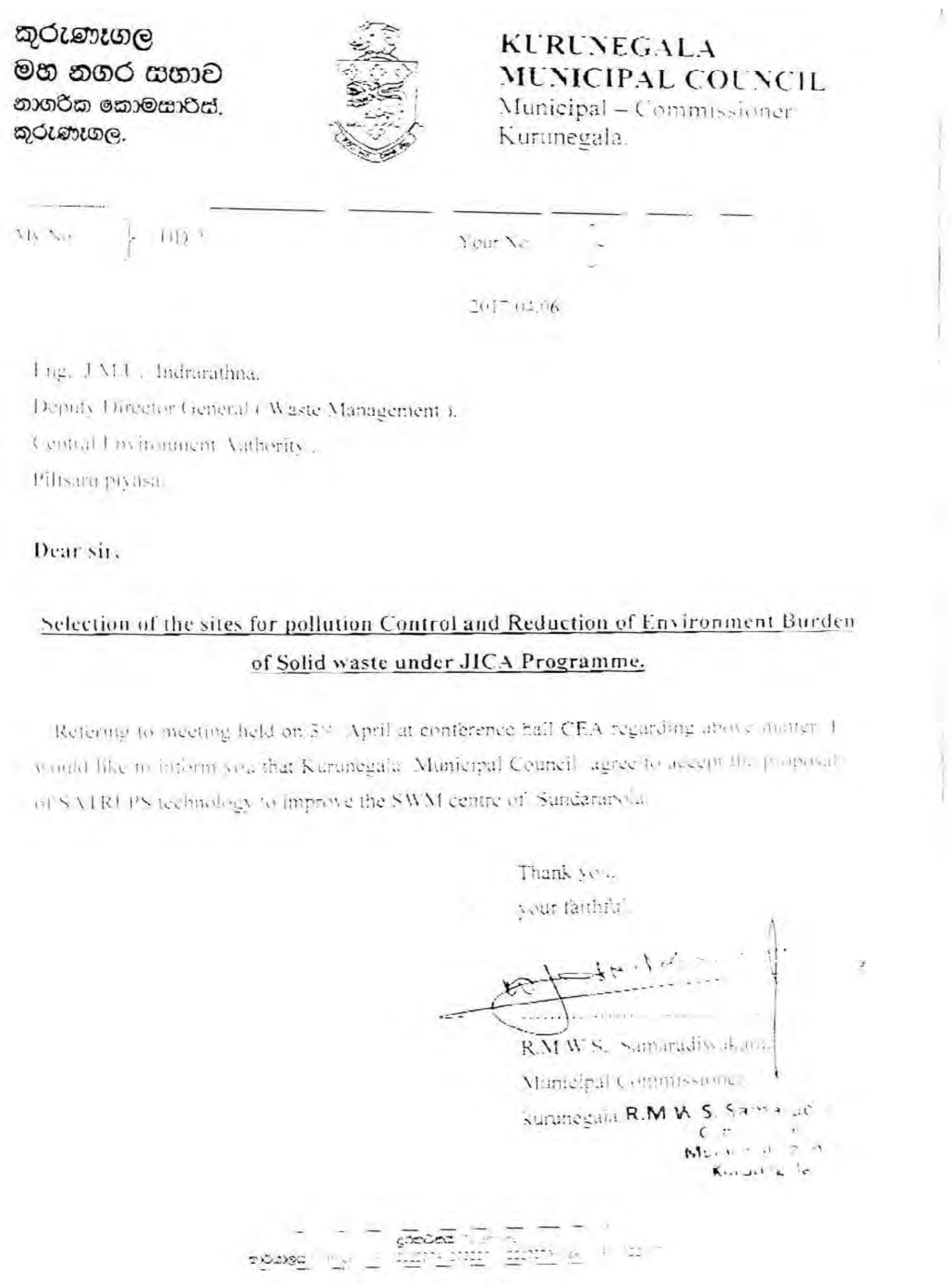
Discussion

☐ CEA questioned about the way forward and continuation of this project. JICA representative explained there is no continuation of this project but master plan for the western province is in the pipe line.
☐ CEA stated that not only MSW, clinical and e waste are also serious issues in western province. Master Plan will also consider these two aspects as well. Though JICA tried to support for clinical waste incinerator due to the poor support of health ministry it was not materialized yet.
☐ Also requested the support from JICA for comprehensive total solution for industrial waste.
☐ JICA representatives explained that for any requirement proposals should come from government side through proper channels.

Confirmations

- Final ReEB waste project seminar will be held on 31 of January.
- ReEB Waste Final Report will be circulated on 1st of February and comments should be submitted by 7th February.

Commitment letter of MCK



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KURUNEGALA
MUNICIPAL COUNCIL
Municipal – Commissioner
Kurunegala.

My No } HD 3
Your No

2017.04.06

Eng. J.M.U. Indrarathna.
Deputy Director General (Waste Management).
Central Environment Authority ,
Pilisaru piyasa.

Dear sir,

Selection of the sites for pollution Control and Reduction of Environment Burden of Solid waste under JICA Programme.

Refering to meeting held on 3rd April at conference hall CEA regarding above matter I would like to inform you that Kurunegala Municipal Council agree to accept the proposal of SATREPS technology to improve the SWM centre of Sundarapola.

Thank you,
your faithful

R.M.W.S. Samaradiwakara.
Municipal Commissioner
Kurunegala.

R.M.W.S. Sam[illegible]
[illegible]
Kurunegala

Appendix 5

RMC Commitment letter

My No RMC 2192
2017.04.06

Deputy Director General (Waste Management)
Central Environmental Authority
"Parisara Piyasa"
No 104, Dezil Kobbekaduwa Mawatha,
Battaramulla,
Colombo

JICA Project for Reduction of Environmental Burden from the disposal of Solid Waste

Reference to the letter dated 2017.03.28 and discussion held on 2017.04.03 regarding the above.

We would like to thank you for including us for the JICA project to improve the waste management programme conduct by the Rathnapura Municipal Council. Rathnapura Municipal Council will make sure to extend the fullest cooperation in accordance with the municipal council ordinance to make the project a success.

Municipal Commissioner
Municipal Council
Rathnapura

カタラガマPS コミットメントレター　KPS Commitment letter

FROM :KATHARAGAMA PRADESHIYA SABHA   FAX NO. :0472235275   Jun. 24 2017 08:58PM P1

"සහජීවනයේ වන්දනීය රම්‍ය පුරවරය"

කතරගම ප්‍රාදේශීය සභාව
கதிரகாமம் பிரதேச சபை
KATHARAGAMA PRADESHIYA SABHA
නව නගරය, කතරගම./ புதிய நகர் கதிரகாமம்./ New Town, Katharagama.

මගේ අංකය / எனது இல / My Ref. } කප්‍රාස/4/1/2/4/1
ඔබේ අංකය / உமது இல / Your Ref. }
දිනය / திகதி / Date } 2017.05.15

නියෝජ්‍ය අධ්‍යක්ෂ ජනරාල්(අපද්‍රව්‍ය කළමණාකරන)
මධ්‍යම පරිසර අධිකාරිය,
පරිසර පියස,
අංක 104,
ඩෙන්සිල් කොබ්බෑකඩුව මාවත,
බත්තරමුල්ල.

<u>ඝන අපද්‍රව්‍ය බැහැර කිරීම හේතුවෙන් සිදුවන පාරිසරික හානිය අවම කිරීම සඳහා වූ JICA ව්‍යාපෘතිය</u>

උක්ත කරුණට අදාලව2017.04.27 දින ඔබ විසින්එවන ලද ලිපිය හා බැඳේ.

02.ඒ අනුව ඝන අපද්‍රව්‍ය බැහැර කිරීම හේතුවෙන් සිදුවන පාරිසරික හානිය අවම කිරීම සඳහාවූ JICA ව්‍යාපෘතිය කතරගම ප්‍රාදේශිය සභාව තෝරා ගැනීම සම්බන්ධයෙන් ස්තූතිය පුදකරන අතර,අදාල ව්‍යාපෘති ක්‍රියාත්මක කිරීම සඳහා අවශ්‍ය ඉඩමේ අයිතිය පිළිබඳ නිරවුල් භාවය ඒ වන විට අවශ්‍ය පරිදි සකස් කර දීමට අවශ්‍ය කටයුතු සිදුකරන බවත්, 2017 සිට 2019 දක්වා සිදුකිරීමට නියමිත මෙම ව්‍යාපෘතිය ජාතික පරිසර පනතට අනුව සාර්ථකව සිදුකිරීමට අවශ්‍ය පූර්ණ සහය ලබා දීමට බලාපොරොත්තු වන බවත්,වැඩි දුරටත් දන්වා සිටිමි.

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කතරගම.

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සා ලේකම් (වැ:බ:)
ප්‍රාදේශීය සභාව
රගම.

දුරකථනය/ෆැක්ස්/தொலைபேசி/ பெக்ஸ்/Telephone/Fax : 047-2235275
E-mail - Chairman-chairmankag@sltnet.lk   office - kag2235275@sltadsl.lk

Pollution Control and Reduction of Environmental Burden in Solid Waste Management (ReEB Waste), Central Environmental Authority (CEA).

Report on Geological Survey Data

Prepared by:

NUN ENGINEERING PVT LTD

For:

EX RESAERCH INSTITUTE

JULY 2017

Location No.1

Fig. 1- Machine setup for drilling at BH-01

Fig. 2 - Carrying out permeability test at BH-01

Fig. 3 - Sample box in BH-01

BH-01 log sheet

PROJECT	**Proposed treatment project at Kurunagala**		
EX Research Ins	**NUN Engineering Pvt Ltd**		
Client	Contractor		
BOREHOLE NO ; - BH01			
Location	Kurnagala dump site	**Drilling Operator**	Chaminda
Date Started	22/6/2017	**Drilling Machine**	Koken
Date Finished	23/06/2017	**Drilling Method**	Rotary
Total depth of hole	9m	**Bit Size**	NX
Cased depth	1.0m	**Casing diameter**	NX
Angle of Hole	Verticle	**Flushing medium**	Water

Depth	**Collected Sample Type**	**Description**	**% Core Recovery**	**R.Q.D**	**Standard Penetration Test** **Test Depth**	**N - Value**	**Graphical Presentation**
0.0m 0.5m	W/S	Dark brown sandy soil			0.0m -0.45 m		
2.0m	W/S	Highly weathered bed rock			1.0m-1.45m		
3.0m	W/S	Highly weathered bed rock			2.0m-2.45m		
4.0m	W/S	Highly weathered bed rock			3.0m-3.45m		
8.0m	W/S	Highly weathered bed rock			4.0m-4.45m		
9.0 m	C/S	Gneissic rock			5.0m-5.45m		

BOREHOLE WAS TERMINATED AT A DEPTH OF 9.0m

Key	**Remarks**	Logged By
D/S - Disturbed Sample **W/S - Washed Sample** **U/D - Undisturbed Sample** **H/B - Hammer Bounce** **GWT - Ground Water Table** **C/S - Core Sample**	* Borehole was terminated atdepth of 9.0 m with the request from client * GWT was below 9.0 m from the existing ground level	Dr. W.I.S. Fernando Sheet No - 1of 1 Date- 03/07/2017

Location No.2

Fig. 4 - Machine setup for drilling at BH-02

Fig. 6 - Sample box in BH-02

PROJECT	**Proposed treatment project at Kurunagala**		
EX Research Ins	**NUN Engineering Pvt Ltd**		
Client	Contractor		
BOREHOLE NO ; - BH-2			
Location	Kurnagala dump site	**Drilling Operator**	Chaminda
Date Started	8/6/2017	**Drilling Machine**	Koken
Date Finished	9/6/2017	**Drilling Method**	Rotary
Total depth of hole	15m	**Bit Size**	NX
Cased depth	6.5 m	**Casing diameter**	NX
Angle of Hole	Verticle	**Flushing medium**	Water

Depth	Sample Collected	Sample Type	Description	% Core Recovery	R.Q.D	Standard Penetration Test Test Depth of	N - Value	Graphical Presentation
0.0m 0.1m	D/S		Black color soil with filled material			0.0m -0.45 m	13	
2.0m	D/S		blackish brown clayey soil			1.0m-1.45m	40	
3.0m	D/S		brown clayey soil			2.0m-2.45m	23	
4.0m	D/S		Yellowish brown hard calyey sand			3.0m-3.45m	H/B	
5.0m	D/S		Yellow hard cayey sand			4.0 m -4.45m	36	
6.5m	D/S					5.0m-5.45m		
7.0 m	W/S		Highly weathered bed rock			6.0m-6.45m		
12.0 m	C/S		weathered bed rock					
15.0 m	C/S		weathered bed rock	20	0			

BOREHOLE WAS TERMINATED AT A DEPTH OF 15.0m

Key
D/S - Disturbed Sample
W/S - Washed Sample
U/D - Undisturbed Sample
H/B - Hammer Bounce
GWT - Ground Water Table
C/S - Core Sample

Remarks

* Borehole was terminated atdepth of 15.0 m with the request from client * GWT was depth of 7.2 m from the existing ground level

Logged By
Dr. W.I.S. Fernando
Sheet No - 1of 1
Date- 03/07/2017

Location No.3

Fig. 7 - Machine setup for drilling at BH-03

Fig. 8 - Carrying out permeability test at BH-03

Fig. 9 - Sample box in BH-03

PROJECT	**Proposed treatment project at Kurunagala**		
EX Research Ins	**NUN Engineering Pvt Ltd**		
Client	Contractor		
BOREHOLE NO ; - BH03			
Location	Kurnagala dump site	**Drilling Operator**	Chaminda
Date Started	21/6/2017	**Drilling Machine**	Koken
Date Finished	22/6/2017	**Drilling Method**	Rotary
Total depth of hole	15m	**Bit Size**	NX
Cased depth	6.0m	**Casing diameter**	NX
Angle of Hole	Verticle	**Flushing medium**	Water

Depth	**Collected**	**Sample Type**	**Description**	**% Core**	**Recovery R.Q.D**	**Standard Penetration Test**		
						Test Depth	**N - Value**	**Graphical Presentation**
0.0m 0.1m	D/S		Dark brown hard clay			0.0m -0.45 m		
2.0m	D/S		Dark brown hard clay			1.0m-1.45m		
3.0m	D/S		Light brown caly with sand			2.0m-2.45m		
4.0m	D/S		Brown caly with sand			3.0m-3.45m		
4.2m	D/S		Brown hard clay with coarse sand					
15.0 m	W/S		Highly weathered bed rock	0	0			

BOREHOLE WAS TERMINATED AT A DEPTH OF 15.0m

Key	**Remarks**	Logged By
D/S - Disturbed Sample **W/S - Washed Sample** **U/D - Undisturbed Sample** **H/B - Hammer Bounce** **GWT - Ground Water Table** **C/S - Core Sample**	* Borehole was terminated atdepth of 15.0 m with the request from client * GWT was depth of 3.0 m from the existing ground level	Dr. W.I.S. Fernando Sheet No - 1of 1 Date- 03/07/2017

Location No.4

Fig. 10 - Machine setup for drilling at BH-04

Fig. 11 - Carrying out permeability test at BH-04

Fig. 9 - Sample box in BH-04

PROJECT	**Proposed treatment project at Kurunagala**	
EX Research Ins	**NUN Engineering Pvt ltd**	
Client	Contractor	

BOREHOLE NO ; - BH04

Location	Kurnagala dump site	**Drilling Operator**	Chaminda
Date Started	19/6/2017	**Drilling Machine**	Koken
Date Finished	20/06/2017	**Drilling Method**	Rotary
Total depth of hole	15m	**Bit Size**	NX
Cased depth	3.0m	**Casing diameter**	NX
Angle of Hole	Verticle	**Flushing medium**	Water

Depth	Sample Type Collected	Description	% Core Recovery	R.Q.D	Standard Penetration Test Test Depth of	N - Value	Graphical Presentation
0.0m 0.1m	W/S	Black color soil with filled material			0.0m -0.45 m		
2.0m	D/S	Yellow to white hard clay			1.0m-1.45m		
3.0m	W/S	yellow soft clay with coarse sand			2.0m-2.45m		
4.0m	W/S	Coarse grained sandy soil			3.0m-3.45m		
4.6m	W/S	Coarse grained sandy soil					
15.0 m	W/S	Highly weathered bed rock					

BOREHOLE WAS TERMINATED AT A DEPTH OF 15.0m

Key	Remarks	Logged By
D/S - Disturbed Sample W/S - Washed Sample U/D - Undisturbed Sample H/B - Hammer Bounce GWT - Ground Water Table C/S - Core Sample	* Borehole was terminated atdepth of 15.0 m with the request from client * GWT was depth of 2.6 m from the existing ground level	Dr. W.I.S. Fernando Sheet No - 1of 1 Date- 03/07/2017

Location No.5

Fig. 10 - Machine setup for drilling at BH-05

Fig. 11 - Carrying out permeability test at BH-05

Fig. 12 - Sample box in BH-05

PROJECT	**Proposed treatment project at Kurunagala**		
EX Research Ins	**NUN Engineering Pvt Ltd**		
Client	Contractor		
BOREHOLE NO ; - BH05			
Location	Kurnagala dump site	**Drilling Operator**	Chaminda
Date Started	13/6/2017	**Drilling Machine**	Koken
Date Finished	14/06/2017	**Drilling Method**	Rotary
Total depth of hole	15m	**Bit Size**	NX
Cased depth	6.0m	**Casing diameter**	NX
Angle of Hole	Verticle	**Flushing medium**	Water

						Standard Penetration Test		
Depth	**Collected**	**Sample Type**	**Description**	**% Core Recovery**	**R.Q.D**	**Test Depth**	**N - Value**	**Graphical Presentation**
0.0m 0.1m	**D/S**		Dark brown hard clay			0.0m -0.45 m	F/D	
2.0m	**D/S**		Yellowish brown hard clay			1.0m-1.45m	11	
3.0m	**D/S**		brown hard caly with sand			2.0m-2.45m	13	
4.0m	**D/S**		Brown hard caly with sand			3.0m-3.45m	23	
5.4 m	**D/S**		Brown hard clay with coarse sand				23 , H/B	
15.0 m	**W/S**		Highly weathered bed rock	0	0			

BOREHOLE WAS TERMINATED AT A DEPTH OF 15.0m

Key	**Remarks**	Logged By
D/S - Disturbed Sample **W/S - Washed Sample** **U/D - Undisturbed Sample** **H/B - Hammer Bounce** **GWT - Ground Water Table** **C/S - Core Sample**	* Borehole was terminated atdepth of 15.0 m with the request from client * GWT was depth of 5.8 m from the existing ground level F/D-Free down	Dr. W.I.S. Fernando Sheet No - 1of 1 Date- 03/07/2017

Location No.6

PROJECT	**Proposed treatment project at Kurunagala**		
EX Research Ins	**NUN Engineering Pvt Ltd**		
Client	Contractor		
BOREHOLE NO ; - BH06			
Location	Kurnagala dump site	**Drilling Operator**	Chaminda
Date Started	15/6/2017	**Drilling Machine**	Koken
Date Finished	16/06/2017	**Drilling Method**	Rotary
Total depth of hole	15m	**Bit Size**	NX
Cased depth	6.0m	**Casing diameter**	NX
Angle of Hole	Verticle	**Flushing medium**	Water

						Standard Penetration Test		
Depth	**Collected**	**Sample Type**	**Description**	**% Core Recovery**	**R.Q.D**	**Test Depth**	**N - Value**	**Graphical Presentation**
0.0m 0.1m	**D/S**		Dark brown hard clay			0.0m -0.45 m		
2.0m	**D/S**		Yellowish brown hard clay			1.0m-1.45m		
3.0m	**D/S**		brown hard caly with sand			2.0m-2.45m		
4.0m	**D/S**		Brown caly with sand			3.0m-3.45m		
5.8 m	**D/S**		Brown hard clay with coarse sand					
15.0 m	**W/S**		Highly weathered bed rock	0	0			

BOREHOLE WAS TERMINATED AT A DEPTH OF 15.0m

Key	**Remarks**	Logged By
D/S - Disturbed Sample **W/S - Washed Sample** **U/D - Undisturbed Sample** **H/B - Hammer Bounce** **GWT - Ground Water Table** **C/S - Core Sample**	* Borehole was terminated atdepth of 15.0 m with the request from client * GWT was depth of 3.0 m from the existing ground level	Dr. W.I.S. Fernando Sheet No - 1of 1 Date- 03/07/2017

Location No.7

PROJECT	Proposed treatment project at Kurunagala		
EX Research Ins	**NUN Engineering Pvt ltd**		
Client	Contractor		
BOREHOLE NO ; - BH07			
Location	Kurnagala dump site	**Drilling Operator**	Chaminda
Date Started	9/6/2017	**Drilling Machine**	Koken
Date Finished	10/6/2017	**Drilling Method**	Rotary
Total depth of hole	15m	**Bit Size**	NX
Cased depth	7.0m	**Casing diameter**	NX
Angle of Hole	Verticle	**Flushing medium**	Water

Depth	**Collected**	**Sample Type**	**Description**	**% Core**	**Recovery R.Q.D**	**Standard Penetration Test** **Test Depth**	**N - Value**	**Graphical Presentation**
0.0m 0.1m	W/S		Wash samples were taken, Brown sandy clay			0.0m -0.45 m		
2.0m	W/S					1.0m-1.45m		
3.0m	W/S					2.0m-2.45m		
4.0m	W/S					3.0m-3.45m		
6.3 mm	W/S							
15.0 m	W/S		Highly weathered bed rock	0	0			

BOREHOLE WAS TERMINATED AT A DEPTH OF 15.0m

Key	Remarks	Logged By	
D/S - Disturbed Sample **W/S - Washed Sample** **U/D - Undisturbed Sample** **H/B - Hammer Bounce** **GWT - Ground Water Table** **C/S - Core Sample**	* Borehole was terminated atdepth of 15.0 m with the request from client * GWT was depth of 5.2 m from the existing ground level	Dr. W.I.S Fernando Sheet No - 1of 1 Date- 03/07/2017	

Permeability Results- Constant Head Method

Testing was done under **BS 5930:1999** standards.

$K = Q/(F*H_c)$.............. Equation 01

Where, K- permeability of Soil

Q - Rate of Flow

F – Intake Factor

H_c – Constant Head

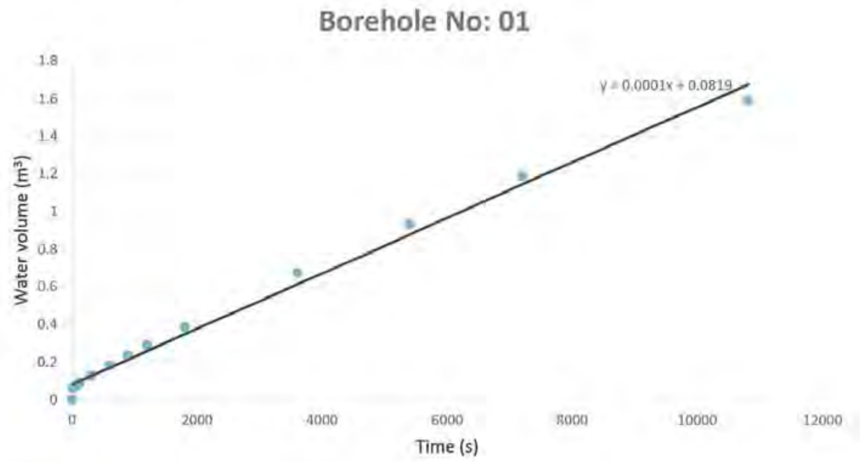
$F= 2\pi L/\log_e\{ L/D + (1+(L/D))^{1/2}\}$........ Equation 02

(For Vertical Permeability)

$F= 2.75D/ \{1+ (11/\pi)*(L/D)\}$ .... Equation 03

(For Horizontal Permeability)

(L- layer length, D- Hole Diameter)

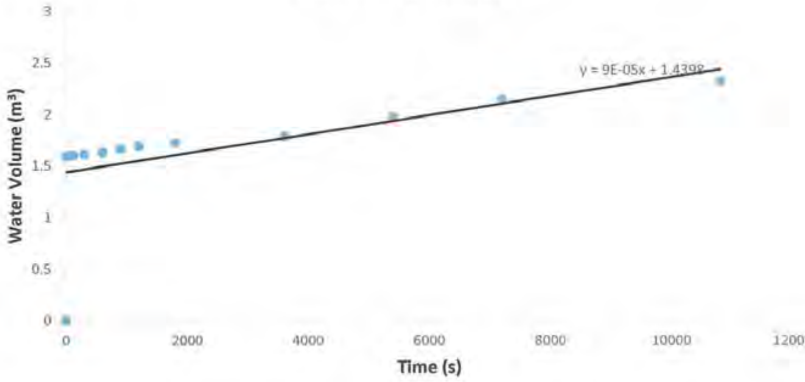


Calculation for permeability of Borehole No: 01

K= 16.07523 mm/s - horizontal permeability of the overall layer

K= 8.591×10^{-4} mm/s – Vertical Permeability of the borehole No 01.

Borehole No: 02

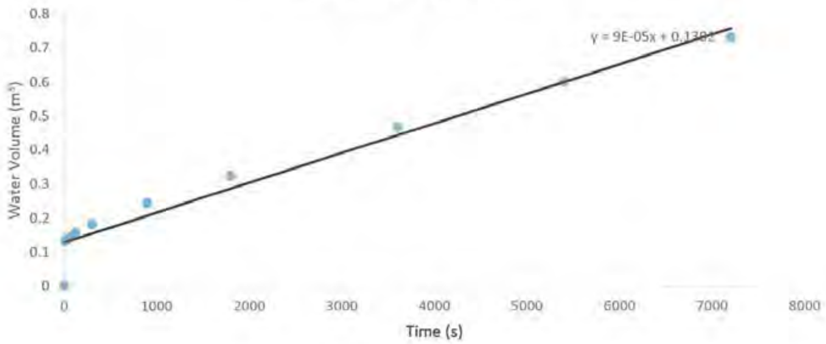


Calculation for permeability of Borehole No: 02

K= 86.7 mm/s - horizontal permeability of the overall layer

K= 4.6793x10^{-3} mm/s – Vertical Permeability of the borehole No 02.

Borehole No: 05

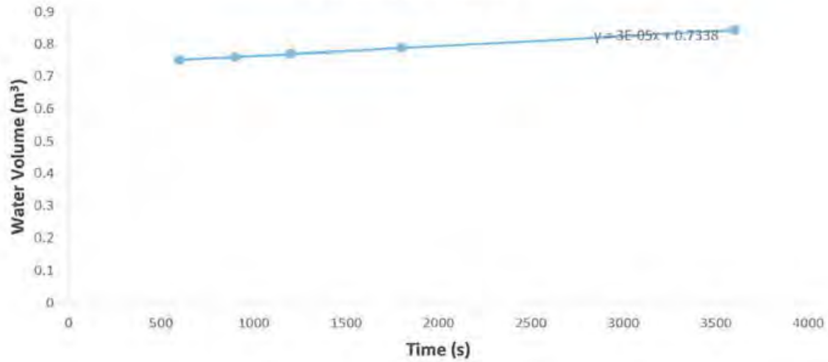


Calculation for permeability of Borehole No: 05

K= 13.258 mm/s - horizontal permeability of the overall layer

K= 3.685x10^{-4} mm/s – Vertical Permeability of the borehole No 03.

Borehole No: 04



Calculation for permeability of Borehole No: 04

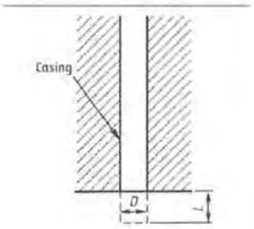
K= 44.179mm/s - horizontal permeability of the overall layer

K= 1.58x10^{-3} mm/s – Vertical Permeability of the borehole No 04.

** 3TH Borehole Comparatively Impermeable.

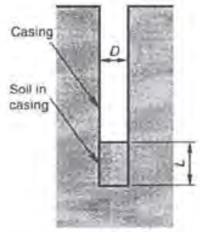
Soil permeability classes for civil engineering

Soil permeability classes	Coefficient of permeability (K in m/s)	
	Lower limit	Upper limit
Permeable	2 x 10^{-7}	2 x 10^{-1}
Semi-permeable	1 x 10^{-11}	1 x 10^{-5}
Impermeable	1 x 10^{-11}	5 x 10^{-7}



$$F = \frac{2\pi L}{\log_e[(2L/D) + \sqrt{(1 + ((2L)^2/D))}]}$$

c) Well point or hole extended at impervious boundary



$$F = \frac{2.75\,D}{1 + (11/\pi)(L/D)}$$

f) Soil in casing with bottom in uniform soil

Field Data:-

Time	Water Volume (m³)				
	BH-1	BH-2	BH-5 (gate)	BH-4 (Road)	BH-3 (cemetery)
0s	0	0	0	0	0
10s	0.0638	1.5955	0.1331		
20s	0.0652	1.5977	0.1346		
30s	0.0676	1.5997	0.1369		
1m	0.0753	1.6049	0.1441		
2m	0.0891	1.612	0.1582		
5m	0.1265	1.6327	0.1827		0.8624
10m	0.1823	1.6651		0.752	0.8743
15m	0.2353	1.6963	0.2433	0.7615	0.8859
20m	0.2869	1.7273		0.7709	0.8956
30m	0.3842	1.7887	0.3235	0.7895	0.9134
60m	0.6752	1.9779	0.4674	0.8444	
90m	0.9352	2.1484	0.5999		
120m	1.1889	2.3248	0.7283		
180m	1.5933				

G/5119

GEOTECHNICAL INVESTIGATIONS AT GALAPITAGALAYAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA

CLIENT – EX Research Institute Ltd.

August
2017

Geotech (Pvt) Ltd
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GEOTECHNICAL INVESTIGATIONS AT GALAPITAGALAYAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA

DATE	PREPARED BY	APPROVED BY
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GEOTECHNICAL INVESTIGATIONS AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA

1. INTRODUCTION

Japan International Corporation Agency (JICA) is the implementing agency for the project of Pollution Control and Reduction of Environmental Burden in Solid Waste Management, Sri Lanka.

Geotech (Pvt) Ltd. has been authorized by the Client, EX Research Institute Ltd. (appointed by JICA) to carry out geotechnical investigations at Galapitagalayaya Disposal Site in Kataragama Pradeshiya Sabha.

The scope of this investigation is to report the geological condition at site and prepare the report of soil investigation.

The field investigations were carried out in accordance with BS 5930:1999 “Code of Practice for Site Investigation".

2. SITE DESCRIPTION

The investigated area is located at Galapitagalayaya Disposal Site in Kataragama Pradeshiya Sabha. Access to the site is being provided from a roadway leading off form Gamudawa Road (Sella-Kataragama Road) at a location on its south-eastern direction.

The site is a part of lateritic hillock, which is sloping down from northern to southern direction. Ground elevations within the site are varying between +92.0m (at northern boundary) and +85.0m (at southern boundary) with respect to an arbitrary datum established at site.

At the time of investigation, some of the features at site are as indicated below.

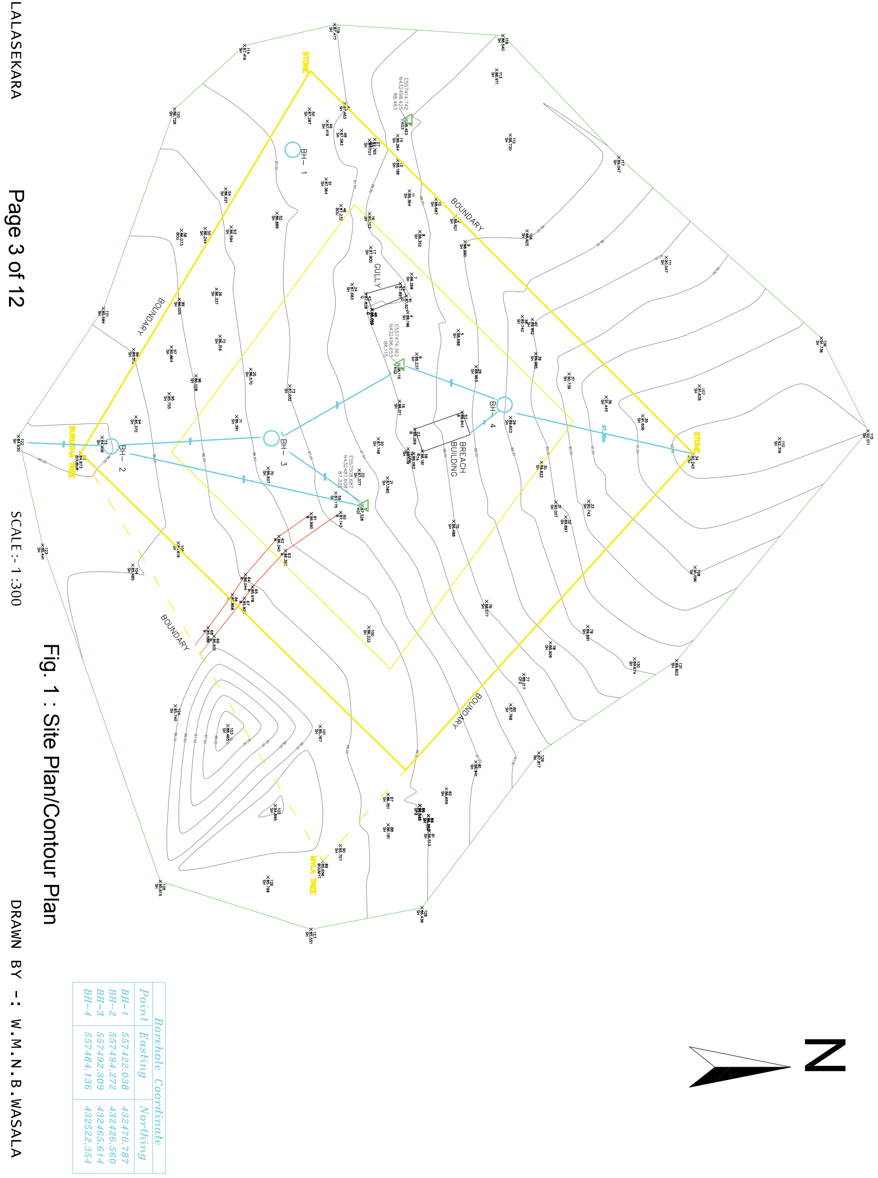
- The site is a jungle covered with large trees and it was being used as a garbage dumping area; and
- There was an abandoned building located around the center of site.

These details are shown in Fig. 1.

The site at Kataragama is located in the Monaragala District of Uva province of Sri Lanka which geologically belongs to the Kataragama Complex. The Kataragama Complex consists of metamorphic rocks that are similar to those of the Highland Group. The main constituents are garnetiferous charnockites ranging from acid to intermediate, granulites with or without garnets, calc gneisses and crystalline limestone. Also associated in a small scale are quartzite bands, pegmatites and hornblende gneiss. This sequence of rock is geographically separated from the Highland Group proper and is surrounded by rocks of Vijayan Complex. *(Reference : J. Natn. Sci. Coun. Sri Lanka 1981 9(2) : 189-197)*

TOPO GRAPHICAL SURVEY DISPOSAL YARD KATHARAGAMA

Appendix 7



Borehole Coordinate		
Point	Easting	Northing
BH-1	557422.038	432470.787
BH-2	557494.272	432426.560
BH-3	557492.309	432465.614
BH-4	557484.136	432522.354

Fig. 1 : Site Plan/Contour Plan

SURVEYED BY -: A.D.D.MALALASEKARA

SCALE :- 1 :300

DRAWN BY -: W.M.N.B.WASALA

3. FIELD INVESTIGATIONS

The field investigations reported herein are that of the Borehole Investigations and the Field Permeability Investigations. The field investigations were carried out from 22nd to 25th July, 2017.

3.1 Borehole Investigation

The borehole investigation was carried out by advancing 4 nos. boreholes at the locations indicated as BH-01 to BH-04 in Site Plan of Fig. 1.

The coordinates and the elevations (with respect to an arbitrary datum established at site) of boreholes are given in Table-1 below.

Table 1 : *Coordinates and Elevations of Boreholes*

BH No.		BH-01	BH-02	BH-03	BH-04
Elevation (m)		+87.2	+85.0	+86.75	+89.5
Coordinates	Easting	557422.038	557494.272	557492.309	557484.136
	Northing	432470.787	432426.560	432465.614	432522.354

The borehole in the size of 75 mm in diameter was advanced through the overburden by rotary wash boring method using a Chinese drilling rig. Cuttings were removed from the hole by the circulating water during drilling. Casing in the size of NX was used during the drilling process.

All boreholes were initially advanced up to the hard rock level. Thereafter, they were further advanced into the hard rock by 1.0m, 1.2m, 1.2m and 1.0m respectively at BH-01 to BH-04 using a double tube core barrel.

The details of the boreholes, together with the depth to GWT, depth to rock and the depth of the boreholes are given below. All depths are indicated with respect to a zero datum at top of the borehole.

Table 2 : *Borehole Information*

BH No.	BH-01	BH-02	BH-03	BH-04
Depth to GWT (m)	N/E (*)	N/E (*)	N/E (*)	N/E (*)
Depth to Rock (m)	3.6	4.8	3.3	3.2
Depth of Borehole (m)	4.6	6.0	4.5	4.2

(*) The GWT was not encountered up to the end of drilling.

Standard Penetration Tests (SPTs) were carried out at 1.0m intervals to assess the relative densities of the ground materials. This was done by driving a standard split spoon sampler into undisturbed soil under the impact of 63.5 kg hammer falling through a height of 760 mm.

The Standard Penetration Tests were performed in accordance with BS 1377:1990: Part 9 and the test results are interpreted in the boring logs at the relevant test depths as shown in Appendix 1A.

Disturbed samples of soil were collected both from the SPT split spoon and the flushed water during drilling.

Ground water level (GWL) was determined as the depth at which the water level stabilized inside the borehole.

Rock coring in boreholes had given following results for the Core Recovery (CR) and the Rock Quality Designation (RQD).

Table 3*–Rock Coring Information*

BH No.	Depth (m)	CR %	RQD %
BH-01	3.6-4.6	75	40
BH-02	4.8-6.0	80	00
BH-03	3.3-4.5	92	21
BH-04	3.2-4.2	45	30

3.2 Permeability Investigation

4 nos. Constant Head Permeability Tests were carried out at a depth of 3.0m in each borehole.

Method of testing

At the test locations, the borehole was initially advanced up to a depth of 3.0m from the ground surface, with the sides supported by 76mm diameter casing.

At the next stage, the casing was raised by 1.0m; and water was added into the hole up to the top of the casing. The test required that the casing be kept full of water. Therefore, water was added into the casing at regular intervals, and a record maintained of the quantity of water so added. The topping up of the hole was done at 5 minute intervals. The test was completed after 60 minutes of testing. The results of the investigation are given in Appendix 1B.

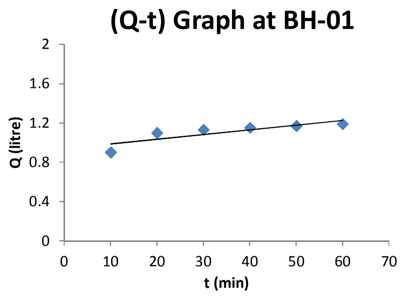
Analysis of results

- **At location BH-01**

Using the results given in Appendix 1B, the following results were next obtained for borehole BH-01.

Borehole No.	BH-01
Depth	3.0 m
Depth to WL	1.8 m
Height of casing above GL	1.0 m
k = q / (FH$_c$)	
q = (Q/t)	0.0048 lit/min.
F	20.9 cm
H$_c$	280 cm

k =	1.367 E-05 **cm/s**
k =	1.367 E-07 **m/s**
Rate of water absorption =	**0.019 lit./min. per sq.m.**

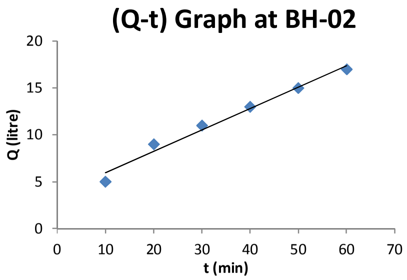


- **At location BH-02**

Using the results given in Appendix 1B, the following results were next obtained for borehole BH-02.

Borehole No.	BH-02
Depth	3.0 m
Depth to WL	1.3 m
Height of casing above GL	1.0 m
k = q / (FH$_c$)	
q = (Q/t)	0.2286 lit/min.
F	20.9 cm
H$_c$	230 cm

k =	7.926 E-04 **cm/s**
k =	7.926 E-06 **m/s**
Rate of water absorption =	**0.939 lit./min. per sq.m.**

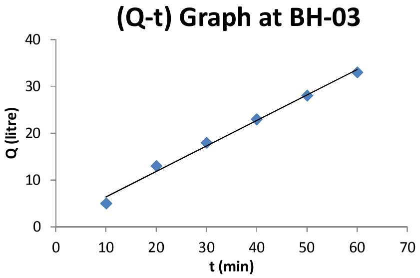


- **At location BH-03**

Using the results given in Appendix 1B, the following results were next obtained for borehole BH-03.

Borehole No.	BH-03
Depth	3.0 m
Depth to WL	1.6 m
Height of casing above GL	1.0 m
$k = q / (FH_c)$	
$q = (Q/t)$	0.5429 lit/min.
F	20.9 cm
H_c	260 cm

k =	1.665 E-03 **cm/s**
k =	1.665 E-05 **m/s**
Rate of water absorption =	**2.231 lit./min. per sq.m.**

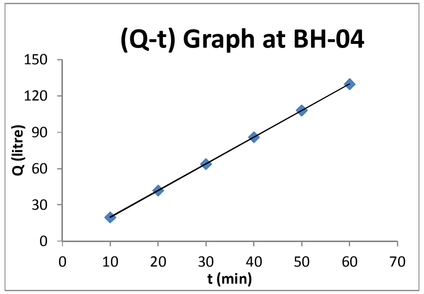


- **At location BH-04**

Using the results given in Appendix 1B, the following results were next obtained for borehole BH-04.

Borehole No.	BH-04
Depth	3.0 m
Depth to WL	2.1 m
Height of casing above GL	1.0 m
$k = q / (FH_c)$	
$q = (Q/t)$	2.2000 lit/min.
F	20.9 cm
H_c	310 cm

k =	5.659 E-03 **cm/s**
k =	5.659 E-05 **m/s**
Rate of water absorption =	**9.042 lit./min. per sq.m.**



4. SUB-SURFACE CONDITIONS

This section briefly describes the soil conditions encountered at site.

From a study of the borehole logs, it is concluded that the sub-surface condition at BH-01 is modeled by successive layers as follows.

(All depths are reported with respect to a zero datum at the top of each borehole.)

Table 4 - *Sub-Surface Layering of BH-01*

Layer No.	Position		Layer Description	Avg. SPT No.
	Depth (m)	Elev. at top of layer (m)		
1	0.0-2.0	+87.2	Lateritic Soils	38
2	2.0-3.6	+85.2	Completely Weathered Rock	>50
3	>3.6	+83.6	Basement Rock	

Ground water level was not encountered up to the end of drilling during the period of field investigations.

Similar layering was observed at other borehole locations. But, Layer No. 1 has a relatively lower strength at BH-02 with SPT N=(12-15).

5. PROFILES OF SUB-SURFACE LAYERING

The summary of borehole data is given in the form of a generalized Sub-Soil Profile which interpolates conditions between boreholes. Profile of sub-surface layering across boreholes was prepared based on the above model as shown in Fig. 2a and 2b below.

- **Fig. 2a :** Sub-Soil Profile across BH-01 and BH-02; and
- **Fig. 2b :** Sub-Soil Profile across BH-02, BH-03 and BH-04.

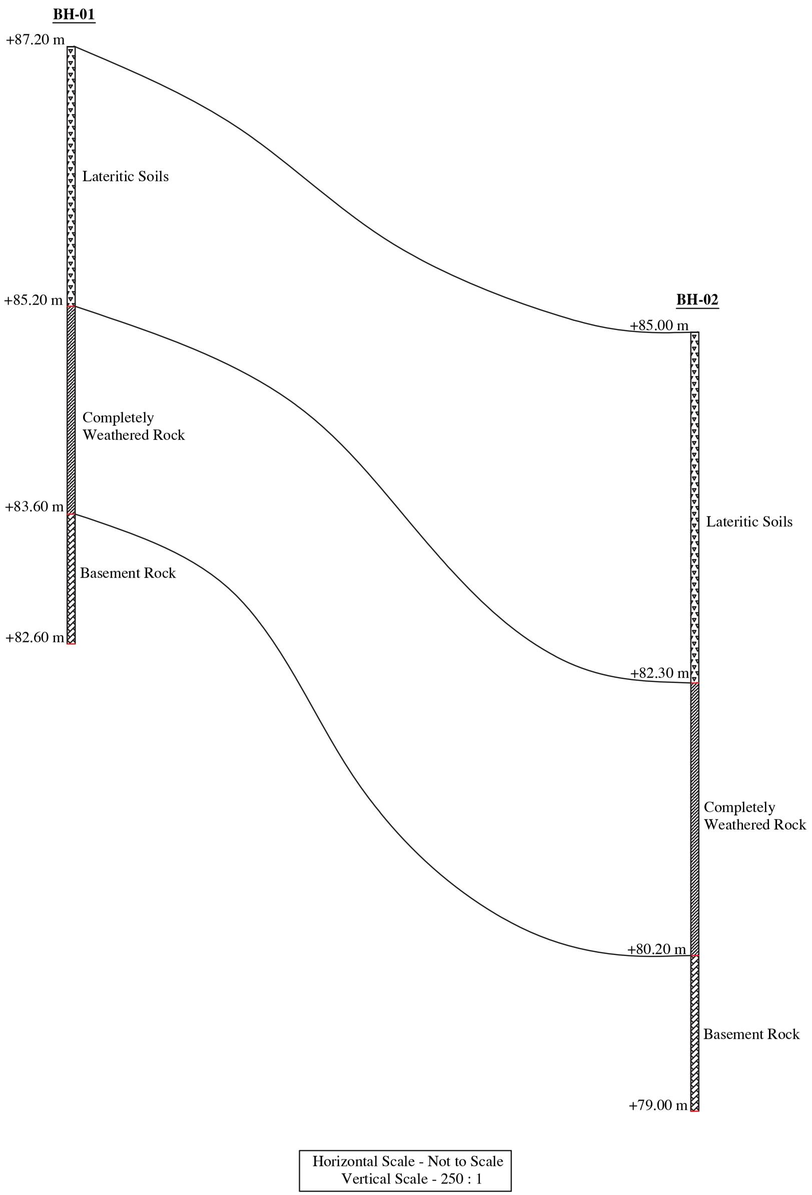


Fig. 2a *: Sub-Soil Profile across BH-01 and BH-02*

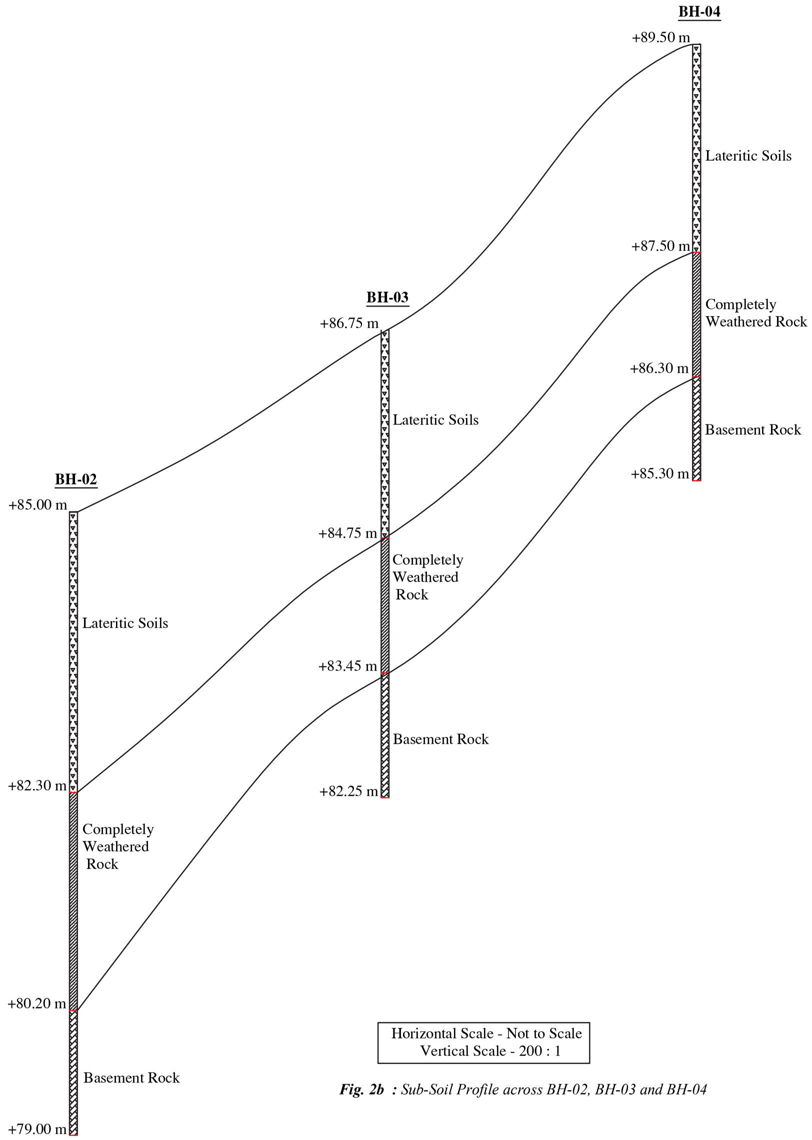


***Fig. 2b** : Sub-Soil Profile across BH-02, BH-03 and BH-04*

***Disclaimer:** These recommendations have been made based on the data gathered in the field, and laboratory test data where applicable. It is therefore, important that these recommendations are adhered to strictly. If for some site related practical consideration, the recommended procedures cannot be adhered to, prior approval in writing must be obtained from Geotech (Pvt) Ltd before any deviation from the recommendation is executed. Geotech(Pvt) Ltd will not be held responsible for any problem arising from any unauthorized deviation.*

APPENDIX 1A

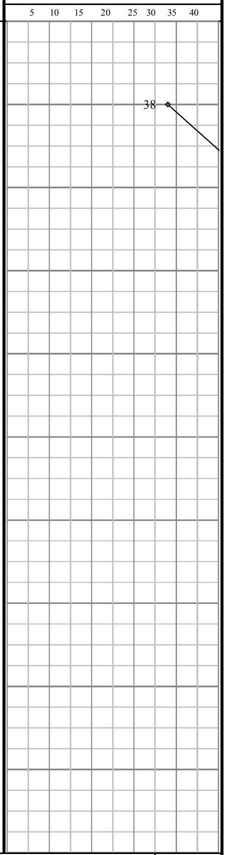
RESULTS OF BOREHOLE INVESTIGATIONS

Project	GEOTECHNICAL INVESTIGATIONS AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA						Borehole No	BH - 01
Client	EX Research Institute Ltd						Sheet	1 of 1
Location	Kataragama	Rig	Chinese Rig	Rock Level	3.60	m	G.W.L	N E m
Date of Started	23/7/2017	Method	Rotary	Terminated Level	4.60	m	Coordinates	0
Date of Finished	23/7/2017	Weather	Sunny	Elevation (MSL)	0.000			0

Logged By : Chamara Alwis
Supervised Chamara Alwis

Depth (m)	Sa. Cond	Sa.NO.	Sa.Type	Ground water Level	Legend	Soil Description	Depth	Field Records (SPT)/(CR,RQD) 15cm	15cm	15cm	N
0.00						Ground level					
	☒	S1	Bulk		▩	Reddish Brown Silty SANDY CLAY	0 to 0.45				
1.00	☒	S2	SPT	GWL at N Em	▩		1 to 1.45	14	17	21	38
2.00						2					
	☒	S3	SPT		▨	Yellowish Brown & Dark Brown COMPLETELY WEATHERED ROCK of fine Silty Sandy Clay	2 to 2.45	25	50		50
3.00	☒	S4	WS		▨		3 to 3.45	50			>50
						Rock Level at 3.6m 3.6		CR | RQD			
4.00					▧	Black to Gray Biotite Gneiss Rock	3.6 to 4.6	75	40		
						Terminated at 4.6m 4.6					
5.00											
6.00											
7.00											
8.00											
9.00											
10.00											

SPT Resistance - Blows/m



Sample Key	
SPT	Standard Penetration Test
WS-	Wash Sample
UD-	Undisturbed Sample
GWL	: Ground Water Level observed inside the Borehole, after the saturation
NR	Not Recovered
HB	-Hammer Bounce
FD	- Free Drop

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The Premier Soil Investigation Company

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Test Key

D - Disturbed Sample
SS -SPT Sample
W - Water Sample
Cr - Core Recovery (%)
RQD-Rock Quality Designation (%)

Remarks :- Existing ground level considered as the zero level

JOB NO :- G/5119

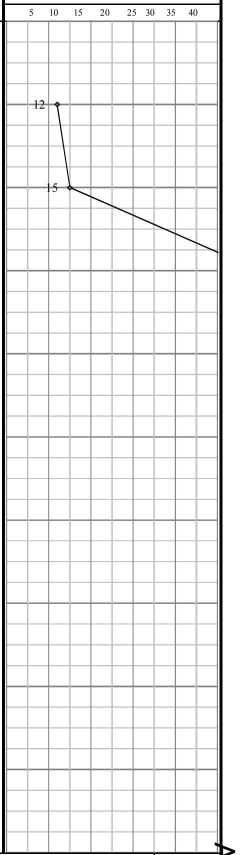
Checked By :- Sampath
0
Drilled By: Laloth

Project	GEOTECHNICAL INVESTIGATIONS AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA						Borehole No	BH - 02
Client	EX Research Institute Ltd						Sheet	1 of 1
Location	Kataragama	Rig	Chinese Rig	Rock Level	4.80	m	G.W.L	N E m
Date of Started	25/7/2017	Method	Rotary	Terminated Level	6.00	m	Coordinates	0
Date of Finished	25/7/2017	Weather	Sunny	Elevation (MSL)	0.000			0

Logged By : Chamara Alwis
Supervised Chamara Alwis

Depth (m)	Sa. Cond	Sa.NO.	Sa.Type	Ground water Level	Legend	Soil Description	Depth	Field Records (SPT)/(CR,RQD) 15cm	15cm	15cm	N
0.00						Ground level					
	☒	S1	Bulk		▩	Dark Brown fine to medium SANDY CLAY	0 to 0.45				
1.00						1					
	☒	S2	SPT		▒	Reddish Brown to Yellowish Brown fine Silty Sandy Clay	1 to 1.45	2	5	7	12
2.00	☒	S3	SPT		▒		2 to 2.45	5	7	8	15
						2.7					
3.00	☒	S4	WS		▨	Dark Brown to Yellowish Brown COMPLETELY WEATHERED ROCK of fine Silty Sand	3 to 3.45	50			>50
4.00	☒	S5	WS		▨		4 to 4.45	50			>50
						Rock Level at 4.8m 4.8		CR | RQD			
5.00	☒				▧	Black to Dark Brown Biotite Gneisic Rock (Slightly Weathered)	4.8 to 6	80	nill		
6.00						Terminated at 6m 6					
7.00											
8.00											
9.00											
10.00											

SPT Resistance - Blows/m



Sample Key	
SPT	Standard Penetration Test
WS-	Wash Sample
UD-	Undisturbed Sample
GWL	: Ground Water Level observed inside the Borehole, after the saturation
NR	Not Recovered
HB	-Hammer Bounce
FD	- Free Drop

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Test Key

D - Disturbed Sample
SS -SPT Sample
W - Water Sample
Cr - Core Recovery (%)
RQD-Rock Quality Designation (%)

Remarks :- Existing ground level considered as the zero level

JOB NO :- G/5119

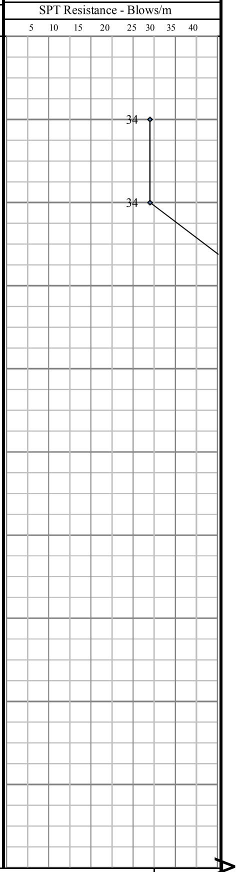
Checked By :- Sampath
0
Drilled By: Laloth

Appendix 7

Project	GEOTECHNICAL INVESTIGATIONS AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA					Borehole No	BH - 04
Client	EX Research Institute Ltd					Sheet	1 of 1
Location	Kataragama	Rig	Chinese Rig	Rock Level	3.20 m	G.W.L	N E m
Date of Started	22/7/2017	Method	Rotary	Terminated Level	4.20 m	Coordinates	0
Date of Finished	22/7/2017	Weather	Sunny	Elevation (MSL)	0.000		0

Logged By : Chamara Alwis
Supervised Chamara Alwis

Depth (m)	Sa. Cond	Sa.NO.	Sa.Type	Ground water Level	Soil Description	Depth	15cm	15cm	15cm	N
0.00					Ground level					
	☒	S1	Bulk		Dark Brown Soil with Grabage (0.5)	0 to 0.45				
1.00	☒	S2	SPT	GWL at N Em	Reddish Brown Silty SANDY CLAY (2)	1 to 1.45	7	18	16	34
2.00	☒	S3	SPT		Dark Brown medium to coarse SAND with trace of CLAY (3.2)	2 to 2.45	7	18	16	34
3.00	☒	S4	WS		Rock Level at 3.2m	3 to 3.45	50			>5
							CR | RQD			
4.00	☒				Gray to Black Biotite Gneisic Rock Terminated at 4.2m (4.2)	3.2 to 4.2	45	30		
5.00										
6.00										
7.00										
8.00										
9.00										
10.00										



Sample Key

SPT Standard Penetration Test
WS-Wash Sample
UD- Undisturbed Sample
GWL : Ground Water Level observed inside the Borehole, after the saturation
NR Not Recovered
HB -Hammer Bounce
FD - Free Drop

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Test Key

D - Disturbed Sample
SS -SPT Sample
W - Water Sample
Cr - Core Recovery (%)
RQD-Rock Quality Designation (%)

Remarks :- Existing ground level considered as the zero level

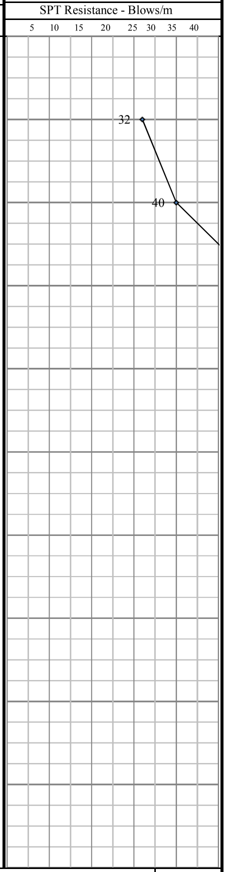
JOB NO :- G/5119

Checked By :- Sampath
0
Drilled By: Lalith

Project	GEOTECHNICAL INVESTIGATIONS AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA					Borehole No	BH - 03
Client	EX Research Institute Ltd					Sheet	1 of 1
Location	Kataragama	Rig	Chinese Rig	Rock Level	3.30 m	G.W.L	N E m
Date of Started	24/7/2017	Method	Rotary	Terminated Level	4.50 m	Coordinates	0
Date of Finished	24/7/2017	Weather	Sunny	Elevation (MSL)	0.000		0

Logged By : Chamara Alwis
Supervised Chamara Alwis

Depth (m)	Sa. Cond	Sa.NO.	Sa.Type	Ground water Level	Soil Description	Depth	15cm	15cm	15cm	N
0.00					Ground level					
	☒	S1	Bulk			0 to 0.45				
1.00	☒	S2	SPT	GWL at N Em	Reddish Brown fine Silty SANDY CLAY (2)	1 to 1.45	12	14	18	32
2.00	☒	S3	SPT		Dark Brown & Yellowish Brown COMPLETELY WEATHERED ROCK of fine to medium CLAYEY Sand (3.3)	2 to 2.45	12	19	21	40
3.00	☒	S4	WS		Rock Level at 3.3m	3 to 3.45	50			>5
							CR | RQD			
4.00	☒				Black to Gray Biotite Gneisic Rock (Weak & Slightly Weathered) Terminated at 4.5m (4.5)	3.3 to 4.5	92	21		
5.00										
6.00										
7.00										
8.00										
9.00										
10.00										



Sample Key

SPT Standard Penetration Test
WS-Wash Sample
UD- Undisturbed Sample
GWL : Ground Water Level observed inside the Borehole, after the saturation
NR Not Recovered
HB -Hammer Bounce
FD - Free Drop

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Test Key

D - Disturbed Sample
SS -SPT Sample
W - Water Sample
Cr - Core Recovery (%)
RQD-Rock Quality Designation (%)

Remarks :- Existing ground level considered as the zero level

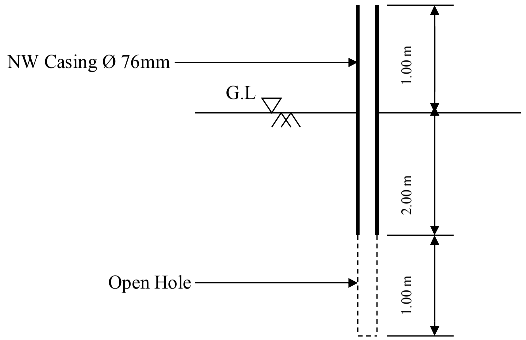
JOB NO :- G/5119

Checked By :- sampath
0
Drilled By: Lalith

APPENDIX 1B

RESULTS OF FIELD PERMEABILITY INVESTIGATIONS

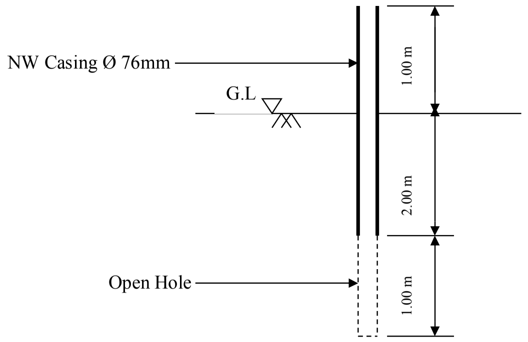
PERMEABILITY TEST DONE AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA



BH No. - 01
Depth - 3.00 m
Date - 23.07.2017

Time (min)	water level (m)	Water taken to fill to casing top level (ml)
3.20 pm	1.80	8000
10	0.10	900
10	0.05	200
10	0.02	30
10	0.01	20
10	0.01	20
4.20pm	0.01	20

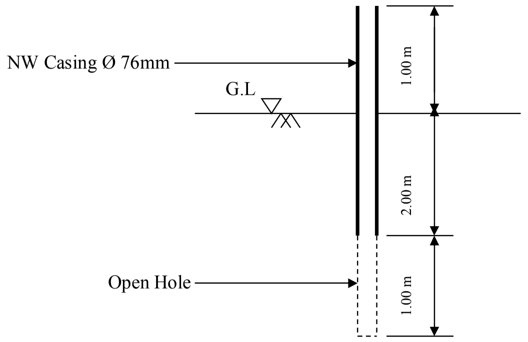
PERMEABILITY TEST DONE AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA



BH No. - 02
Depth - 3.00 m
Date - 25.07.2017

Time (min)	water level (m)	Water taken to fill to casing top level (ml)
11.30 am	1.30	8000
10	0.80	5000
10	0.60	4000
10	0.45	2000
10	0.50	2000
10	0.45	2000
12.30pm	0.45	2000

PERMEABILITY TEST DONE AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA

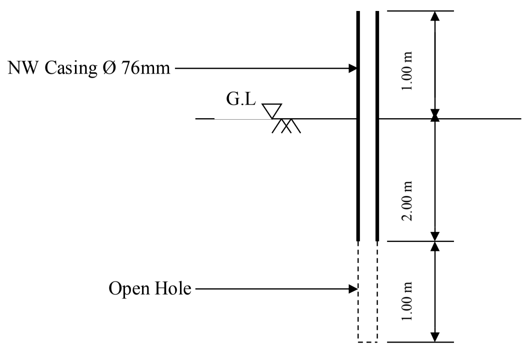


BH No. - 03
Depth - 3.00 m
Date - 24.07.2017

Time (min)	water level (m)	Water taken to fill to casing top level (ml)
2.50 pm	1.60	8000
10	1.15	5000
10	1.30	8000
10	1.12	5000
10	1.10	5000
10	1.15	5000
3.50pm	1.15	5000

Annexure

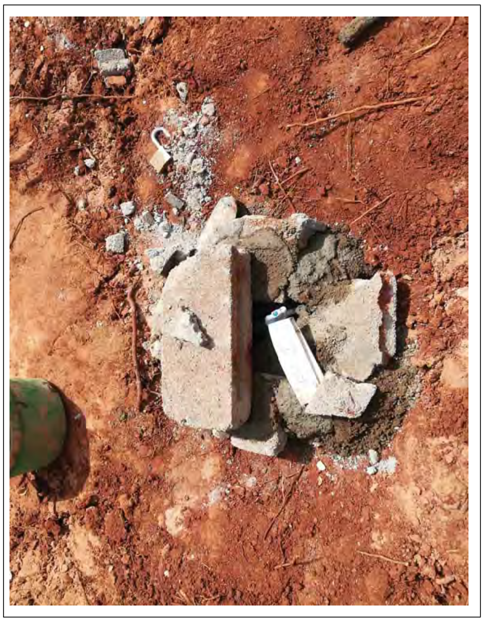
PERMEABILITY TEST DONE AT GALAPITAGALA YAYA DISPOSAL SITE IN KATARAGAMA PRADESHIYA SABHA



BH No. - 04
Depth - 3.00 m
Date - 22.07.2017

Time (min)	water level (m)	Water taken to fill to casing top level (ml)
4.00 pm	2.10	22000
10	2.00	20000
10	2.10	22000
10	2.10	22000
10	2.10	22000
10	2.10	22000
5.00pm	2.10	22000


BH - 4



Basic Design Report

Design and Supervision at Sundarapora Disposal Site in Kurunegala MC for Pollution Control and Reduction of Environmental Burden in Solid Waste Management in Sri Lanka

INSTALLATION OF PERMEABLE REACTIVE BARRIER (PRB) SYSTEM FOR GROUNDWATER REMEDIATION

Submitted to

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by

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SRI LANKA

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1 INTRODUCTION

Landfills have been identified as one of the major threats to groundwater resources (Fatta et al., [1999]) not only in Sri Lanka but throughout the world (United States Environmental Protection Agency US EPA, [1984]). More than 90% of the Municipal Solid Waste (MSW) generated in Sri Lanka is directly dumped on land in an unsatisfactory manner. The solid waste placed in landfills or open dumps are subjected to either groundwater underflow or infiltration from precipitation or any other possibility of infiltration of water. During rainfall, the dumped solid wastes receivers water and the by-products of its decomposition move into the water through the waste deposition. The liquid containing innumerable organic and inorganic compounds is called 'leachate'. This leachate accumulates at the bottom of the landfill and percolates through the soil and reaches the groundwater.

Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby dumping site. Such contamination of groundwater results in a substantial risk to local groundwater resource user and to the natural environment. The impact of landfill leachate on the surface and groundwater has given rise to a number of studies in recent years and gained major importance due to drastic increase in population. There are many approaches that can be used to assess the groundwater and surface water contamination. It can be assessed either by the experimental determination of the impurities or their estimation through mathematical modeling (Moo-Young et al., [2004]).

Sundarapola Municipal Solid Waste (MSW) dumpsite is also a typical open disposal site that threaten the groundwater resources in and around the site, especially the downstream water resources. The site is partly covered by rock formation on the upper terrain as the area was originally used as a quarry mine. However, there is no proper liner system at the bottom of the dump to prevent the groundwater contamination. Therefore, there is a great risk of groundwater contamination which can ultimately risk the health and wellbeing of downstream populations. Thus, there is an urgent need for a remediation measure.

After extensive lab scale researches, it has been found that permeable reactive barrier (PRB) can be a used as potential solution for groundwater remediation in unlined dumpsites such as Sundarapola. Therefore, this design project aims to design and installed a PRB system to remediate groundwater in the contaminated flow beneath the dumpsite.

2 THE DESIGN METHODOLOGY

The overall methodology for the application of a PRB at a given site is shown in Figure 2-1. PRB design involves the following steps:

i. Preliminary assessment
ii. Site characterization
iii. Reactive media selection
iv. Treatability testing
v. Modeling and engineering design
vi. Selection of a suitable construction method
vii. Monitoring plan preparation
viii. Economic evaluation.

The preliminary assessment is conducted to evaluate the technical and economic suitability of a given site for PRB application. Once a site is determined to be suitable, additional design steps are initiated.

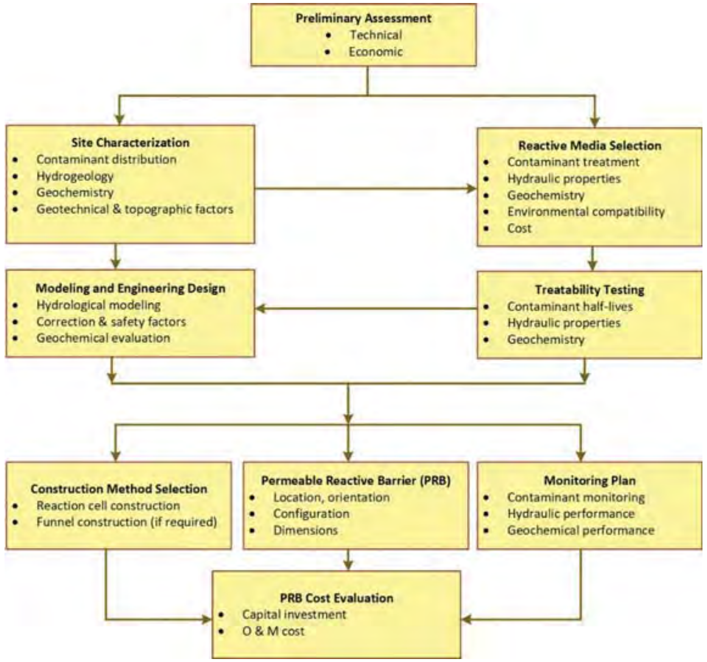


Figure 2-1 PRB Design criteria

2.1 Design criteria

2.1.1 Site characteristics

Final disposal site is located at Sundarapola, at about 3.9 km away from the Kurunegala town. The dumpsite lies within Kalawegedara GN division of Maspotha Divisional Secretariat and also comes under Kurunegala PS administration limits. Sundarapola waste disposal site is one of the largest MSW dumpsite in North Western Province of Sri Lanka and one of the oldest MSW dumpsite in Sri Lanka. The site is commonly shared by MCK and Kurunegala PS for MSW and toilet waste disposal since late 1920s. In addition, several government and privet organizations also use the site for MSW and non-hazardous solid waste disposal.

The available records showed the dumpsite was first started in year 1921. At that time, the surrounding land use was mainly coconut plantations and scrub lands. However, during the recent years, there are more than 200 families reside very close to the dumpsite on west side over the access road. The dumpsite is boarded to Wawagedara forest reserve on East and North sides and to a small cemetery on south. The forest reserve extends over 1000 acres on West - North side of the dump.

Final disposal site is located at Sundarapola, at about 1 km away from Wariyapola - Kurunegala highway (A10). According to official records at MCK, the extent of the final waste disposal site is 12.5 acres. The closet proximity to residence is around 10 m from the site boundary on the western side across the 3 m wide public road. The land is having a mild slope toward the road on the left. The storm water drain on right side of the road has been concreted which carry storm water from the site area during the rainy season and also leachate water throughout the year.

2.2 Hydraulic characteristics of the site

Figure 2-2 Identified surface water pathways

2.3 Horizontal gradient and hydraulic conductivity

Groundwater flow was assumed to flow in east-west direction with a horizontal gradient of 0.02 to approximate observed on-site conditions. Following figure shows the estimated hydraulic conditions of the site.

Table 2-1 Hydraulic characteristics of the site

BH	G. Elevation (MSL) (m)	GWL [from MSL] (m)	Kh (cm/s)	Kv (cm/s)
BH # 1	141.0	Below 132	1.61E-01	8.59E-06
BH# 2	131.0	123.8	8.67E-01	4.68E-05
BH # 3	127.0	124.0		
BH# 4	126.5	123.9	4.42E-01	1.58E-05
BH # 5	129.0	123.2	1.33E-01	3.69E-06
BH # 6	127.0	124.0		
BH # 7	127.0	121.8		
	Distance (m)	**GWL difference (m)**	**Gradient (m/m)**	
BH2-BH7	67.8	0.2	0.0030	
BH5-BH6	27.5	0.8	0.0290	
BH4-BH5	16.3	0.7	0.0429	
BH4-BH6	22.8	0.1	0.0044	

Field estimation of in-situ permeability showed that permeability values are closer to upper limit of semi-permeable range, indicating comparatively higher ground water flow than in a typical impermeable soil. Thus, the barrier layer shall have sufficient porosity to facilitate easy flow across the barrier, but shall minimize longitudinal flow paths along the barrier.

The higher value of aquifer k was used in the estimation to provide a conservative or high estimate of the anticipated groundwater flow rates through the barrier (lowest retention time in the reactive iron).

2.4 Reactive media selection

Reactivity: The candidate medium should be able to degrade the target contaminants within an acceptable residence time. Generally, the shorter the half-life of the contaminant with a given media, or higher the reaction rate constant, the better the media.

Hydraulic Performance: Selection of the particle size of the reactive medium should take into account the trade-off between reactivity and hydraulic conductivity. Generally, higher reactivity requires lower particle size (higher total surface area), whereas higher hydraulic conductivity requires larger particle size.

Stability: The candidate medium should be able to retain its reactivity and hydraulic conductivity over time. This consideration is governed by the potential for precipitate formation and depends on how well the candidate medium is able to address the inorganic components of the site groundwater. One important characteristic of the groundwater that limits precipitate formation is alkalinity, which acts as a buffer. If natural buffers are absent from the groundwater, a reactive medium that provides the required buffering capacity could be incorporated.

Environmentally Compatible Byproducts: The byproducts generated during degradation should not have deleterious effects of their own on the environment. For example, during degradation of TCE by iron, small amounts of potentially toxic byproducts (such as vinyl chloride) may be generated. However, given sufficient residence time for groundwater flow through the reactive cell, these byproducts are themselves degraded to potentially nontoxic compounds. Any alternative reactive medium selected should demonstrate similar environmental compatibility.

Construction Method: Some innovative construction techniques, such as jetting, may require a finer particle size of the reactive medium.

Availability and Price: The candidate medium should be easily available in large quantities at a reasonable price, although special site considerations may sometimes justify a higher price.

No	PRB Material	Pollutant Removed	Absorption Capacity	Reference
			phosphate solid phase, chernikovite. >12 300 microgram U (VI)/g in batch samples of bone meal, bone charcoal, and reagent-grade hydroxyapatite.	
18	Column packed with soil-activated carbon	Organic matter	60% of NOM is removal in packing columns at 60 min	Martinez-Gallegos et al. 2017
19	Iron Reactive Barrier	Uranium and Nitrate		Gu et al., 2003
20	FeS - coated sand	Arsenic(III)	Removal of As (III) by FeS - coated sand was 30% of that by nano particulate FeS at pH 5 and 7. At pH 9, the relative removal was 400%.	Han et al. 2011
21	Acid-washed zero-valent iron/aluminum mixtures	Cr(VI), Cd^{2+}, Ni^{2+}, Cu^{2+}, and Zn^{2+}	Cr(VI), Cd^{2+}, Ni^{2+},Cu^{2+}, and Zn^{2+}were all above 99.5% can keep about 300 h using 80 g/40 g acid-washed ZVI/ZVAl when treating wastewater containing each heavy metal ions (Cr(VI), Cd^{2+}, Ni^{2+}, Cu^{2+}, and Zn^{2+}) concentration of 20.0 mg/L.	Han et al. 2016
22	Spongy iron/pine bark	Nitrate–nitrogen	NO^{3}N removal efficiency (>91%) before 38 pore volumes (PVs) of operation (corresponding to 504 d), form little or even negative NO^{2-} N during the 45 PVs, and produce low NH^{4+} –N after 10 PVs. Hydrogenotrophic denitrification removed 10–20% of the initial NO^{3-}N. Effluent total organic carbon decreased from 403.44 mg L 1 at PV 1 to 9.34 mg L 1 at PV 45.	Huang, Huang, et al. 2015
23	Zero-valent iron(Fe), zero-valent iron and microorganism(M + Fe), microorganism(M)	Tetracycline	PRB columns packed with zero-valent iron (Fe), zero-valent iron and microorganism(M + Fe), microorganism (M) - Removal rate 50%, 40% and 10% respectively	Huang et al. 2017
24	(PRB) with oxygen-releasing compound (ORC) and clinoptilolite	Ammonium-nitrogen	NH^{4+} N depletion (>99%). NH^{4+} N of 5.23 - 10.88 mg/L was removed, and NO^{2-} N of <1.93 mg/L and NO3- N of 2.03 - 19.67 mg/L were generated.	Huang, Liu, et al. 2015
25	Novel, low-cost, PRB	Acidic, and metal-rich, spoil heap drainage (pH < 4, [acidity] > 1400 mg/L as CaCO$_3$, [Fe] > 300 mg/L, [Mn] > 165 mg/L, [Al] > 100 mg/L and [SO$_4$] > 6500 mg/L)	The drainage has typical chemical characteristics of pH < 4, [acidity] > 1400 mg/L as CaCO$_3$, [Fe] > 300 mg/L, [Mn] > 165 mg/L, [Al] > 100 mg/L and [SO$_4$] > 6500 mg/L. During 2 years of operation the PRB has typically removed 50% of the iron and 40% of the sulphate. overall reductions in iron and sulphate concentrations are 95% and 67% respectively.	Jarvis et al., 2006
26	Sand + zeolite	waste disposal site leachate	NH$^{+}_{4}$ (at 100%), K^{+} (at 93%) and Fe$_{total}$ (at an average of 86%)	Joanna et al,2013
27	Zeolite-sand mixtures (Vistula sand (medium sand acc. to USCS) with Slovak zeolite)	Groundwater at waste disposal sites	Batch test - copper by 32%. Column test - NH$^{+}_{4}$ (at 100%), K^{+} (at 93%) and Fe$_{total}$ (at an average of 86%)	Joanna & Kazimierz 2013
28	Zero valent iron (ZVI) and the mixture of ZVI and zeolites + oxygen releasing compounds	Zn, Mn, Mg, Cd, Sr, and NH$_4^+$	BOD5/COD increased from initial 0.32 up to average 0.61 and 0.6. Zn, Mn, Mg, Cd, Sr, and NH$_4^+$, and removal efficiency was 97.2%, 99.6%, 95.9%, 90.5% and 97.4% respectively.	Jun et al. 2009
29	Fly ash zeolites	Heavy metals (viz., As, Cd, Cr, Cs, Cu, Fe, Hg, Mn, Ni, Pb, Sr, W and Zn) and ionic species (viz., ammonium, chloride, fluoride, nitrate, phosphate and sulphate)		Koshy & Singh 2016
30	Bio barrier + Activated carbon	nitrate	More than 94%	Liu et al. 2013
31	Nano-sized manganese coatings on bone char	Arsenic (V)	Uncoated bone char has a higher retention factor (44.7) than bone char with 0.465 mg/g of Mn (22.0), but bone char samples with between 5.02 mg/g and 14.5 mg/g Mn have significantly higher. Between 0.2% and 0.6% of the sorbed As is desorbed	Liu et al. 2016

Table 2-2 Different types of materials used in PRB designs

No	PRB Material	Pollutant Removed	Absorption Capacity	Reference
1	Organic mulch	RDX- and HMX-contaminated groundwater	87.1 (83.6-90.6) µg/L to < 0.1 µg/L	Ahmad et al. 2007
2	Clinoptilolite and Y-type zeolite - Isotope exchange	Cd(II)	1.2 mg/kg	Ahmed et al. 2010
3	Zeolite with high SiO2/Al2O3	Methyl tert-butyl ether (MTBE), Chloroform, trichloroethylene	100 µg/L	Anderson 2000
4	Nano sized iron	Nitrate	20 - 300 mg/L to 3-50 mg/L	Araújo et al. 2016
5	Silica sand + Ca crushed limestone + readily available metal oxides	Phosphate	Short term - 99% of PO4 from a 10 mg/L PO4-P solution within 1 h. Long term - 50 wt % silica sand, 45 wt % limestone, and 5 wt % iron/calcium oxide averaged >90% reduction in phosphate over 4 years. A second column containing 50 wt % silica sand, 40 wt % limestone, and 10 wt % activated aluminum oxide achieved >99% reduction in PO4 over a period of 2 years	Baker et al. 1998
6	Polyhydroxybutyrate (PHB) and zero valent iron (ZVI)	Chlorinated ethanes	Acetate 2500 mg/L and butyrate 700 mg/L	Baric et al. 2012
7	Fe0	Acidic leachates		Bartzas et al. 2006
8	Pine sawdust mixes with soil	Nitrate	Preliminary groundwater is having, N (tot) equal to 704 mg dm-3, NO3-N equal to 228 mg dm-3and NH4-N to 347 mg dm-3. Preliminary results showed nearly 90% reduction of all forms of nitrogen.	Bednarek et al. 2010
9	Fly ash	Pb	Lead ion reduces from 1000 ppm to less than 2 ppm with 10 liters of solution and Lead ion from 10 ppm to less than 0.01 ppm.	Brooks et al. 2010
10	20% iron and 80% sand	Dissolved contaminants (PCE, TCE, cis-DCE, trans-DCE and VC) and inorganic (Ca^{2+}, Fe^{2+})		Carniato et al. 2012
11	Apetite II	Zn, Pb and Cd	Cd and Pb to below detection (2 lg L 1), has reduced Zn to near background in this region (about 100 lg L 1), and has reduced SO4 by between 100 and 200 mg L 1 and NO3 to below detection (50 lg L 1). The PRB, filled with 90 tons of Apatite II, has removed about 4550 kg of Zn, 91 kg of Pb and 45 kg of Cd, but 90% of the immobilization is occurring in the first 20% of the barrier, wherein the reactive media now contain up to 25 wt% Zn.	Conca & Wright 2006
12	Fly ash zeolites	Groundwater remediation		Czurda & Haus 2002
13	Biological control	Leachate	95% of COD and 100% inorganic Nitrogen.	Ding et al. 2001
14	Zero-valent iron	As(III)	Oxidation of As (III) to As (V), sorption of As (III) and sorption of As (V).	Eljamal et al. 2011
15	Grey cast-Fe shavings mixed with gravel	Chromate contaminated groundwater		Flury et al. 2009
16	Granular activated carbon and natural clinoptilolite zeolite	Petroleum hydrocarbon		Freidman et al. 2017
17	Bone apatite material (Contain HAP)	Uranium	< 5500 microgram U (VI)/g for all materials with the exception of crushed bone char pellets. >5500 microgram U (VI)/g in the absence of dissolved carbonate, formation of the uranyl	Fuller et al. 2003

No	PRB Material	Pollutant Removed	Absorption Capacity	Reference
50	Fe(0)	Different pollutants from contaminated aquifers	Column tests showed that all fractions achieved good TCE removal with a slight advantage for smaller grains.	Ruhl & Jekel 2012
51	Fe(0)	Hazardous substances		Ruhl et al. 2014
52	Clayey sandstone and entonite	Methanogenic leachates		Ruiz et al. 2012
53	Granular activated carbon	Atrazine and oxyfluorfen		Santos et al,2016
54	MgO + saw dust	Borate	Boron accumulation was more than 1.6 times greater in the presence of saw dust, although MgO alone performed well.	Sasaki et al. 2011
55	Fe(0),municipal leaf compost, sawdust, and wood chips	Se(VI)	Influent concentration (40 mg/L) of Se$_2$O $_4$ decreased to less than 2 mg/L within one week and to less than 0.014 mg/L within 1 month. SO$_2$ 4 concentration was reduced from 620 to 220 mg/L.	Sasaki et al. 2008
56	Uranium in hydroxyapatite: 237U as a radio indicator	Uranium	HAP can sorb more than 2900 mg/kg uranium	Simon et al. 2004
57	Natural clays containing small amounts of carbonates and sulfates	Leachate		Soto et al., 2012
58	Granular zero-valent iron (ZVI)	Copper and Zinc	The hydraulic retention time decreased by 15–18%. Decrease in the uniformity of the particle size distribution and the agglomeration of particles.	Statham et al. 2015
59	Zeolite, activated carbon	Heavy metal and hydrocarbon, Phosphorus	Phosphorus concentrations were reduced during flow through the iron/sand section and iron concentrations were reduced within the zeolite section.	Statham et al. 2016
60	Cotton burr compost, zero valent iron, and sediment	Nitrate	Cotton burr compost alone removed added nitrate at a greater rate than did Peerless Fe0 alone. Cotton burr compost also removed added nitrate at a faster rate than did cotton burr compost mixed with Peerless Fe0 and/or the sediment. No substantial accumulation of ammonium ions in the cotton burr compost system, system, in contrast to the systems containing Peerless Fe0 in which ammonium ions persisted as major products of nitrate reduction.	Su & Puls 2007
61	Cement kiln dust (CKD)-filter sand	Cu(II) and Zn(II) from simulated acidic groundwater	Decrease in the hydraulic conductivity, which can be attributed to an accumulation of most of the quantity of the contaminant masses in the first sections of the column bed.	Sulaymon et al. 2015
63	Fe^0	Nitrate	Nitrate reduction efficiency was enhanced by either increasing the Fe0 content in the Fe0 reactive barrier or decreasing the initial anode pH. Nitrate reduction efficiency was reduced by increasing the applied voltage from 10 V to 40 V. Nearly all nitrate nitrogen was recovered in either anode or cathode wells as nitrate or ammonium within 100 h.	Suzuki et al. 2012
64	Calcium carbonate ($CaCO_3$) and partly-weathered volcanic ash	Arsenic (As), lead (Pb), copper (Cu) and zinc (Zn)	Presence of $CaCO_3$ drastically reduced the amount of hazardous elements released from the altered rock. Combining neutralization and adsorption effectively reduced the amount of As and heavy metals in the effluent	Tatsuhara et al. 2012
65	Clay (illite) and wood chippings	Cs (137)	Portability (104 Bq/m^3)	Torres et al. 2017
66	Calcite	Fluoride	For SPL contaminant mixtures, fluoride removal is initially less than expected from idealized, pure, solutions. With time, the effect of other contaminants on fluoride removal diminishes. Fluoride removal increased with decreasing pH. 99% of 2300	Turner et al. 2008

No	PRB Material	Pollutant Removed	Absorption Capacity	Reference
			from the Mn-coated bone char at an initial pH value of 4, compared to 30% from the uncoated bone char.	
32	Partially saturated mixture of potassium permanganate and sand grains	Trichloroethylene, toluene, and ethanol vapors	High removal efficiency and reactivity of potassium permanganate for all target compounds at the highest water saturation (Sw = 0.6). A change in pH within the reactive layer reduced oxidation rate of VOCs.	Mahmoodlu et al. 2014
33	Biobarriers with electro kinetics	Diesel	After two weeks of operation, 30% of pollutants are removed and energy consumption is under 70kWhm^{-3}	Mena et al. 2015
34	Sand + peat and sand + sawdust	Trichloroethene		Mondal et al. 2016
35	Autotrophic sulfur-oxidizers	Nitrate	Over 90%	Moon et al. 2004
36	Oxidative process by Fenton's reagent combined with membrane separation system	Leachate	COD (63%), true color (76%) and humic substances (50%)	Moravia et al., 2013
37	Amorphous ferric hydroxide	U(VI)	Uranium(VI) (8.40·10−7−2.10·10−3 mol L−1; 0.2–500 mg L−1), sulfur(VI) (0–0.07 mol L−1; 0–2240 mg L−1) and carbon(IV) (0–0.0195 mol L−1; 0–234 mg L−1)	Moravia et al. 2013
38	Bio-reactive (5 cells each cell having different materials)	Petroleum hydrocarbons		Mumford et al. 2014
39	Activated carbon	Tetrachloroethylene (PCE)		Nardo et al,
40	Activated carbon	Cd(II)		Di Natale et al. 2008
42	Sand, carbon, bentonite clay and iron (10%)	Cr(VI)	Thermal treatment increased the amount of Fe_3O_4 from 25 to 55% by reduction of Fe_2O_3 and highly dispersed Fe^{3+} by the carbon present in the waste. Reduction of Cr (VI) to Cr (III).	Oliveira et al. 2011
43	Cay mineral	Silica in leachates, Ammonium	Observed SiO_2 values average 26.9 mg/l SiO_2 (s.d. 12.1 mg/l. The youngest (<2 a) leachates have highest SiO_2 levels (27-47 mg/l). Ammonium also appears to be controlled by exchange with K within clays.	Owen & Manning 1997
44	Geotextile clay liners	Hydraulic conductivity and self-healing properties		Parastar et al. 2017
45	Clinoptilolite (a natural zeolite)	Ammonium and heavy metals (Pb and Cu)	One gram of clinoptilolite showed removal efficiencies of more than 80% against those contaminants in all cases except in very high initial concentrations of ammonium (80 ppm) and copper (40 ppm)	Park et al. 2002
46	Fly ash	Pyrite oxidation	With time, pyrite microencapsulation inhibited oxidation in practically 97% of the pyritic sludge. Rapid pyrite-surface passivation decreased its reactivity, preventing AMD production in the relatively short term.	Pérez-López et al. 2009
47	Clay	Cs-137	The model was used to predict the performance of a hypothetical 2 m thick barrier with versus a real solution containing 105 Bq/m^3 Cs-137 and K^+ and NH_4^+ concentrations as high as 740 and 337 mg/L. The barrier treats high concentrations of Cs-137 more efficiently since its operation time decreases linearly with the logarithm of the inflow Cs-137 concentrations.	De Pourcq et al. 2015
48	Pozzolanic fly ash	Hydraulic barrier - Landfill		Prashanth et al. 2001
49	Fe^0	Mercury	Mercury removal percentage of 76.30%. Permeable reactive barrier of Fe, where 84.47% of the Hg^{2+} was recovered from water.	Robles et al. 2015

No	PRB Material	Pollutant Removed	Absorption Capacity	Reference
			materials can be successfully used as PRB materials to treat leachate contaminated with lead.	
83	Wooden shavings, as porous matrix, and clay	Cs-137	A residence time of 1 h of water in the barrier is enough to reach a retention rate close to the maximum (equilibria).	Ayora et al. 2012
84	In situ PRB	Hexavalent Chromium and Trichloroethylene		Blowes et al. 1999
85	Coconut coir fiber, rice straw, saw chips and rice husks	Landfill leachate	Organic matter, saw chips were the best at both adsorption and biodegradation; coconut coir fiber and rice husks were the best at biodegradation; both rice straw and saw chips were equally good at adsorption. Ammonia could be treated mainly by adsorption and nitrification. Based on the results, rice husks could be the most supportive reactive media for nitrification. Adsorption could be the dominant mechanism for chloride removal in all media that equally performed in removing chloride with greater than 90 percent removal.	Jayalath n.d.
86	Ex situ PRB	Arsenic	The high iron (Fe) and calcium (Ca) content of the slag reacts with the As removing it from solution.	Manchester et al. 2009
87	Amorphous ferric oxyhydroxide	Uranium	Uranium exhibits a sharp rise in the extent of adsorption with increasing pH.	Morrison et al. 1995
88	Coconut husk (CH)	Cd(II) and Pb(II)	Maximum adsorption capacities of Cd^{2+} and Pb^{2+} onto HACH were 47.28 and 66.26 mg/g, respectively, and 24.24 and 21.21 mg/g, respectively, for RCH.	Sewwandi et al. 2014
89	Granular activated carbon (GAC)	Atrazine and oxyfluorfen	10% of atrazine and oxyfluorfen remained in the soil after 15 days. Adsorption onto the GAC bed was an important removal mechanism (15–17% of herbicide retained). The evaporation loses in REKAB were lower than those obtained in EKSF (45–50% compared to 60–65%).	Vieira dos Santos et al. 2017
90	Mixture of WTR and pea gravel	Copper	The mean total copper concentration in groundwater was found to be 0.273 ppm. PRB based on mean K values from soil at the site was calculated to be 0.240 cm/s. Soil porosity was found to be 36.5%. A design pore water velocity value was calculated to be 0.07 cm/s.	Walkons 2016

No	PRB Material	Pollutant Removed	Absorption Capacity	Reference
			mg/L fluoride can be removed when CO_2 is injected directly into the barrier.	
67	Zeolites	Petroleum hydrocarbons	Test was interrupted for six months for removing by backwashing the inorganic and biological deposits formed on the filters.	Vignola et al. 2011
68	Calcium carbonate (limestone and crushed concrete)	Fe(II), Mn(II)	Influent groundwater to the PRBs contained mean Fe and Mn concentrations of approximately 30 mg/L and 1.62 mg/L. Fe was removed from influent water at average rates of 91% and 95% (by mass) for the limestone and crushed concrete PRBs in first year. Fe removal efficiency decreasing to 64% and 61% for limestone and concrete PRBs in 3rd year.	Wang et al. 2015
69	Gray cast iron	Cr(VI)	Cr (VI) reduction efficiency of ca. 15%.	Wanner et al. 2012
70	Novel Pd - bionanocatalyst	Alkaline Cr(VI)	Removing 4% and 64% of Cr (VI) observed from model Cr (VI) solutions, when formate and H2 were used as electron donors, respectively.	Watts et al. 2015
71	Compacted clay	Leachate or methane		Wijeyesekera et al. 2001
72	Granular iron	(Hexavalent chromium and trichloroethylene)	Chromium concentrations exceeding 3 µg/L have not been detected in regions located hydraulically down-gradient of the PRB. Trichloroethylene treatment has also been effective, although non-constant influent concentrations of trichloroethylene have at times resulted in incomplete dechlorination.	Wilkin et al. 2014
73	Natural zeolite	Copper ion exchange	The ion exchange of copper in slightly saline waters is decreased at both 22 and 2 °C compared to uptake in simple binary systems	Woinarski et al. 2003
74	Appetite	Cd, Pb, Zn, SO42-, NO3-	Elizabeth City - Inorganic carbon(IC) and sulfer (S) accumulation 0.09 and 0.02 $kg/m^2/year$. TDS < 400 mg/L in upgradient groundwater. Denver site - Inorganic carbon (IC) and sulfer (S) accumulation 2.16 and 0.8 $kg/m^2/year$. TDS 1000 - 1200 mg/L in up gradient groundwater.	Wilkin et al. 2003
75	Mycobacterium sp. CHXY119 and Pseudomonas sp. YATO411 immobilized bead	Benzene, toluene, ethylbenzene and xylene	97.8% for benzene, 94.2% for toluene, 84.7% for ethylbenzene and 87.4% for p-xylene	Xin et al. 2013
76	Fe0–Granular Activated Carbon (GAC)	1,4-dichlorobenzene	1, 4-dichlorobenzene (1, 4-DCB) could be efficiently dechlorinated in both anode and cathode. Long term performance of the process was significantly better. Iron efficiency (IE) of the proposed setup was averagely 225.7%.	Yang et al. 2012
77	Clayey soils	Leachate pollutants	The clayey soils showed a relatively high attenuation capacity for COD with the estimated retardation factor of 5.	Zhan et al. 2014
78	Calcined-hydrotalcite with electro kinetics	Cr(6+)	0.16–1.65 mg/g Cr (VI)-contaminated soil was remediated.	Zhang et al. 2012
79	(Activated carbon) Electrokinetics process	Copper contaminated Kaolin	The average removal rate reached the highest of 96.60% when the initial Cu^{2+} concentration was 2000 mg/kg.	Zhao et al. 2016
80	Zero valent iron, zeolite, activated carbon	Landfill leachate	Average reductions in chemical oxygen demand (COD) and contents of total nitrogen (TN), ammonium, Ni, Pb and 16 polycyclic aromatic hydrocarbons (PAHs) from test samples using this mixture were 55.8%, 70.8%, 89.2%, 70.7%, 92.7% and 94.2%, respectively.	Zhou et al. 2014
81	Natural Red Earth and Peat	Lead in leachate	Both NRE and peat show high BET surface areas and remove high percentages of low concentrated lead. Therefore, both	Abhayawardana 2015

2.5 Physical properties of PRB materials

In a PRB treatment, the barrier is commonly built with reactive materials whose hydraulic conductivity is higher than that of the surrounding soils, so that the contaminated groundwater is forced to pass through the barrier itself, moving under natural hydraulic gradient. The mechanism of action of a PRB depends on the choice of the reactive material used to build the barrier.

2.5.1 Grain sizes

The site investigation showed that the clay layers has moderate permeability (*Kv*) in order of 10^{-5} to 10^{-6} cm/sec. thus the PRB material should have equal or higher permeability to facilitate flow across the barrier.

Thus, one of the most widely accepted and simplest model for the permeability-porosity relationship is the Kozeny-Carman (KC) model ([Kozeny, [1927]; Carman, [1937]) which provides a link between media properties and flow resistance in pore channels was used to estimate the required particle size distribution of the PRB material (Carrier, [2003]; Onur, [2014]; Onur and Shakoor, [2015]).

$$k = \frac{g}{v} 8.3 \times 10^{-3} \left[\frac{n^3}{(1-n)^2} \right] D_{10}^2$$

Where:
k = permeability (cm/sec)
g = the acceleration due to gravity (cm/sec^2)
v = kinematic viscosity (mm^2/sec)
n = porosity
D_{10} = grain size corresponding to 10% by weight passing (mm).

The Kozeny-Carman (KC) equation was used to derive the D_{10} values of PRB material to satisfy a hydraulic conductivity greater than 1 x 10^{-5} cm/s. It was estimated that PRB material with grain sizes between 1-100 µm will have a satisfactory permeability at 0.4 to 0.6 porosity levels.

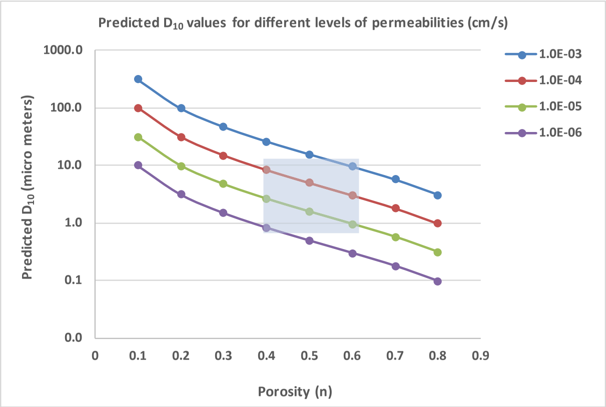


Figure 2-3 Estimation of optimum grain sizes for PRB materials

2.6 Potential PRB materials

Reactive media used in permeable barriers should be compatible with the subsurface environment. That is, the media should cause no adverse chemical reactions or byproducts when reacting with constituents in the contaminant plume, and should not act as a possible source of contaminants itself. This requires that the material be well understood and characterized. To keep PRB costs to a minimum, the material should persist over long periods of time, i.e., it should not be readily soluble or depleted in reactivity, and the material should be readily available at a low to moderate cost. The material selected should minimize constraints on ground-water flow by not having excessively small particle size and it should not consist of a wide range of particle sizes that might result in blocked inter-granular spaces (i.e., it should preferably be unimodal with respect to grain size). Worker safety, with regard to handling the material, should also be considered.

As shown in *Table 2-2*, literature describes a wide range of materials for PRB installations. However, most of the PRB materials have only tested in laboratory conditions, thus actual feasibility of usage in field application is unavailable. Therefore, the proposed system intends to use locally available and cost effective PRB materials.

2.6.1 Treatability of organic constituents in contaminated groundwater

Many reactive media combinations can be envisioned for use in PRBs and numerous media and mixtures of media are being investigated for a variety of contaminants (*Table 2-1*). In many applications, iron metal, variously designated as Fe0, Fe(0), or zero-valent iron, is the most common reactive media in the majority of field-scale and commercial implementations. Scrap iron is not expensive and can be obtained in a granular form in the large quantities needed. It has the ability to reduce oxidized inorganic species and reductively dehalogenate hydrocarbon compounds. Reactive iron barriers depend upon corrosion to drive these reactions. For example, chromate plumes are reduced from Cr(VI) to Cr(III) and precipitated, in situ, as chromium (III) hydroxides or chromium-iron hydroxide solid solutions. An example from among the amenable halocarbon plumes are those resulting from the dense, non-aqueous phase liquid (DNAPL) halogenated hydrocarbons.

These include chlorinated ethenes such as perchloroethylene (PCE), trichlorethylene (TCE), dichloroethylene (DCE), and vinyl chloride (VC). The reductive dehalogenation of these compounds occurs due to electron transfers from the iron to the halocarbon at the iron surface. This results in the halogen ions (e.g., Cl-) being replaced by hydrogen species, ultimately yielding ethene or ethane that can be mineralized via biodegradation.

The ability to perform dehalogenation in a reactive barrier is significant since the sources of DNAPL contamination, such as residual saturation, often cannot be easily located and may continue to generate a continuous plume of dissolved halocarbons. Although these plumes can often be controlled by pump-and-treat, the systems require extensive maintenance and continual energy input. PRBs are also designed for plume control, but with significant differences from pump-and-treat systems. PRBs are in situ systems, are intended to operate in a totally passive manner, do not routinely bring the contaminant to the surface, and should operate for years with minimal, if any, maintenance.

Although simple in concept, there is a great breadth of science and technology involved in the selection of reactive materials for different contaminants and in the design, installation, and monitoring of these emplacements in the subsurface. The purpose of this document is to provide an introduction and a guide to the science and technology of PRBs.

2.6.2 Treatability of inorganic constitutes in contaminated groundwater

Through untreated landfill leachate, depending on the type of landfill, metal contaminants such as Cd, Hg, Ni, Mn, Cu, Zn, Pb, As and Fe are often released to the environment. In recent years, there are many technologies and methods used to remove heavy metals from groundwater or wastewater such as adsorption, chemical precipitation, ion exchange and membrane. These technologies have their own different advantages and disadvantages to remediate heavy metals contaminated groundwater or surface water.

Generally, PRB systems required large quantities of reactive materials to be used in field applications. Consequently, few researchers have found various possible locally available reactive materials for organic and inorganic remediation.

Table 2-3 Pollutant removal capacity of locally available PRB materials

PRB Material	Target pollutants	Removal Capacity	Reference
Natural Red Earth (NRE)	Lead (Pb) in contaminated water	73% (Initial 1000 µg Pb(II)/mL)	Abhayawardana, 2015
Peat	Lead (Pb) in contaminated water	64% (Initial 1000 µg Pb(II)/mL)	Abhayawardana, 2015
Mixture of Red Soil (RS), Laterite Soil (LS), Bangadeniya Soil (LS), Burnt Clay Tile (BCT) and Coconut Shell Biochar (CSB)	Cd(II), Cu(II), Fe(II) and Pb(II)	> 90% from innitial initially raw value of Cd = 4.55 ppm, Cu=17.05 ppm, Fe= 16.75 ppm and Pb= 4.06 ppm	Yin et al., 2017
Burnt Brick clay, Rice husk-brick clay, Brick clay-rice husk, Rice husk	Cd(II), Cr(III), Cu(II), Ni(II), Pb(II) and Zn(II)	Efficiency in order of Brick clay > Rice husk+ brick clay> Brick clay+ rice husk > Rice husk	Navaratne et al., 2013
Mixture of Coconut shell biochar and Bangadeniya soil	Cd(II) and Pb(II)	Absorption 30.1 mmol/g for Cd(II) and 44.8–46.7 mmol/g for Pb(II)	Paranavithana et al., 2016
Peat, Laterite and Red earth	Phosphate and Phenol	More than 88% removal from initial 50 mg/L phosphate and 50 mg/L phenol	Pitawala et al., 2013
Reddish Brown Earth	Phosphorus	14285 mg/kg of soil	Sanjeevani et al., 2013
Mixtures of Bangadeniya soil, Coconut charcoal, and Clay brick particles	Cd(II) and Pb(II)	Adsorption Cr= 27.5-31 mmol/kg and Pb=45-65 mmol/kg	Saito et al., 2016

2.6.3 General conditions of leachate and groundwater pollution in Sri Lanka

A number of research have been conducted in Sri Lanka to describe the amounts of pollutants present in landfill as well as dumpsite leachate. Few studies have reported the degree of pollutants presence n contaminated soils and groundwater in and around dumpsites. In order to set general levels of pollutant that may presence in contaminated groundwater, a summary of reported information is presented in following table.

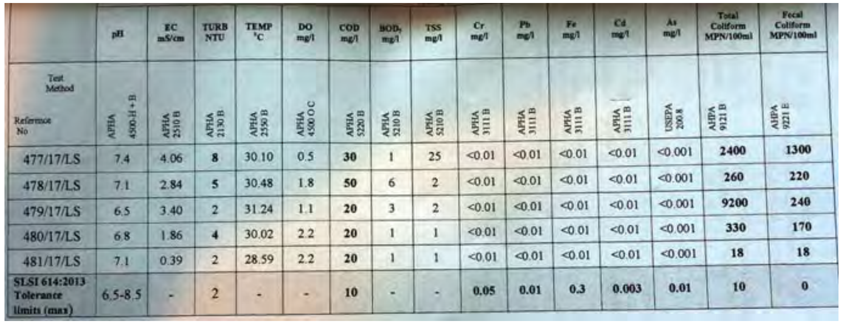
Table 2-4 Occurrence of heavy metal in landfill leachate and contaminated groundwater in Sri Lanka (micrograms/L)

Dumpsite/Location	Cr	Fe	Ni	Cu	Zn	As	Se	Cd	Pb	Reference
Matale	345	60,762	115	573	6,876	522	1,935	100	1,777	Sewwandi et al., 2016
Hambantota	80	5,341	226	166	19,909	678	2,522	172	492	Sewwandi et al., 2016
Kataragama	11	1,117	89	58	638	106	400	50	123	Sewwandi et al., 2016
Bandaragama	329	7,167	912	227	5,362	722	2,607	90	479	Sewwandi et al., 2016
Kolonnawa	1,968	346,930	4,473	55	11,759	705	2,443	15	421	Sewwandi et al., 2016
Gampola	220	5,546	335	734	462	164	461	4	34	Sewwandi et al., 2016
Gohagoda	139	3,004	331	334	389	148	465	1	19	Sewwandi et al., 2016
Wennappuwa	363	2,501	399	431	409	939	2,812	53	87	Sewwandi et al., 2016
Ratnapura	439	56,343	1,311	627	1,685	1,551	4,922	52	168	Sewwandi et al., 2016
Negombo	330	20,111	666	535	2,062	846	2,184	51	333	Sewwandi et al., 2016

Dumpsite/Location	Cr	Fe	Ni	Cu	Zn	As	Se	Cd	Pb	Reference
Matara	830	7,528	571	464	500	1,219	3,705	48	60	Sewwandi et al., 2016
Galle	486	15,477	673	664	593	1,796	5,947	52	169	Sewwandi et al., 2016
Gohagoda (GW1)	130	-	330	220	1,150	-	-	40	180	Wijesekara et al., 2014
Gohagoda (GW2)	90	-	110	70	300	-	-	10	140	Wijesekara et al., 2014
Max. Permissible level	100	3,000	3,000	3,000	5,000	200	500	100	100	CEA standards

As shown in Table 2-4, amounts of heavy metals in leachate are exceeding the levels that should be presence in surface waters, thus treatment of leachate is necessary before discharge into surface water resources. However, the limited amount of research conducted on leachate contaminated groundwater revealed that there is a tendency to pollute shallow groundwater from the heavy metals presence in leachate. Especially, highly toxic elements such as Cr, Pb and Cd.

Table 2-5 Occurrence of pollutants in groundwater samples collected from downstream dug-wells of Sundarapola dumpsite



	pH	EC mS/cm	TURB NTU	TEMP °C	DO mg/l	COD mg/l	BOD$_5$ mg/l	TSS mg/l	Cr mg/l	Pb mg/l	Fe mg/l	Cd mg/l	As mg/l	Total Coliform MPN/100ml	Fecal Coliform MPN/100ml
Test Method Reference No	APHA 4500-H+B	APHA 2510 B	APHA 2130 B	APHA 2550 B	APHA 4500 O C	APHA 5220 B	APHA 5210 B	APHA 5210 B	APHA 3111 B	APHA 3111 B	APHA 3111 B	APHA 3111 B	USEPA 200.8	AHPA 9121 B	AHPA 9221 E
477/17/LS	7.4	4.06	8	30.10	0.5	30	1	25	<0.01	<0.01	<0.01	<0.01	<0.001	2400	1300
478/17/LS	7.1	2.84	5	30.48	1.8	50	6	2	<0.01	<0.01	<0.01	<0.01	<0.001	260	220
479/17/LS	6.5	3.40	2	31.24	1.1	20	3	2	<0.01	<0.01	<0.01	<0.01	<0.001	9200	240
480/17/LS	6.8	1.86	4	30.02	2.2	20	1	1	<0.01	<0.01	<0.01	<0.01	<0.001	330	170
481/17/LS	7.1	0.39	2	28.59	2.2	20	1	1	<0.01	<0.01	<0.01	<0.01	<0.001	18	18
SLSI 614:2013 Tolerance limits (max)	6.5-8.5	-	2	-	-	10	-	-	0.05	0.01	0.3	0.003	0.01	10	0

The Sundarapola site evaluation showed that the level of heavy metals in groundwater is far below the levels recorded by Wijesekara et al., (2014). However, the likelihood of groundwater contamination from leachate from Sundarapola shall not be overlooked. Therefore, the proposed PRB system shall designed to remove and remediate heavy metals that likely to be occurred in future.

After reviewing the extensive amounts of international and local literature, it was found that Clay soil, coconut shell charcoal and clay brick particles have showed higher capacities for heavy metal removal from aqueous solutions. Several types of clay soils have been tested and clay soil commonly found in Bangadeniya (Entisol) have showed remarkable capacity over other soils.

Most of research highlighted the advantage of mixing few types of materials to form a uniform mixture thereby enhancing the pollutant removal and keeping the hydraulic properties. The mixing ratios of different materials shall have higher adsorption and reactivity but shall not compromise the desired hydraulic properties. Hydraulic properties are mainly governed by particle sides and mixing ratios. Saito et al., [2016] and Kawamoto et al., [2016] have tested different ratios of Clay brick particles, coconut coir power and Bangadeniya soil as candidate mixture for PRB, and found that a ratio of 75%, 12.5% and 12.5 of materials satisfied all requirements for a PRB system.

Therefore, considering the material availability, convenience of material processing, hydraulic performances and cost, it was decided to use a mixture of Bangadeniya Soil (12.5%) + Charcoal powder (12.5%) + Brick particles (75%). The tested particles sizes were less than 2mm of Bangadeniya soil, <75 micrometer for coconut shell powder, and 2- 4.75 mm for clay brick particles.

Table 2-6 Mixing ratio and longevity of PRB materials (after Saito et al., [2016] and Kawamoto et al., [2016])

Criteria	Units	Bangadeniya Soil (25%) + Charcoal powder (25%) + Brick particles (50%)			Bangadeniya Soil (12.5%) + Charcoal powder (12.5%) + Brick particles (75%)		
Degree of compaction	%	Dr= 75	Dr= 80	Dr= 90	Dr= 75	Dr= 80	Dr= 90
Hydraulic conductivity	cm/s	2.00E-03	7.00E-04	3.30E-05	2.50E-03	2.40E-03	9.80E-04
Heavy metal adsorption	mg/year	3.10E+05	1.10E+05	5.30E+03	3.90E+05	3.80E+05	1.50E+05
Dry bulk density	g/cm^3	0.93	1.06	1.19	0.92	1.05	1.20
Heavy metal removal	mg/m^3	2.10E+06	2.40E+06	2.70E+06	2.40E+06	2.80E+06	3.20E+06
Expected lifetime	Years/m^3	6.90	22.00	523.00	6.20	7.30	20.50

2.7 Characteristics of proposed PRB materials

2.7.1 Aalluvial clay soil from Bangadenia

Alluvial deposits have adequately tested for pollutant removal and has showed promising results as a low cost absorbent (Sewwandi et al., [2014]; Paranavithana et al., [2016]). These soils mainly consist of SiO$_2$, Al$_2$O$_3$ and Fe$_3$O$_2$, where SiO$_2$ is present in crystalline form while Al (as Al$_2$O$_3$) and Fe (as Fe$_2$O$_3$) exist as an amorphous coating around the silica grains (Vithanage et al., [2006]; Mahatantila et al., [2011]). Further, Sewwandi et al., [2014] and Abhayawardana, [2015] and Vithanage et al., [2007] have suggested Alluvial soil to be a starting material in decontaminating water polluted with heavy metals.

Similarly, other types of locally available soils such as Natural Red Earth (NRE) has showed the potential to be used as absorbent in heavy metal contaminated water purification. Rajapakse et al., [2011] have observed that NRE is a good adsorbent for As (III) and As (V). Nikagolla et al., [2012] have also stated that NRE can effectively be used to mitigate Cr (III) from aqueous solutions and this method is found to be simple, effective, economical and environmentally benign. Mahatantila et al., [2012] have studied the removal of Cd using NRE and the study indicates NRE to be a material suitable for decontaminating environmental water polluted with Cd. In recent study by Abhayawardana, [2015] has suggested that Aalluvial soils have < 75 µm in D$_{30}$ fraction suggesting that the material fail within upper level of permeability expect for proposed PRB system.

2.7.5 Characteristics of proposed PRB materials

Table 2-7 Characteristics of proposed PRB materials

PRB material	Main purposes	Target pollutant	Adsorption /Reactivity	Availability	Cost (Rs/MT)	Proposed ratio (V/V)	Particle size	Processing cost
Bangadeniya clay	1) Heavy metal absorbent 2) Bulking agent to maintain K	Heavy metals Chlorinated hydrocarbons	Moderate	Readily available in local areas	Moderate	12.5%	2 mm max. @ 30% WC	*Dry sieving is possible
Coconut shell charcoal	3) Organic pollutant absorbent 4) Biologically reactive material	Organic pollutants Heavy metals	High	Available as a commercial product	High	12.5%	75µm max.	*Can be crushed & sieved with simple crushing machines **Dry sieving is possible
Crushed clay tiles made out of Natural Red Earth (roofing/ bricks)	5) Bulking agent 6) Heavy metal absorbent	Heavy metals Chlorinated hydrocarbons	Moderate	Available	Low	75%	2 mm < D < 4.75 mm @ 3.5% WC	*Requires heavy crushing machines **Dry sieving is possible

2.7.2 Charcoal/Biochar

Charcoal and biochar have been tested widely for its reactive and absorptive properties to be used in PRB. Charcoal is derived from biological materials thus exhibit excellent absorptive characteristics of heavy metals as well as organic pollutants (e.g. especially chlorinated hydrocarbons) and nutrients such as Nitrate, Ammonium and soluble phosphorus (Sewwandi et al., [2014]; Vieira dos Santos et al., [2017]; Zhao et al., [2016]; Statham et al., [2016]).

2.7.3 Burnt clay brick/ tile particles

Though the amount of research on burnt clay brick/ tile as a potential PRB material is not much, several researches have proposed the potential of burnt clay to absorb heavy metals and organic pollutants (Priyantha et al.; Nawaratna et al., [2013]). Recently, Paranavithana et al., [2016] have tested a mixture of biochar and soil for Cd^{2+} and Pb^{2+} in PRB systems and found that adsorption capacities are similar to or higher than the values of bio-sorbents tested for wastewater treatment in previous studies, suggesting benefits of biochar amendments with soil in PRB.

2.7.4 Mixing ratio of proposed materials

Saito et al., [2016] and Kawamoto et al., [2016] have shown that a mixture of soil, biochar and brick in the ratio of 12.5%: 12.5%: 75% showed the highest hydraulic conductivity at degree of compaction with around 75%, showing more than 10^{-3} cm/s and the value was 5 times greater than that of entisols from Bangadeniya. Therefore, following mixture of materials are proposed to be used in the PRB system.

Figure 2-4 Picture of proposed PRB materials

3 PRB SYSTEM DESIGN

The design and optimization of an in-situ effective depuration technology must also take into account the hydrological and geotechnical properties of the entire polluted aquifer. Hence, a complete characterization of the site chemical, hydro-geological and geotechnical properties is required.

The design of a Permeable Adsorptive Barrier for a polluted aquifer, for which a hydraulic, geotechnical and contaminant characterization has been previously performed, mainly consists in the definition of the barrier location, orientation and dimensions. The problem cannot be approached by direct calculation and an iterative procedure has to be applied. First the location and size of the barrier have to be chosen and then it is necessary to check whether the choice allows a thorough pollutant capture during the whole lifetime of the barrier. Moreover, the minimum dimensions of the barrier have to be identified for it to be cost-effective. Since the calculation procedure may be very time-consuming, an optimization criterion is necessary.

There are only a few PRB design methodologies to determine the thickness of a PRB documented in literature. The Environment Agency of UK (National Groundwater & Contaminated Land Centre report, [2002]) proposed estimating wall thickness using the following equation, based on treatment process that can be described as a first order reaction:

$$L_B = t_{res} \times V_B \times S_F \qquad \text{and} \qquad t_{res} = \frac{ln(C_T/C_o)}{R}$$

Where L_B = thickness of wall barrier; C_T = concentration target (μg/l); C_o = concentration at source (μg/l); t_{res} = time of residence in the wall (d); V_B = velocity of the water (m/d); R = reaction rate (d^{-1}); and S_F = safety factor.

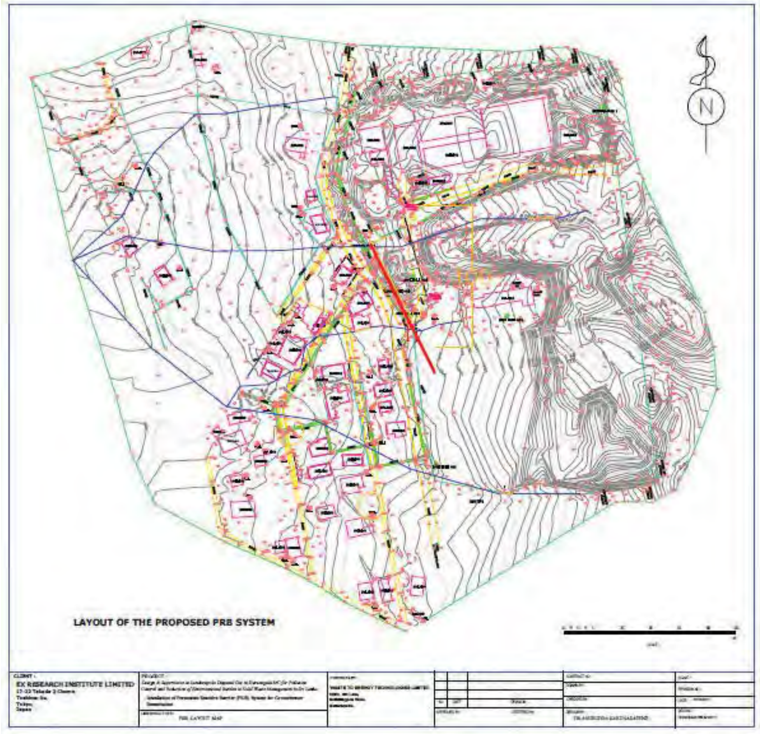
Table 3-1 Calculation of PRB thickness (worst case scenario where PRB directly in contact with upstream PRB)

Landfill leachate		**S_F=1**	**S_F=1.5**	**S_F=2**	**Estimated S_F**
	Co (μg L^{-1})	L_B (m)	L_B (m)	L_B (m)	**L_B = 2.0m**
Hambantota	492	1.40	2.10	2.81	1.4
Kataragama	123	0.90	1.36	1.81	2.2
Bandargama	479	1.39	2.09	2.79	1.4
Kolonnawa	421	1.35	2.02	2.69	1.5
Rathnapura	168	1.02	1.52	2.03	2.0
Negombo	333	1.26	1.89	2.52	1.6
Galle	169	1.02	1.53	2.04	2.0
C_T (μg L^{-1})	10	Background Pb in surface water (Gunatilake et al., [2014])			
R (d^{-1})	2.4	Varies from 2.4 to 89.2 (Metz, [2007]; Komnitsas [2007])			
V_B (m d^{-1})	0.846	Permeability, k = 5 x 10^{-4} (cm s^{-1}) [between 10^{-5} and 10^{-4})			

A series of calculation were performed based on literature data in order to find the thickness of barrier. Following table shows the procedure to select the optimum barrier thickness for the proposed PRB system. The calculations were performed assuming a worst case scenario where dumpsite leachate may directly flow into the PRB and required to lower the indicator pollutant (Pb) level to most likely occurrence background concentration of μg L^{-1} (Gunatilake et al., [2014]). Accordingly, it was found that a 2.0 m thickness satisfy the treatment requirements with a minimum safety factor of 1.4.

3.1 Layout and configuration of the PRB system

Following figure shows the proposed configuration of the PRB system (Refer "PRB layout map.pdf" for high resolution image).



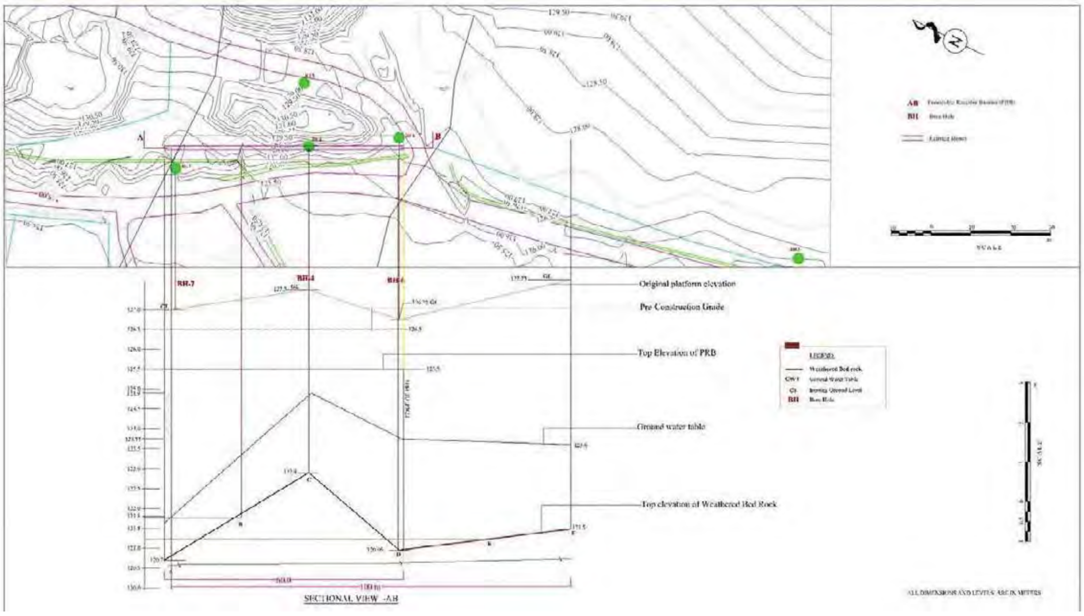


Figure 3-1 Cross Sectional Views of proposed PRB system

The PRB system will lay at 125.5 MSL and below down to weathered bed rock formation (BR). The level of bed rock formation varies from 120.7 MSL at its deepest to 122.9 MSL at its shallowest across the proposed 60m length of PRB. The 60 m length was proposed based on possible groundwater flow patterns that intersect two flow lines (shown in blue flow net lines). Following figures show;

- PRB longitudinal section along the 60 m length (PRB longitudinal section.pdf)
- PRB profile of longitudinal profiles of along 160 m distance (PRB - Layed Profile.pdf)
- PRB layers across selected cross sections where borehole logs are available/ predicted (PRB Layed Cross Section.pdf)

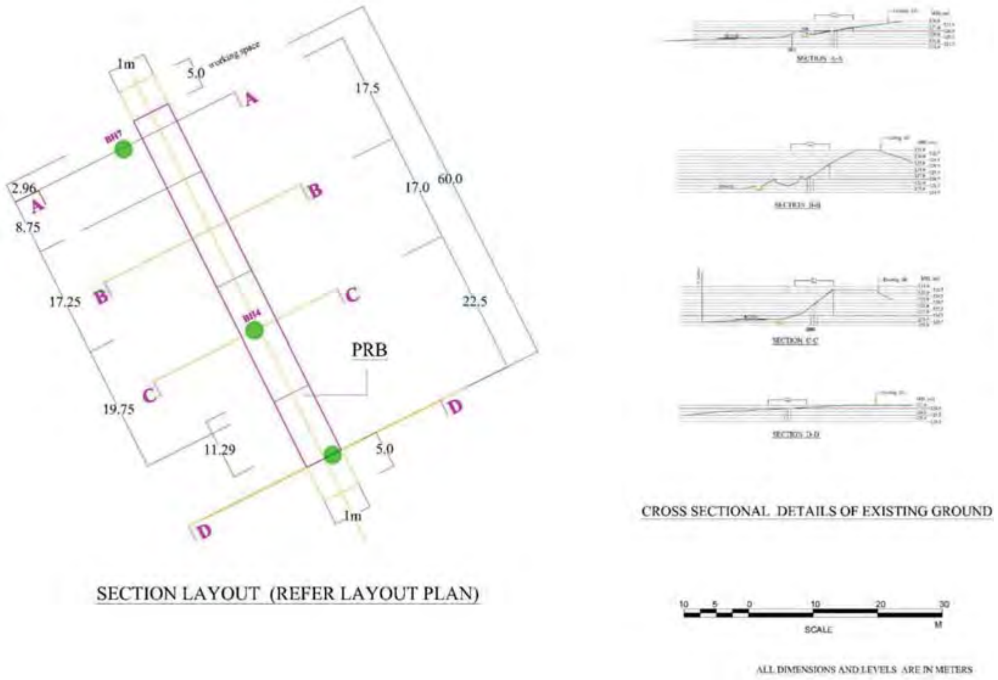


Figure 3-3 Layout of the PRB system

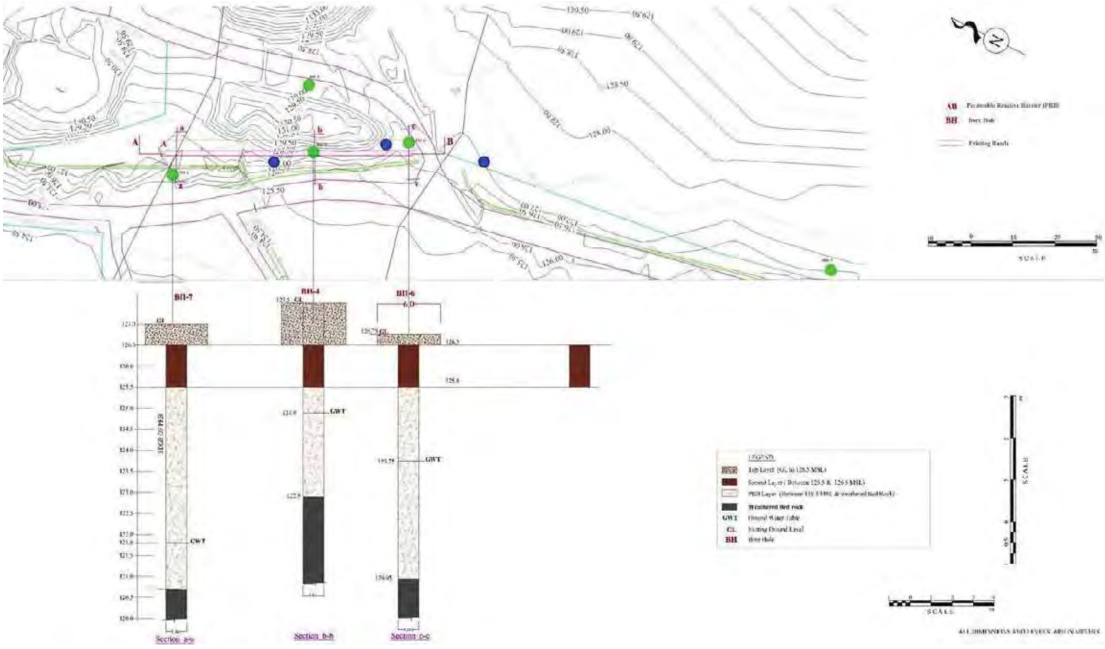


Figure 3-2 Proposed heights and location of PRB system

The preliminary estimates showed the amount of earthworks to be done at the site. Following Table shows the amount of material handling for PRB installation.

Table 3-2 Preliminary estimates of earthwork quantities

	Sectional area (m²)			Section width (m)		Volume (m³)		
Section	Top layer (above 126.5 MSL)	Layer (126.5-125.5 MSL)	Layer (125.5 to BR)	Top layer (above 126.5 MSL)	PRB capping	Top layer (above 126.5 MSL)	Layer (126.5-125.5 MSL)	PRB
BH7 -BH4	25.88	34.51	131.24	6	2	155.28	69.02	262.48
BH4 -BH6	14.16	22.65	80.97	6	2	84.96	45.30	161.94
BH6 -End	32.13	42.84	183.94	6	2	192.78	85.68	367.88
						433.02	***200.00***	***792.3***

Notes:

1) Waste contaminated soils above 126.5 MSL to be excavated to a width of 6.0 m (except in road intersects that make to a minimum workable width). The excavated soil/debris it to be discarded (shall be stockpiled to use as cover soil in active filling area). The amount to be excavated is approximately m^3.
2) PRB will be installed from the top level of weathered bed rock formation up to the level of 125.5 MSL. The total estimated excavation is m^3 of soil below the 126.5 MSL. A portion of the excavated soil shall be backfilled in the trench as the capping layer of PRB from 125.5 to 126.5 MSL (approximately 200 m^3).
3) The remaining portion of the excavation can be used to re-form the ground elevation to pre-construction landform.
4) The volumetric quantity of PRB material installed in the trenches is approximately 792 m^3.

4 CONSTRUCTION PROCESS

Following table shows the detail specification of proposed PRB materials to be used at Sundarapola dumpsite.

Table 4-1 Detail specifications of proposed PRB materials

#	Material	Description
1	Clay bricks	i. Made out of soil having > 90±5% of particles less than 2.00 mm through dry sieving ii. Common clay bricks hand or machine molded iii. Burnt in kiln at 600 °C to 900 °C for minimum of 3 hours iv. Dimensions L= 210±3 mm; D=72±3; W=140±3 v. Maximum allowable water content is 4% by weight vi. Allow to use broken/shattered clay bricks, if appropriate qualities are achieved and appropriate quantities are supplied in accordance with clauses 1-iv.
2	Coconut shell charcoal particles	i. Made out of coconut shell burnt at 400 °C to 600 °C for minimum of 0.5 hours ii. Free from unburnt coconut shell particles (maximum allowable unburnt particles = 5% by dry weight) iii. Free from soil, sand or any other inert particles (maximum allowable unburnt particles = 2% by dry weight) iv. Maximum allowable water content is 10% by weight
3	Clay soil	i. Soil having > 100% of particles less than 2.00 mm through sieving ii. Soil having at least 40% clay by dry weight iii. Maximum available field water content of 30% by weight iv. Maximum allowable organic matter content of 2% by weight v. Sourced from clay mines of Alluvial deposits (Entisol) in Bangadeniya

4.1 Processing of PRB materials

4.1.1 Pre-processing of bricks

i. Bricks or brick particles as specified in above table, shall be crushed or hammered using suitable equipment or machine to obtain solid brick particles sized between 2.00 to 4.75 mm.
ii. The entire crushed mass shall be sieved through 4.75 mm mesh to obtain particles smaller than 4.75 mm.
iii. The mesh apparatus of the sieve shall be equivalent to standard size 4.75 mm (BS 410:1986 apparatuses BS mesh No. 3 ½).
iv. All oversize particles (> 4.75 mm) shall dispose or further crushed to obtain particles less than 4.75 mm.

v. The mass fraction of brick particles less than 4.75 mm shall be sieved through a 2.00 mm mesh to obtain particles in between 2.00 to 4.75 mm in size.

vi. The mesh apparatus of the sieve shall be equivalent to standard sizes of 2.00 mm (BS 410:1986 apparatuses BS mesh No. 8).

vii. Processed brick particles (2.00 mm < D < 4.75 mm) shall be stored for further processing to PRB mixture.

viii. All sieved fraction less than 2.00 mm shall be disposed of at the location shown on-site as directed by the Employer's Representative.

4.1.2 Pre-processing of Coconut Charcoal

i. All coconut charcoal particles shall be sieved through a mesh with nominal apparatus size of 0.075 mm using suitable equipment or machine to obtain particles less than 0.075 mm.

ii. The mesh apparatus of the sieve shall be equivalent to standard sizes of 0.075 mm (BS 410:1986 apparatuses BS mesh No. 200).

iii. All oversize particles (> 0.075 mm) shall dispose or further crushed to obtain particles less than 0.075 mm.

iv. Processed charcoal particles (D < 0.075 mm) shall be stored for further processing to PRB mixture.

v. All remaining charcoal and other charcoal derbies shall be a property of contractor.

vi. If disposed of at the location shown on-site as directed by the Employer's Representative.

4.1.3 Pre-processing of clay

i. Clay shall be air dried to obtain a water content below its plastic limit (PL).

ii. All agglomerations and large lumps shall be crushed to obtain friable mass that can be effectively mixed with brick and charcoal particles.

iii. Processed clay shall be stored for further processing to PRB mixture.

iv. All remaining clays and other derbies shall be disposed of at the location shown on-site as directed by the Employer's Representative.

4.1.4 Mixing of PRB materials

i. The mixture shall consist of 50% of brick particles (2.00 mm < D < 4.75 mm) by dry weight, 25% of charcoal particles (D < 0.075 mm) by dry weight and 25% of processed clay by dry weight.

ii. The accurate weight ratios of the components in the mixture shall be obtained after measuring the actual water content of processed materials.

iii. The brick particles (2.00 mm < D < 4.75 mm), charcoal particles (D < 0.075 mm) and processed clay shall be mixed into a uniform mixture using suitable equipment.

iv. During the mixing, satisfactory means, incorporating weighing, or metering shall be provided to assure the proper ratio of components is maintained.

v. Equipment such as front end loaders, excavators, backhoe loaders, concrete trucks, mobile concrete mixers, or stationary concrete mixers are suitable alternatives.

vi. All equipment should be clean of foreign materials (e.g. concrete mix, soil, stones, etc.).

vii. The PRB mixture may be stored prior to installation.

4.1.5 Backfilling of PRB material

i. Prior to placement of the PRB material, the water content of the mixture may be adjusted to 27±3 % by adding or drying the mixture.

ii. The PRB material is typically placed up to the level of 125.5 MSL.

iii. If the excavated trench is filled with water, dewatering shall be done and the trench shall keep dry throughout the installation process until finishing to the level 125.5 MSL.

iv. When the excavated trench is dry, the backfilled can be placed by freefall.

v. The PRB material should be placed in lifts with a maximum lift being 300mm of loose PRB material and compacted to meet optimum Seventy-five percent (75%) standard proctor density (BS 1377:1990 series) at 27±3 % water content, which is equal to 1000 kg/m^3.

vi. Water from an approved source may be added to the backfill to assist in placement and/or as a dust control measure. However, the moisture content of the mixture during backfilling and compaction shall no exceed 27±3 %.

vii. The Contractor shall excavate a sufficient length of trench to accommodate the slope of the mixture or provide means of preventing the placed mixture from reaching the excavation face in progress.

4.1.6 Backfilling on top of PRB material

i. After the trench has been filled with the PRB material, a geotextile may be place on top.

ii. The trench shall be backfilled to level of 126.5 MSL as specified in Drawings using native soil excavated priory.

iii. The backfill on top of the PRB material should be placed in lifts with a maximum lift being 300mm of loose soil and compacted to meet minimum Ninety percent (90%) standard proctor density (BS 1377:1990 series) at optimum water content.

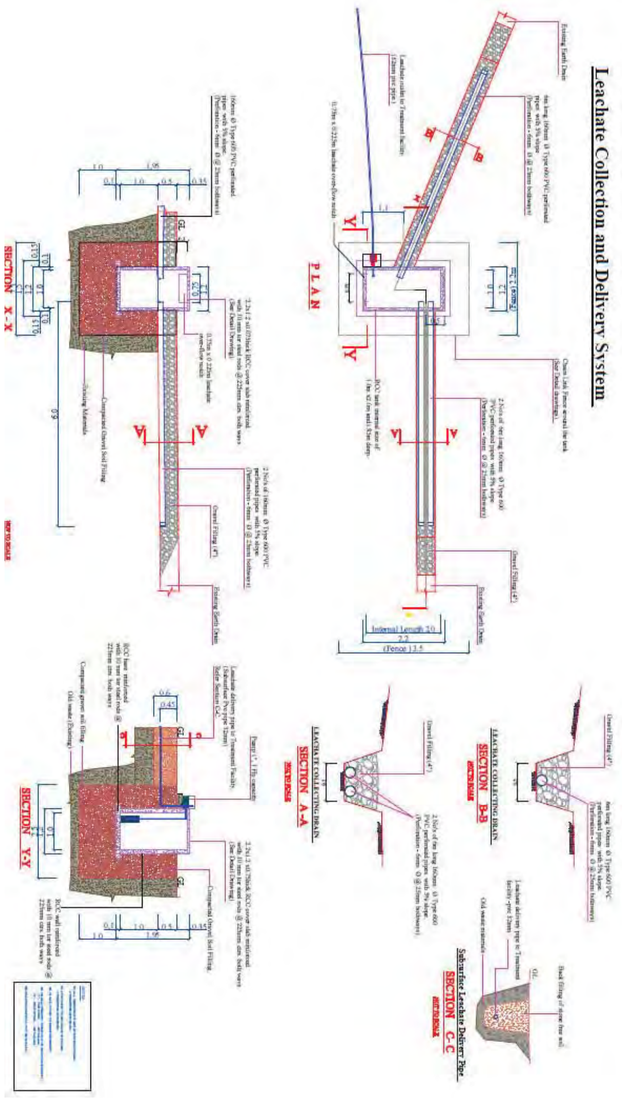


Figure 5-1 Leachate collection tank and piping system

5 AXILLARY FACILITIES TO BE CONSTRUCTED/REHABILITATED

5.1 Leachate collection and pumping system

Leachate in MSW landfills are contaminated liquids that contain a number of dissolved or suspended materials. Leachate is generated as a result of the expulsion of liquid from the waste due to its own weight or imposes pressure (termed Primary Leachate) and the percolation of water through a landfill system (termed Secondary Leachate). The source of percolating water could be precipitation, groundwater seepage (especially in low-lying areas), or leachate recirculation through landfill. During the percolation process, the percolating water dissolved some of the chemicals in the waste through chemical reactions; it may also mix with the liquid that is squeezed out due to weight of the waste and compaction pressure. Even if no water is allowed to percolate through the waste, some amount of contaminated liquid is expected to form due to biological and chemical reactions. Both the quantity and quality of produced leachate are important issues for landfill design.

In order to minimize the contamination of surface and ground water by leachate, the quantity generated has to be collected and directed to an appropriate treatment facility. The leachate collection and removal system (LCRS) facilities usually an integration of a few components such as low permeable bottom liner, drainage layer and leachate collection pipe network or/and leachate collection wells. However, the present site condition allows only installation of leachate intercept drains and collection of overland flow.

Proposed leachate collection system consists of horizontal pipes, trenches and collection tank.

The leachate collection tank is equipped with automated pumping system where the collected leachate will be automatically delivered to leachate and gully suck waste co-treatment facility. Therefore, the tank capacity has been estimated to be 2.0 m^3.

The overland flow of leachate is collected to the tank through large perforated pipe system (diameter = 160 mm) installed on semi-buried trenches. The pipes are covered with gravel pack and geo-net in order to prevent blockages by large solid objects.

5.2 Leachate and gully suck waste co-treatment system

The existing gully suck waste treatment system needs immediate rehabilitation, especially replacement of coir-brushes. Moreover, the system will be used as a means of leachate and gully waste co-treatment.

Figure 5-2 Existing condition of gully suck waste treatment facility

The system consists of four large concrete tanks having approximate sizes of L=16.76m, W=3.75 m and D=1.45m. First, the debris in first two tanks shall be cleaned before installation of coir fibers. Then, tensioned plastic string with minimum diameter of 3.0mm shall be installed as shown in the figure. The coconut coir fiber strings shall be installed with a raw spacing of 300 mm across the length of the tank as shown in the figure. The coconut coir fiber loop shall be suspended in the tank using pre-fabricated concrete blocks.

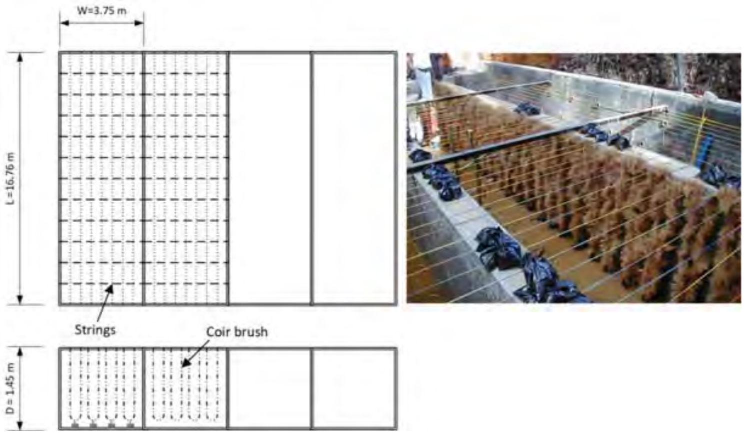


Figure 5-3 Installation of suspended coir-brush system on treatment tanks

5.3 Groundwater monitoring well

In order to monitor the treatability and long term performance of PRB, a monitoring well shall be installed downstream of the PRB. The location of the monitoring well shall be identified after installation of PRB. The well shall be bored from the surface of the location down to the underground bedrock using appropriate equipment and machines. The bore hole shall be cased with perforated uPVC pipe with minimum diameter of 4 inch up to the maximum encountered groundwater level and casing shall continue to 0.5 m above the surface. The top opening of the pipe shall be capped with removable cap for water sampling.

5.4 Excavation of test pits and analysis

The correct identification of composition and quantity of waste dumped in disposal site is important to prepare site rehabilitation and remediation plan. The potential for resources recovery, especially recyclable items and usable products such as decayed organic matter.

However, soil boring is not a practical method to examine the dumpsite as the mix waste, especially plastic residues make it difficult to penetrate. Therefore, pit excavation is often recommended for examining dumpsite wastes.

5.4.1 Test pit excavation

In order to have sufficient quantities of samples for composition analysis, the test pits shall be excavated on the garbage dump with approximate sizes of L= 3.0m, L=3.0 m and D=5.0 m using appropriate machinery such as backhoe loader or crawler excavator.

Three mined-waste sub-samples, each weighing not less than 50 kg shall be taken from a waste layer at 2.5m below the surface for composition analysis.

Three mined-waste sub-samples, each weighing not less than 50 kg shall be taken from a waste layer at 5.0 m below the surface or at the level of termination of excavation for composition analysis.

Minimum three pit excavations and six sampling events shall be performed at the site to have a representative information.

5.4.2 Composition analysis of mined-waste samples

Thee sub-samples collect from a designated level of a pit shall be placed on a clean plastic sheet and mix well before composition analysis. The mix composite sample shall be weighted and recorded prior to composition analysis. The mix composite sample shall be sieved through a 4.0 mm sieve to separate particles larger than 4.0 mm and smaller.

Composition of larger fraction of mined-waste sample shall be analyses by manually separating the materials as Plastics, Metal, Stones (> 4 mm), Paper and Other inert (> 4 mm). All separated component shall be weighted and recorded.

The obtained data can be used to determine the composition of waste in the dump.

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INCEPTION REPORT

ON

GALAPITAGALAYAYA SANITARY LANDFILL

FOR

KATARAGAMA PRADESHIYA SABHA

Submitted to

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EX Research Institute Ltd.

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by

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1.0 Introduction

Under the "Pollution Control and Reduction of Environmental Burden in Solid Waste Management" project, the, client Ex Research Institute Ltd has appointed Dakshina Cost Consultant (DCC) as the Consultant for this project. In this project, it is expected to introduce a low cost, but highly effective Semi-Aerobic Engineering Landfill in Galapitagalayaya dump site which is located in Kataragama. The scope of this report is to present the collected data related to solid waste management for Kataragama Pradeshiya Sabha at the pre-design stage.

2.0 MSW generation, collection and final disposal

Based on the report of "Data Collection Survey of Solid Waste Management on Pilot Project for Kataragama Pradeshiya Sabha"(August, 2017) average solid waste generation is about 16.8 MT/day as shown in Table 1. However, it was reported that during the Perahera festival season, solid waste generation may increase up to about 50 MT/day. Based on the survey, average solid waste collection per day is about 9.032 MT (54% of waste generation), out of that 3.799 MT (42%) of biodegradable waste is separated at the composting site and used for composting, whereas rest of the non-degradable fraction of about 5.232MT (58%) is disposed at the Galapitagalayaya final disposal site.

Table 1 – Summary of solid waste generation at Kataragama Pradeshiya Sabha

Category	Amount (MT/day)
Residential	9.282
Commercial	5.012
Institutional	2.350
Industries	0.042
Other	0.120
Total	**16.806**

3.0 Landfill Capacity

The Designed Landfill Capacity shall be determined by calculating the product of the sum of planned waste to be landfilled and soil covered per year, by the number of years that the landfill is to be operated. The input waste amount by facility was estimated based on the following assumption. The target lifespan shall be the designed operational duration of the landfill site and was set at 15 years of operations for this landfill.

It is predicted that the incoming amount will rise every year due to an increase in the amount of wastes and improvement of the collection rate resulting from population growth and improved collection routes and equipment. Waste Generation is often expressed in terms of a unit waste generation rate, this being the quantity of waste produced per person-per day. The unit waste generation rate is very useful for planning and comparing purposes. As per the National Policy on Solid Waste Management in 2007, average per capita per day waste generations is 0.40 kg in Pradeshiya Sabhas. However, in this study there was no annual statistics on unit waste generation and 0.41 kg per capita day was taken from Data Collection Survey of Solid Waste Management on Pilot Project at Kataragama Pradeshiya Sabha. It is assumed that 1% increase yearly in residential waste generation. Usually, the annual increase rate of the commercial and institutional waste is usually greater than that of the domestic waste. Therefore, for the commercial and institutional waste (other waste), rate of increase of, 3%, is assumed and adopted for design.

In facilitating area of Kataragama, the present unit waste collection rate is increased from 54% to 58%. It is assumed that after starting the operation of new sanitary landfill, the collection rate would be improved with providing waste collection equipment and proper final disposal system. As there is no data for waste collection, it is assumed that the unit waste collection would be increased by 0.5 % in every year.

The number of pilgrims, temporary shopping centres also increases during the Perahera Festival Season thereby the waste generation may increase as much as 50 MT/day (Data Collection Survey, 2017). Perahera season is usually two weeks (14 days) per year and it is assumed that 54% of waste is collected along with other non-degradable waste which is accounted as 378 MT/Year at the present condition.

Starting the operation, this Sanitary Landfill in Kataragama was predicted to take in the waste amount of approximately 3320 tons per year in the target year after 15 years.

The capacity of landfill facilities at Kataragama was calculated considering the density of waste landfill, cover soil rate, waste settlement rate, annual operational days, and input waste amount and summary of the calculations are shown in Table 2.

Table 2 - Calculation Standards of Landfill capacity prediction at Kataragama

Items	Calculation Criteria
Landfill capacity	43,559 m^3
Operation date	240 days/year
Density of landfilling	1.0 MT/m^3
Cover soil rate	20 %
Waste settlement rate	15 %

Landfill Height

Top/ bottom areas and capacity estimation were designed considering planned landfill height and safe slope angle. The proposed total height of the landfill is 9 m, where the landfill will have a height of 6 m is above the ground level and 3 m below the ground level. By considering width of the landfill as 75.0 m, the total cross-sectional area is 590 m^2 as shown in Figure 1. Typical cross section of a sanitary landfill is shown in Figure 3.

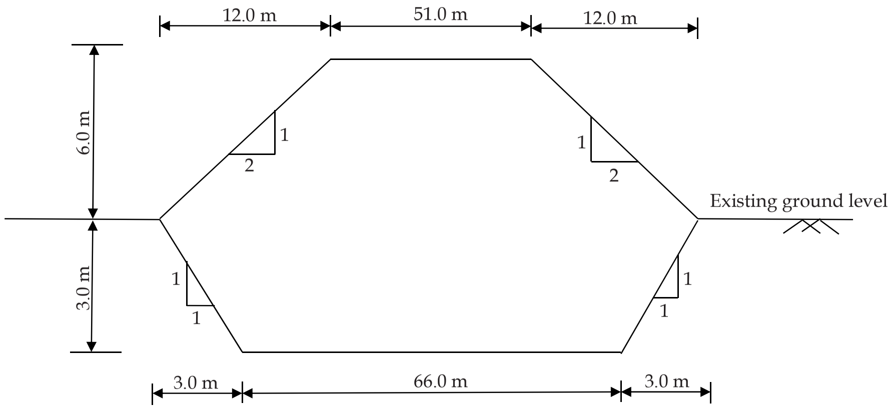

Figure 1 – Cross section of proposed landfill

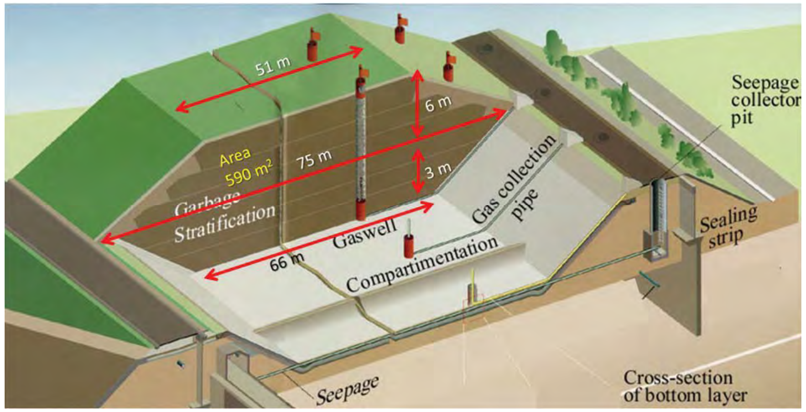

Figure 2 – Cross section of typical landfill

Landfill waste density

Applied landfill waste density was taken as 1.0 tons/m3 after comparing waste characteristics, and literature as shown in Table 3.

Table 3 - Reference data related to landfill density

Reference	Density of landfilling (ton/m³)	Remarks
Geotechnical properties of municipal solid wastes and their use in landfill design, Proc, of Waste Tech 93 Conference, Fasset et al., 1993	0.92 ~ 1.07	Good compaction
Unit weight of municipal solid waste, Dimitrios Zekkos, Journal of geotechnical and geoenvironmental engineering, 2006	1.0 ~ 1.3	Typical
Compaction characteristics of municipal solid waste, James L. Hanson	0.6 ~ 0.8	

Covering soil amount analysis

Final cover material must be suitable for planting and sustain plant growth. Generally good top soil is recommended. The cover material quantity is generally expressed as the thickness of the applied material. To complete the cell, it is covered with a 0.10 to 0.15 m layer of earth. The cells should be covered daily after the entry of the last load of waste.

The amount of cover material necessary is 1 m³ of earth for each 4 or 5 m³ of MSW, that is, from 20 to 25% of the volume of the compacted waste (Pan American Centre for Sanitary Engineering and Environmental Sciences, 2003). For this landfill design, it was assumed that thickness of daily cover is 150 mm and amount of soil cover 20% of the volume of compacted waste.

Settlement Analysis

Settlement of landfill is addressed by considering a lot of landfill aspects such as ground and soil condition, waste characteristics, waste decomposition, covering soil condition, etc. However, an average value of non-biodegradable waste of 15% was applied after reviewing landfill design data and literatures due to difficulties in exact prediction of settlement.

Landfill capacity and life span prediction at Kataragama

Table 4 shows the calculation of the capacity of the landfill in Kataragama. The facility capacity was planned to be approximately 43,599 m³ which can take in waste for about 15 years. However, landfill capacity can be changed by landfill operation condition. Summary of the landfill caapcity calculations are presented in Table 5.

Table 5 – Summary of landfill capacity calculations

Design lifespan	15 years
Landfill capacity	43900 m³
Cross sectional area	590 m²
Landfill plan area	5600 m² (75.0 m x 75.0 m)

4.0 Landfill Liner Design

Sub surface soil profile

Detailed descriptions of the sub-surface soil profile encountered during field investigation are presented in the borehole logs in Geotechnical Investigation report. The following section described the general site condition that can be interpreted from the available borehole test data. Topographical survey data and borehole locations are shown in Figure 3.

Typical subsoil profile at borehole location BH-1 can be given as in Table 6.

Table 6- Subsurface soil profile at BH-1

Layer No.	Elevation (m)	Position (m)	Layer description	Average SPT-N value
1	87.20	0 – 2.0	Sandy clay	38
2	85.20	2.0 -3.6	Completely weathered rock	>50
3	83.60	3.6 ~	Bed rock	3.6-4.6m → CR=75% RQD=40%

Typical subsoil profile at borehole location BH-2 can be given as in Table 7.

Table 7- Subsurface soil profile at BH-2

Layer No.	Elevation (m)	Position (m)	Layer description	Average SPT-N value
1	85.00	0 – 2.7	Sandy clay	12
2	82.30	2.7 -4.8	Completely weathered rock	>50
3	80.20	4.8 ~	Bed rock	3.8-6.0m → CR=80% RQD=0%

Typical subsoil profile at borehole location BH-3 can be given as in Table 8.

Table 8- Subsurface soil profile at BH-3

Layer No.	Elevation (m)	Position (m)	Layer description	Average SPT-N value
1	86.75	0 – 2.0	Sandy clay	32
2	84.75	2.0 - 3.3	Completely weathered rock	>50
3	83.45	3.3 ~	Bed rock	3.3-4.5m → CR=92% RQD=21%

Table 4 - Calculation of Landfill Capacity

Year	Population	Residential Waste		Other Waste	Total	Collection Ratio	Collection	Domestic + Other Waste		Perahera Season	Total to Lanfill	Density	Volume	Settlement	Cover Soil	Annual Landfill	Cumulative Landfill
		Generation	Generation					To Landfill	To Landfill								
		kg/person/day	kg/day	kg/day	kg/day		kg/day	kg/day	Ton/yr	Ton/yr	Ton/yr	Ton/m³	m³/yr	m³/yr	m³/yr	m³/yr	m³/Yr
1	22640.0	0.410	9282	7500	16782	0.540	9062	5256	1919	378	2297	1.0	2297	230	459	2526	2526
2	22889.0	0.414	9478	7725	17203	0.543	9336	5415	1976	380	2356	1.0	2356	353	471	2474	5000
3	23140.8	0.418	9678	7957	17635	0.545	9618	5579	2036	382	2418	1.0	2418	363	484	2539	7539
4	23395.4	0.422	9883	8195	18078	0.548	9909	5747	2098	384	2482	1.0	2482	372	496	2606	10145
5	23652.7	0.427	10091	8441	18533	0.551	10209	5921	2161	386	2547	1.0	2547	382	509	2674	12819
6	23912.9	0.431	10304	8695	18999	0.554	10519	6101	2227	388	2614	1.0	2614	392	523	2745	15564
7	24175.9	0.435	10522	8955	19477	0.556	10837	6286	2294	389	2684	1.0	2684	403	537	2818	18382
8	24441.9	0.440	10744	9224	19968	0.559	11166	6476	2364	391	2755	1.0	2755	413	551	2893	21275
9	24710.7	0.444	10971	9501	20472	0.562	11505	6673	2436	393	2829	1.0	2829	424	566	2970	24245
10	24982.6	0.448	11202	9786	20988	0.565	11854	6875	2509	395	2905	1.0	2905	436	581	3050	27296
11	25257.4	0.453	11439	10079	21518	0.568	12214	7084	2586	397	2983	1.0	2983	447	597	3132	30428
12	25535.2	0.457	11680	10382	22062	0.570	12585	7300	2664	399	3064	1.0	3064	460	613	3217	33645
13	25816.1	0.462	11927	10693	22620	0.573	12968	7522	2745	401	3147	1.0	3147	472	629	3304	36949
14	26100.1	0.467	12179	11014	23193	0.576	13363	7751	2829	403	3232	1.0	3232	485	646	3394	40343
15	26387.2	0.471	12436	11344	23780	0.579	13770	7987	2915	405	3320	1.0	3320	498	664	3486	43829

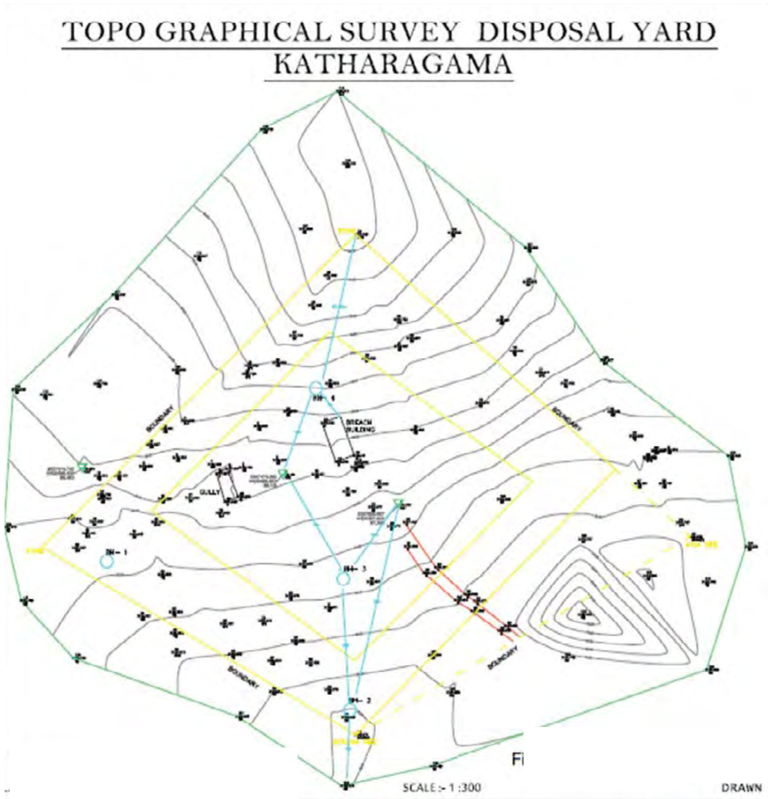

Figure 3 – Topographical survey plan and borehole locations

Typical subsoil profile at borehole location BH-4 can be given as in Table 9.

Table 9- Subsurface soil profile at BH-4

Layer No.	Elevation (m)	Position (m)	Layer description	Average SPT-N value
1	89.50	0 – 3.2	Sandy clay	34
2	86.30	3.2 ~	Bed rock	3.2-4.2m → CR=45% RQD=30%

Based on borehole logs as reported and information provided in Table 6 to Table 9, the subsurface at the site consists of dense sandy clay up to a depth of 2.0-3.2 m followed by very dense completely weathered rock layer. Bed rock is below the very dense completely weathered rock layer. Water table was not encountered up to the test depth. Further, average SPT-N values at each layer in BH-1 to BH-4 are depicted in Table 6 to Table 9, respectively.

Sub surface soil across BH-4, BH-3 and BH-2 are presented in Figure 4. Similarly, Sub surface soil across BH-1 and BH-2 are presented in Figure 5.

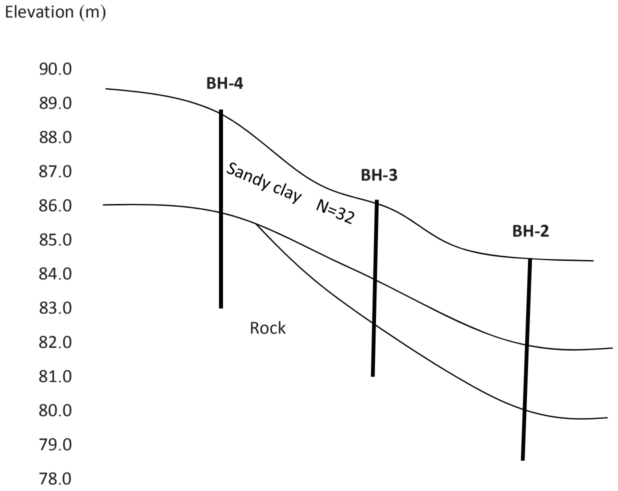

Figure 4- Sub surface soil profile across BH-4, BH-3 and BH-2

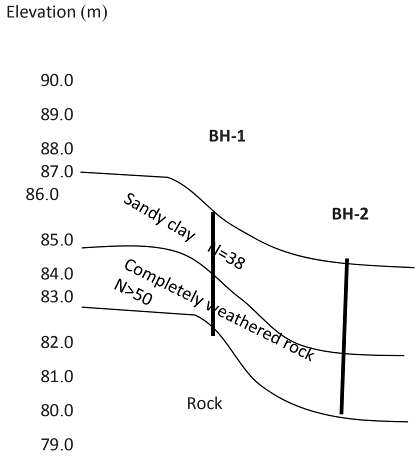

Figure 5- Sub surface soil profile across BH-1and BH-2

Engineering properties of sub surface soil

Engineering properties of the sub surface soil were determined based on laboratory tests as well as field tests. Permeability of the sub surface was determined using field constant head permeability tests as depicted in the Geotechnical Investigation report and results are summarized in the Table 10.

Table 10- Permeability test results

BH No.	Depth (m)	Elevation (m)	Soil type	Coefficient of permeability, k (m/s)
1	2.0 – 3.0	85.20 - 84.20	Completely weathered rock	1.367×10^{-7}
2	2.0 – 3.0	83.00 – 82.00	Sandy clay	7.926×10^{-6}
3	2.0 – 3.0	84.75 – 83.75	Completely weathered rock	1.665×10^{-5}
4	2.0 – 3.0	87.50-86.50	Sandy clay	5.659×10^{-5}

Development of landfill liner

Landfill liner should be developed in accordance with the Central Environmental Authority (CEA) guidelines as shown below;

- Hydraulic conductivity $\leq 1\times10^{-9}$ ms^{-1}
- Plasticity index≥ 7-10 %
- Percentage fines ≥ 20-30 %
- Percentage gravel ≤ 30%
- Maximum particle size ≤ 25-50 mm

The laboratory test results on dense sandy clay soil collected from the Galapitagalayaya waste disposal site can be summarized as depicted in Table 11.

Table 11 – Laboratory test results of dense sandy clay

Physical property	**Value**
Liquid Limit (LL)	42 %
Plastic Limit (PL)	25 %
Plasticity Index (PI)	17 %
Maximum dry unit weight $\gamma_{d(max)}$	18.37 kN/m^3
Optimum moisture content ω_{opt}	12.5 %
Specific gravity G_s	2.624
Linear shrinkage	7.6 %
Fine content	44.2 %
Sand content	55.6 %
Gravel content	0.2 %

It can be noted that except the hydraulic conductivity, all other requirements of the CEA guidelines for landfill clay liner is satisfied by the sandy clay available at the Galapitagalayaya site. Since hydraulic conductivity of sandy clay in natural form is greater than 1×10^{-9} m/s, it cannot be used as a natural clay liner for the proposed landfill. Hence, it is necessary develop a clay liner using the locally available material with satisfying the CEA guidelines.

According to the Priyankara et al. (2013), expansive soil can be improved to use as landfill clay liners. Type of the mineral in the sandy clay can be identified as using the method proposed by Salvage (2007).

Liquid Limit/Plastic ratio =R= 42/25=1.68

Activity = PI/Clay percentage = $0.16R^{2.13} = 0.48$

Hence, based on the Figure 6, mineral type presents in the sandy clay can be identified as Illite.

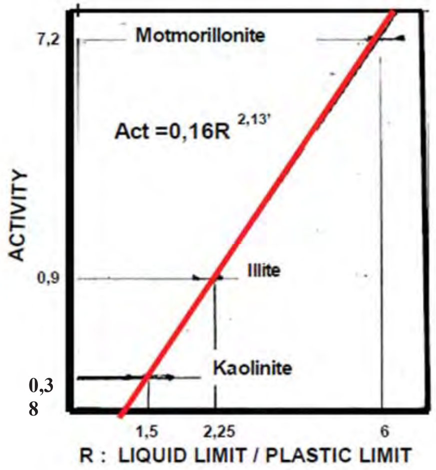

Figure 6 – relationship between Activity and ratio of Liquid limit/Plastic limit

According to the Priyankara et al. (2013), hydraulic conductivity characteristics of expansive soil, available in Buttala, were improved by mixing with different percentages of bentonite as shown in Figure 7. It can be noted that the hydraulic conductivity of soil-bentonite mixtures decrease with the increase of bentonite. With the increase of bentonite, which mainly consists of montmorillonite mineral, the diffused double layers surrounding the clay particles are getting thicker. As a result, the flow paths between the double layers become pinched off and the hydraulic conductivity decreases. Further, according to the Gouy-Chapman theory, the hydraulic conductivity is inversely proportional to the double layer thickness. The clay liner requirement with

respect to hydraulic conductivity, i.e. 1 × 10^{-9} m/s, can be achieved with the addition of 10% of bentonite to the original soil.

Since physical properties of the original soil at Galapitagalayaya is very similar to the Buttala soil, it is recommended to mix the sandy clay soil at with 10% of bentonite on weight basis and compacted at its optimum moisture content in order to achieve clay liner requirement with respect to hydraulic conductivity, i.e. 1 × 10^{-9} m/s.

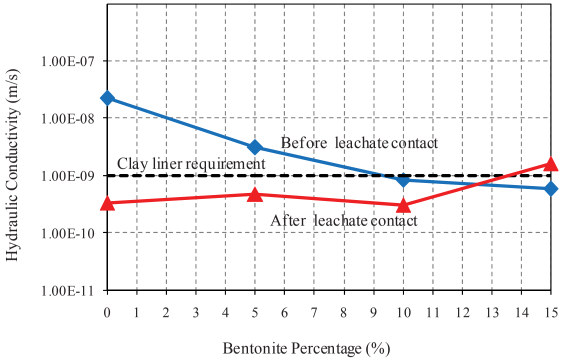

Figure 7 – Variation of hydraulic conductivity with percentages of bentonite

It is a common natural phenomenon that the formation of shrinkage cracks in landfill clay liners in dry zone of Sri Lanka and it leads to infiltrate of leachate into ground during the rainy season. According to the Priyankara et al. (2015), it was found that development of shrinkage cracks can be significantly controlled by amending soil-bentonite mixture with coconut coir fibers as shown in Figure 8. Hence, it is recommended amend soil-bentonite mixture with 5% coconut coir fibers by volume in order to control the shrinkage cracks.

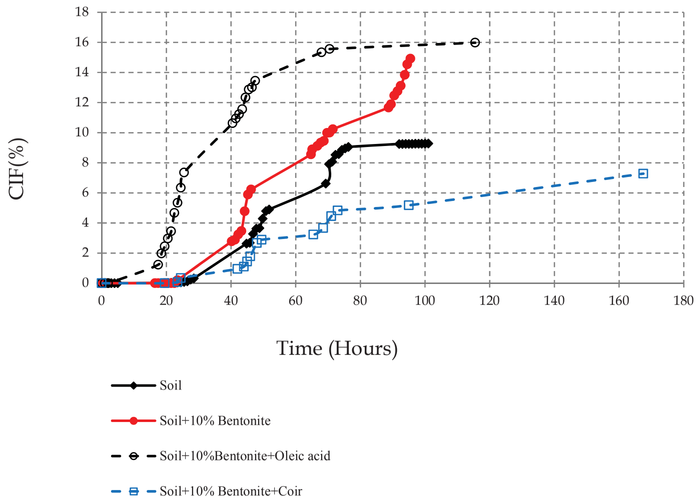

Figure 8 – Effect of coir on CIF

According to field scale study of SATREPS project, it was realized that there is no any leachate infiltration through 0.6 m thick soil+bentonite+coconut coir fiber mixture liner. Hence, it is recommended to adopt 0.6 m thick clay liner for this development.

5.0 Slope stability of landfill

Upper waste layers are planned considering the slope stability, surrounding environment, economical efficiency, etc. The shear strength parameters of the sub surface soil together with solid waste are presented in Table 12. In order to construct the semi-aerobic landfill, excavation is proposed to a depth of 3.0 m from the ground surface (up to the bed rock level) at a slope of 1:1 as shown in Figure 9. Further 10.0 kN/m^2 surcharge has been placed on the ground surface as an obligatory surcharge. Stability of the cut slope has been analyzed for both dry and saturated condition as shown in Figure 9 and Figure 10, respectively. Based on Figure 9 and Figure 10, it can be noted that cut slope is safe even under the development of perched water table at the ground surface.

Table 12 – Shear strength parameters of sub surface soil

Soil type	Unit weight (kN/m^3)	Cohesion (kPa)	Friction angle (^{0})
Sandy clay	17.0	6.0	28
Completely weathered rock	18.0	10.0	38

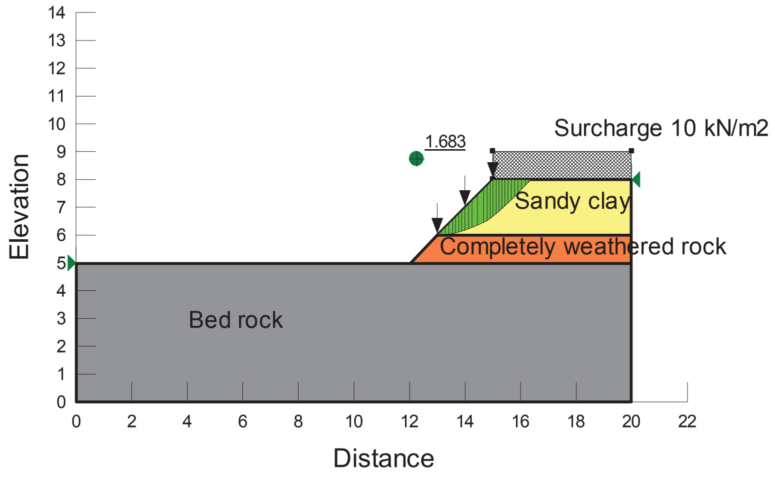

Figure 9 – Slope stability of landfill during cutting under dry condition

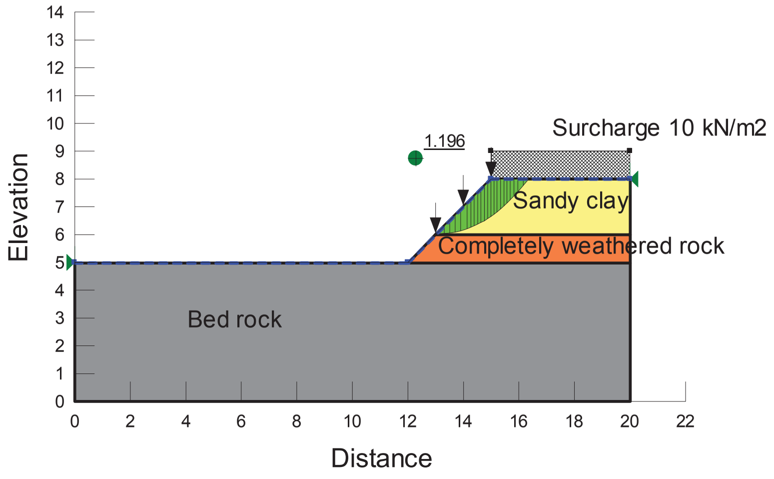

Figure 10 – Slope stability of landfill during cutting under saturated condition

It is a well-known factor that shear strength parameters of solid waste vary with time due to biodegradation. Hence, shear strength parameters of solid waste of upper waste layers and lower waste layers are determined based on Yamawaki et al. and are depicted in Table 13. By considering waste fill height of 6.0 m above the existing ground level and maintaining a slope of 1:2, the stability of the landfill after closure under dry condition and saturated condition due to development of perched water table are shown in Figure 11 and Figure 12 respectively. Hence, it can be concluded that upper water layers have sufficient safety margin against slope failure even under worst condition.

Table 13 – Shear strength parameters of material

Soil type	Unit weight (kN/m³)	Cohesion (kPa)	Friction angle (⁰)
Solid waste-upper	8.0	10.0	16
Solid waste-lower	14.0	3.0	32

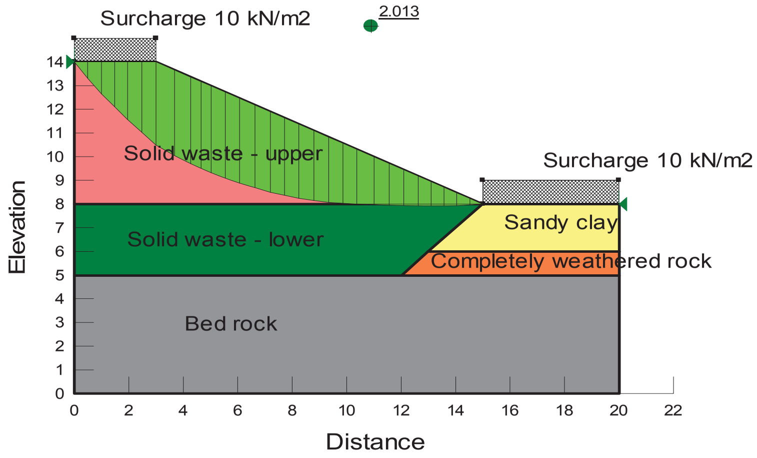

Figure 11 – Slope stability of landfill after closure under dry condition

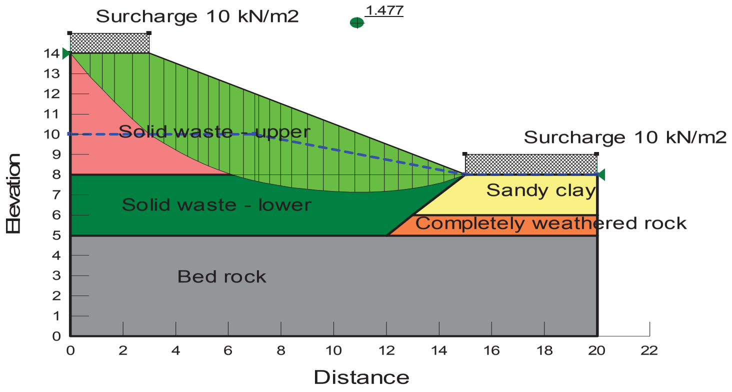

Figure 12 – Slope stability of landfill after closure under saturated condition

6. Leachate Treatment

Leachate treatment facility consists of leachate collection facility, leachate control facility, leachate transport facility, leachate treatment facility and leachate discharge facility. The general function of leachate collection facility is to quickly collect and channel the leachate generated from the landfilled waste layers to the leachate treatment facility. The leachate volume generated in a landfill shall be kept minimum and removed immediately to the leachate treatment facility, so that there will be no trapped leachate in the landfill site.

Components of Leachate collection facility

The components of a leachate collection facility are depending on the landfill types and structures. General conceptual layout plans for leachate collection facility are shown in Figure 13.

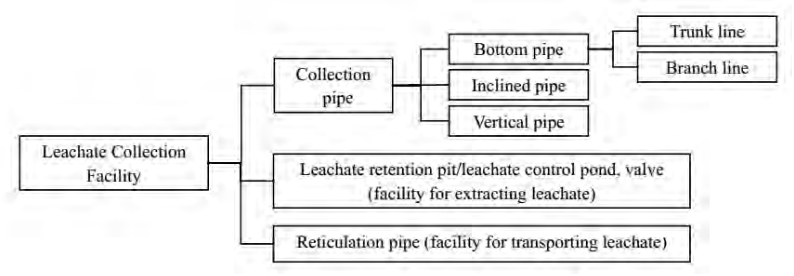

Figure 13 - The conceptual layout plan for leachate collection facility

Calculation of leachate generation

The volume of leachate in a sanitary landfill depends on several factors, such as:

- Rainfall in the landfill area
- Surface runoff and/or groundwater filtration
- Evapotranspiration.
- Natural moisture of the MSW
- Degree of compaction.
- Field capacity (Capacity of the soil and the MSW to retain moisture)

The design of inflow for leachate treatment facility between maximum and minimum values shall be determined. At the same time, the calculation procedure for determining the capacity of the leachate control facility to store the leachate exceeded the design capacity of leachate treatment facility shall be determined, so that the system is able to treat the leachate generated day by day.

In general, the volume of leachate generated is calculated as follows:

$Q = (C / 1000) \cdot I \cdot A$

Where,

Q : Leachate volume (m^3/day)
I : Rainfall intensity (mm/day)
C : Leachate coefficient
A : Landfill area (m^2)

Leachate generation coefficient indicates the ratio of rain water collected as leachate to the total precipitation within the landfill area. It holds values from 0.2 to 1.0 according to the type of waste, type of covering soil, degree of compaction and topography of the landfill site.

The annual average rainfall and maximum annual precipitation in Katharagama area are shown in Table 14.

Table 14 - Rainfall Data at Kataragama

	Annual Precipitation	Daily Precipitation
Annual Average: From1961 to 1990	1049.6 mm	2.99 mm
Maximum Annual Precipitation 2008 – 2013	1294.4 mm	3. 5 mm

Leachate Treatment Method

Once the size of the leachate treatment facility is established, the treatment process shall be the next item to be considered. When planning the treatment process, the local conditions, maintenance and control of the treatment facilities based on fluctuations in the leachate volume, quality, land size, climatic conditions etc. have to be given careful considerations. Leachate treatment facility consists of leachate collection facility, leachate control facility, leachate transport facility, leachate treatment facility and leachate discharge facility.

Evaporation amount was considered during calculation. The evaporation amount was calculated by the Thornthwaite method under the condition of the latitude of the 6.4 degrees north latitude in Kataragama. As the calculation result, the value obtained by multiplying the leachate generation by the leaching coefficient 0.57 which is expected to be evaporated is set as the planned leachate generation amount. Summary of the calculation is shown in Table 15.

Table 15 - Calculation of Leachate Generation

	Area of landfill	Daily leachate generation	Coefficient	Leachate generation amount including evaporation
Average Year	5,600 m^2	16.2 m^3/day	0.57	9.2 m^3/day
Maximum Year		19.6m^3/day		11.2 m^3/day

The leachate treatment for this system includes a Primary Oxidation Tank. The tank volume was designed to secure 14 days processing time or more for the daily leachate amount calculated by the maximum annual daily average value.Required volume of the Primary Oxidation tank is calculated as 160 m^3 (11.2 m^3/day x 14 days = 156 m^3).

During the rainy season in October to December the rainfall accounts for half of the whole year. The average daily precipitation in the rainy season (October to December) is 7.5 mm, which is about 2.14 times the above set value (3.5 mm).However, in order to avoid excessive design of the facility, maximum annual daily precipitation is adopted for design.

Vegetation Purification Process

Vegetation Purification Process as the leachate treatment is considered in accordance with "Case study on water purification measures" issued by Ministry of Land, Infrastructure and Transport, Japan. According to the Case Study, surface loading rates are 1g/m2/day for T-N and 0.15 g/m2/day for T-P.

Component of the Leachate Treatment Facilities

1. Leachate Pumping Pit - Leachate Pumping Pit will be installed in the landfill Cell. The facility should be composed by a Manhole (PE pipe) and a concrete base.
2. Leachate Pump - The capacity of the leachate Pump should be at least Daily Average Amount. In case of heavy rain, internal water storage in the landfill area shall be taken since this design is not including flow adjustment tank. As there is no electricity supply in the field, solar powered pump or diesel pump can be used.
3. Leachate Pipes - HDPV or HDPE pipes shall be installed to pump the leachate up to the Leachate treatment facility. Diameter of the pipes shall be 60 mm. The pipes shall be installed buried or ground installation.
4. Intake Notch tank
5. The flow rate will be measured with a triangular weir.
6. Primary Oxidation Tank - Capacity of the tank shall be secured 14 days processing time for daily leachate generation amount. It is better to include 12% margin rate; 160×1.12=180m^3.
7. The tank shall be separated to 4 sub-tanks - The size of each sub-tank: 10m Length, 2.5m width and 1.8, depth (Effective water depth)45m^3/tank × 4 tanks = 180m^3.
8. Coir-Fiber Biofilm Treatment System shall be installed at the oxidation tank -

   The tank shall be composed by concrete wall (t=200mm) and concrete base (t-150).

   Bars: D16, Single, pitch is 200 mm.
   Partition wall shall be masonry mortar finished wall thickness 100 mm.
9. Vegetation Purification Process - Vegetation Purification Process shall be designed in accordance with "Case study on water purification measures" issued by Ministry of Land, Infrastructure and Transport, Japan. According to the Case Study, surface loading rates are 1g/m2/day for T-N and 0.15 g/m2/day for T-P.
10. Instead of installing a structure, it is constructed as a structure that naturally accumulates and flows down treated effluent water from the oxidation tank.

Operation

It is recommended that the waste not be deposited in the lower part of the slope, but rather at the top of the finished cell, to facilitate the work and form the new cell in this way.

Dimensions of the daily cell

The daily cell is the basic construction unit of the sanitary landfill. It is made up of the amount of waste buried in one day and the earth needed to cover it. The dimensions of the daily cell vary in each year, in each year. The width is equivalent to the working face necessary so that the collection vehicles can unload the waste at the same time. The length is defined by the amount of waste arriving at the landfill in one day; and the height is limited to 1.0 to 1.5 m, to ensure greater compaction. As the annual landfill volume is 2526 m^3 and the landfill is only operated 240 days annually, the volume of daily cell is 9.4 m^3 in the first year and 14.5 m^3 in the 15th year.

Steps for forming the first daily cells

It is recommended to follow subsequent steps to proper operation of the landfill (Pan American Center, 2003). Figure 14 shows the sequence of construction of embankments for filling the site.

- Unload the waste at the working face, in such a way that a single, small area remains uncovered during the day, and the waste will not need to be moved over long distances.
- Spread the waste in thin layers of 0.20 to 0.30 m and compact it to obtain a cell height of 1 to 1.5 m, forming a gentle gradient in the external slopes.
- Cover the compacted waste completely with a layer of earth 150 cm thick once the cell has reached maximum height.
- Compact the cell until a uniform surface is obtained at the end of the working day.
- Once the first cell has been completed, the second can be constructed immediately beside or on top of it, always following the landfill construction plan.

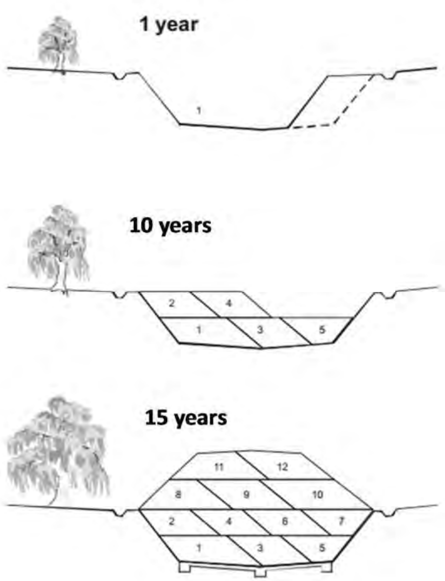

Figure 14 - Sequence of the construction of embankments for filling the site

Leachate Collection Facility

Leachate collection facility consists of collection pipes, leachate retention pits, leachate control valves, etc.

Collection Pipes

a) Bottom Pipes

Ducting placed at the bottom of landfill sites for leachate collection. It comprises of trunk and branch pipes that are installed at a gradient to enable natural flow potential.

b) Inclined Pipes

Placed along the slope of the landfill sites and connected to collection pipes at the landfill bottom. Preferred to vertical drainage pipe which shall be avoided from the aspect of intermediate covering. It also serves as gas vent.

c) Vertical Pipes

Leachate collection pipes placed vertically in the landfill. The heights of the pipes will be extended vertically as landfilling continues. The bottom ends of the vertical pipes are connected with the bottom pipes. It can also serve as gas vent like the inclined pipes

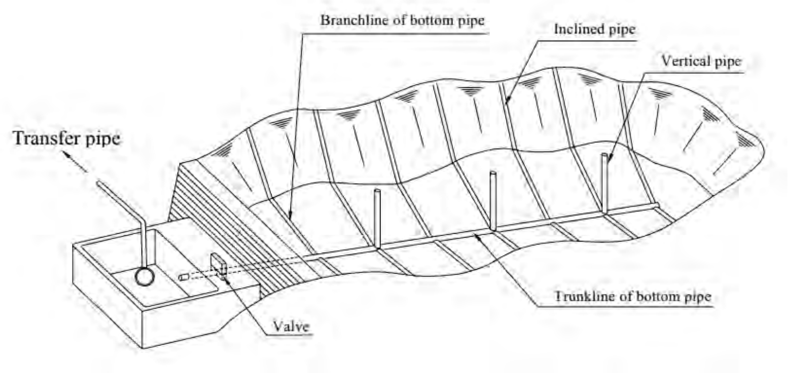

Figure 15 - Concept of Leachate Collection Facility

Sundarapola 処分場のスコーピング結果　The results of scoping at Sundarapola disposal site

Impacts of EPC		During Construction	After Construction
Natural Environment			
1.	**Air pollution**		
	- Dust	C	D
	- Exhaust gas	C	D
	- Concentration of exhaust gas	C	D
2.	**Water pollution**		
	- Groundwater pollution	B	P
	- Surface water pollution	C	P
3.	**Soil pollution**		
	- Soil pollution by leachate	D	P
	- Soil pollution by hazardous waste	D	D
4.	**Solid Waste**		
	- Excavated soil disposal	D	P
	- Construction waste	D	D
	- Municipal waste	D	D
5.	**Noise and vibration**		
	- by heavy construction equipment	C	D
	- by Garbage trucks	D	D
6.	**Ground subsidence**		
	- Inconformity subsidence	D	D
	- Large-scale subsidence	D	D
7.	**Offensive odor**		
	- from leachate/ water pollution	C	P
	- from solid waste	D	D
8.	**Geographical features**		
	- Flooding by the change of storm water route	D	D
	- Land slip	D	P
9.	**Bottom sediment**		
	- Erosion of riverbed	D	D
	- Inflow of soil into the river	D	D
10.	**Fauna and flora**		
	- Flora	D	D
	- Birds	D	D
	- Animals	D	D
	- Fish	D	P
11.	**Water usage**		
	- Surface water pollution	C	P
	- Groundwater pollution	B	P
	- Movement of groundwater	D	D
12.	**Accidents**		
	- Increase of traffic accidents	C	D
	- Accidents of equipment (construction equipment, garbage collection trucks, compost machines, etc.)	C	D

	Impacts of EPC	During Construction	After Construction
13.	**Global warming**		
	- Increase of CO_2	D	D
	- Increase of methane gas	C	D
Social Environment			
	Impacts	During Construction	After Construction
1.	**Involuntary resettlement**		
	- Condemnation of land property	D	D
2.	**Local economy such as employment and livelihood etc.**		
	- Job opportunities by construction	P	D
	- Job opportunities by the operation of the facility	P	P
	- Impacts by the facility to the economy nearby	P	P
3.	**Land use and utilization of local resources**		
	- Impacts on agriculture activity nearby	D	P
	- Lost of forest	D	P
4.	**Social institutions such as social infrastructure and local decision-making institutions**		
	- Impacts of communities	P	P
5.	**Existing social infrastructures and services**		
	- Impacts to roads	C	D
	- Impacts to electricity	C	D
	- Impacts to water supply and wells	B	P
6.	**The poor, indigenous and ethnic people**		
	- Impacts on poor people	D	P
	- Impacts on social minorities	D	P
7.	**Misdistribution of benefit and damage**		
	- Loss-benefit Imbalance	D	D
	- Uneven distribution of loss and benefit	D	D
8.	**Local conflict of interests**		
	- Magnitude of local conflict of interests	D	D
9.	**Gender**		
	- Deterioration of living condition of female by loss of income.	D	D
10.	**Children's right**		
	- Existence of schools nearby	D	P
11.	**Cultural heritage**		
	- Existence of cultural heritage nearby	D	P
12.	**HIV/AIDS etc. epidemics**		
	- By inflow of construction workers	U	U

Rating:

A : Very serious impact is expected,	B : Serious impact is expected.
C : Little impact is expected	D : Impact is negligibly small/ no impact
U : Impacts are unknown	P : Positive impacts are expected

The result of Scoping at Galapitiyagayaya

Impacts of EPC	During Construction	After Construction
Natural Environment		
1. Air pollution		
- Dust	C	D
- Exhaust gas	C	D
- Concentration of exhaust gas	C	D
2. Water pollution		
- Groundwater pollution	D	D
- Surface water pollution	D	D
3. Soil pollution		
- Soil pollution by leachate	D	P
- Soil pollution by hazardous waste	D	P
4. Solid Waste		
- Excavated soil disposal	C	D
- Construction waste	D	D
- Municipal waste	D	D
5. Noise and vibration		
- by heavy construction equipment	C	D
- by Garbage trucks	D	C
6. Ground subsidence		
- Inconformity subsidence	D	C
- Large-scale subsidence	D	C
7. Offensive odor		
- from leachate/ water pollution	D	D
- from solid waste	D	D
8. Geographical features		
- Flooding by the change of storm water route	D	D
- Land slip	D	D
9. Bottom sediment		
- Erosion of riverbed	D	D
- Inflow of soil into the river	D	D
1(Fauna and flora		
- Flora	D	P
- Birds	D	P
- Animals	B	P
- Fishes	D	D
11 Water usage		
- Surface water pollution	D	D
- Groundwater pollution	D	D
- Movement of groundwater	D	D
1 Accidents		
- Increase of traffic accidents	C	D
- Accidents of equipment (construction equipment, garbage collection trucks, compost machines, etc.)	C	D
1 Global warming		

	Impacts of EPC	During Construction	After Construction
	- Increase of CO_2	D	D
	- Increase of methane gas	D	D
Social Environment			
	Impacts	During	After
1.	**Involuntary resettlement**		
	- Condemnation of land property	D	D
2.	**Local economy such as employment and livelihood etc.**		
	- Job opportunities by construction	P	D
	- Job opportunities by the operation of the facility	P	P
	- Impacts by the facility to the economy nearby	P	P
3.	**Land use and utilization of local resources**		
	- Impacts on agriculture activity nearby	D	D
	- Lost of forest	C	D
4.	**Social institutions such as social infrastructure and local decision-making institutions**		
	- Impacts of communities	P	P
5.	**Existing social infrastructures and services**		
	- Impacts to roads	C	P
	- Impacts to electricity	C	C
	- Impacts to water supply and wells	D	D
6.	**The poor, indigenous and ethnic people**		
	- Impacts on poor people	D	P
	- Impacts on social minorities	D	P
7.	**Misdistribution of benefit and damage**		
	- Loss-benefit Imbalance	D	D
	- Uneven distribution of loss and benefit	D	D
8.	**Local conflict of interests**		
	- Magnitude of local conflict of interests	D	D
9.	**Gender**		
	- Deterioration of living condition of female by loss of income.	D	D
10.	**Children’s right**		
	- Existence of schools nearby	D	P
11.	**Cultural heritage**		
	- Existence of cultural heritage nearby	D	P
12.	**HIV/AIDS etc. epidemics**		
	- By inflow of construction workers	U	U

Rating:

A : Very serious impact is expected
B : Serious impact is expected.
C : Little impact is expected
D : Impact is negligibly small/ no impact
U : Impacts are unknown,
P : Positive impacts are expected

CEA/WQL/LQMS/F-12/A

[illegible]
2017/08/23

LABORATORY
CENTRAL ENVIRONMENTAL AUTHORITY NO 104,"PARISARA PIYASA",
DENSIL KOBBEKADUWA MAWATHA, BATTHARAMULLA
Tel 94-011-2872459, 2872604, 2867268
Fax 94-011-287605

TEST REPORT

Report No: WQL 2017/196

Issued Date: 23/08/2017

Name and address of the Industry

Sundarapola Waste Disposal Site
Kurunegala Muncipal Council
Kurunegala

Report No : WQL 2017/196

ANALYTICAL RESULTS

Parameter	Units	Test Method	Ref No 475/17/LS	Ref No. 476/17/LS
pH		Electrometric APHA, 4500 -H $^+$ B	6.5	6.8
Electrical Conductivity	mS/cm	Electrometric APHA, 2510 B	3.33	3.94
Temperature	^{0}C	Thermometric APHA, 2550 B	31.61	32.09
Turbidity	NTU	Nephelometric APHA, 2130 B	>999	>999
COD	mg/l	Open Reflux Titrimetry APHA, 5220 –B	80	80
BOD$_5$	mg/l	Titrimetry APHA 5220 B	4	5
TSS	mg/l	Gravimetric APHA, 2540 D	432	268
Lead as Pb	mg/l	AAS APHA 3111 B	<0.01	<0.01
Chromium as Cr	mg/l	AAS APHA 3111 B	<0.01	<0.01
Iron as Fe	mg/l	AAS APHA 3111 B	<0.01	<0.01
Cadmium as Cd	mg/l	AAS APHA 3111 B	<0.01	<0.01
Arsenic as As	mg/l	AAS APHA 3125 B	<0.001	<0.001
Total Coliform	MPN/ 100ml	MPN Method APHA 9221-B	940	5400
Feacal Coliform	MPN/ 100ml	MPN Method APHA 9221-E	700	540

Remarks : No water in one bore hole. Samples collected from two bore holes.

Conclusion:

Signature 2017/08/23
Name
Director (Laboratory Services)
Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name T.C Pelawatte
Technical Manager

Report No : WQL 2017/196

Description of Sample :

Reference no.	Description	Sample Location	GPS Coordinates
475/17/LS	Blackish coloured sample	Borehole No.1	0730531 N 08021166 E
476/17/LS	Blackish coloured sample	Borehole No.2	0730526 N 08021166 E

Type of Sample /Sampling : Grab

Requested officer or client : Thushara Pelawatte (Chemist)

Sampling Carried Out By : Thushara Pelawatte (Chemist)
Chethika Ambalangodage (SLA)

Witness : Mr. Naofumi SATO (JICA Expert)

Date of sample Collected : 13/07/2017

Date(s) of Test Perform : 13/07/2017 – 20/07/2017

Reference : Standard methods for the examination of water and Wastewater APHA 22nd Edition.

23/08/17

---

customer
23/08/17

LABORATORY
CENTRAL ENVIRONMENTAL NO 104,"PARISARA PIYASA",
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Fax 94-011-287605

TEST REPORT

Report No: WQL 2017/197

Issued Date: 23/08/2017

Name and the location of the Surface Waters

Sundarapola Waste Disposal Site
Kurunegala Muncipal Council
Kurunegala

Report No : WQL 2017/197

CEA/WQL/LQMS/F-12/A

	Analytical Results														
	pH	EC mS/cm	TURB NTU	TEMP °C	DO mg/l	COD mg/l	BOD$_5$ mg/l	TSS mg/l	Cr mg/l	Pb mg/l	Fe mg/l	Cd mg/l	As mg/l	Total Coliform MPN/100ml	Fecal Coliform MPN/100ml
Test Method Reference No	APHA 4500-H + B	APHA 2510 B	APHA 2130 B	APHA 2550 B	APHA 4500 O C	APHA 5220 B	APHA 5210 B	APHA 5210 B	APHA 3111 B	APHA 3111 B	APHA 3111 B	APHA 3111 B	USEPA 200.8	AHPA 9121 B	AHPA 9221 E
477/17/LS	7.4	4.06	**8**	30.10	0.5	**30**	1	25	<0.01	<0.01	<0.01	<0.01	<0.001	**2400**	**1300**
478/17/LS	7.1	2.84	**5**	30.48	1.8	**50**	6	2	<0.01	<0.01	<0.01	<0.01	<0.001	**260**	**220**
479/17/LS	6.5	3.40	2	31.24	1.1	**20**	3	2	<0.01	<0.01	<0.01	<0.01	<0.001	**9200**	**240**
480/17/LS	6.8	1.86	**4**	30.02	2.2	**20**	1	1	<0.01	<0.01	<0.01	<0.01	<0.001	**330**	**170**
481/17/LS	7.1	0.39	2	28.59	2.2	**20**	1	1	<0.01	<0.01	<0.01	<0.01	<0.001	**18**	**18**
SLSI 614:2013 Tolerance limits (max)	6.5-8.5	-	2	-	-	**10**	-	-	**0.05**	**0.01**	**0.3**	**0.003**	**0.01**	**10**	**0**

Abbreviations

DO	: Dissolved Oxygen	COD	: Chemical Oxygen Demand	BOD$_5$	: Biochemical Oxygen Demand	EC	: Electrical Conductivity
TURB	: Turbidity	TEMP	: Temperature	TSS	: Total dissolved solids	Cl$^-$	: Chlorides
PO$_4^{-3}$	: Dissolved Phosphate	NO$^-_3$	: Dissolved Phosphate				

2017/08/23

Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

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Page 3 of 4
Rev 02-01/01/2016

CEA/WQL/LQMS/F-12

Report No : WQL 2017/197

Description of Sample :

Reference No.	Description of sample	Sampling Location	GPS Cordinates
477/17/LS	Slightly Turbid sample	Existing well No.1	0730517 N 08021168 E
478/17/LS	Slightly Turbid sample	Existing well No.2	0730545 N 08021151 E
479/17/LS	Clear sample	Existing well No.3	0730528 N 08021143 E
480/17/LS	Clear sample	Existing well No.4	0730485 N 08021128 E
481/17/LS	Clear sample	Existing well No.5	0730440 N 08021150 E

Type of Sample /Sampling	: Grab
Requested officer or client	: Thushara Pelawatte (Chemist)
Sampling Carried Out By	: Thushara Pelawatte (Chemist) Chethika Ambalangodage (SLA)
Witness	: Mr. Naofumi SATO ()
Date of sample Collected	: 13/07/2017
Date(s) of Test Perform	: 13/07/2017 – 20/07/2017
Reference	: Standard methods for the examination of water and Wastewater APHA 22nd Edition.

22/08/17

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Page 2 of 4
Rev 02-01/01/2016

Remarks :

Conclusion:

In Ref Nos.477/17/LS, 478/17/LS & 480/17/LS – Turbidity, COD, Total Coliform and Fecal Coliform do not comply with the requirement of Lanka standard specifications for potable water, physical, organoleptic and chemical requirements of SLSI 614: 2013.

In Ref Nos.479/17/LS & 481/17/LS – COD, Total Coliform and Fecal Coliform do not comply with the requirement of Lanka standard specifications for potable water, physical, organoleptic and chemical requirements of SLSI 614: 2013.

Signature 2017/08/23
Name
Director (Laboratory Services)

Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name F.C Pelawatte.
Technical Manager

---

customer
23/08/19

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TEST REPORT

Report No: WQL 2017/198

Issued Date: 23/08/2017

Name and address of the Industry

Sundarapola Waste Disposal Site
Kurunegala Muncipal Council
Kurunegala

Report No	: WQL 2017/198
Description of Sample	:
Reference No	: 482/17/LS
Description	: Slightly turbid Sample
Sampling Location	: Leachate inside the facility.(Leachate No.1)
Type of Sample /Sampling	: Grab
Requested officer or client	: Thushara Pelawatte (Chemist)
Sampling Carried Out By	: Thushara Pelawatte (Chemist) Chethika Ambalangodage (SLA)
Witness	: Mr. Naofumi SATO ()
Date of sample Collected	: 13/07/2017
Date(s) of Test Perform	: 13/07/2017 – 20/07/2017
Reference	: Standard methods for the examination of water and Wastewater APHA 22nd Edition.

23/08/17

Report No : WQL 2017/198

ANALYTICAL RESULTS

Parameter	Units	Test Method	Ref No. 482/17/LS
pH		Electrometric APHA, 4500 -H^{+}B	4.85
Electrical Conductivity	mS/cm	Electrometric APHA, 2510 B	33.5
Temperature	^{0}C	Thermometric APHA, 2550 B	31.24
Turbidity	NTU	Nephelometric APHA, 2130 B	>999
COD	mg/l	Open Reflux Titrimetry APHA, 5220 –B	10000
BOD_5	mg/l	Titrimetry APHA 5220 B	348
TSS	mg/l	Gravimetric APHA, 2540 D	212
Total Coliform	MPN/ 100ml	MPN Method APHA 9221-B	>16000
Feacal Coliform	MPN/ 100ml	MPN Method APHA 9221-E	16000

Remarks :

Conclusion:

Signature 2017/08/23
Name
Director (Laboratory Services)

Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name T. C. Pelawatte
Technical Manager

JICA Project
2018/09/03

LABORATORY
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TEST REPORT

Report No: WQL/2018/194

Issued Date: 2018/09/03

Name and Address of Surface water

Well water samples around
Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala

Report No : WQL/2018/194

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
580/18/LS	Clear sample	Well (Mr.Subramaniyam)	00830049N 00428555E
581/18/LS	Clear sample	Well (Mr.Ruhmal)	00829974N 00428524E
582/18/LS	Clear sample	Well (Mrs.Rodrigo)	00829885 N 00428558 E
583/18/LS	Turbid sample	Existing Well No.1 inside the facility near leachate tank	00832228 N 00428598 E
584/18/LS	Clear sample	Existing Well No.2 inside the facility	00830087 N 00428559 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)
Chethika Ambalangodage (SLA)

Witnessed by : B.D.Nuwan Chathuranga
(Assistant Health Administrative Officer)

Date of sample collected : 2018.08.08

Date(s) of test performed : 2018.08.08-2018.08.29

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

2018/09/03

Report No : WQL/2018/194

Remarks :

Conclusion :

The tested sample 580/18/LS do not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to pH, COD, Total coliform and fecal coliform.

The tested sample 581/18/LS do not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to COD, Total coliform and fecal coliform.

The tested sample 582/18/LS does not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to Total coliform.

The tested sample 583/18/LS do not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to Turbidity, COD, Fe, Total coliform and fecal coliform.

The tested sample 584/18/LS do not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to Turbidity, COD, Total coliform and fecal coliform

Signature 2018/09/03
Name
Director (Laboratory Services)

Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name Aruna Wijesinghe
Technical Manager

Report No : WQL/2018/194

	Analytical Results													
	pH**	EC** mS/cm	TURB** NTU	TEMP** °C	COD mg/l	BOD mg/l	TSS mg/l	Pb mg/l	Fe mg/l	Cr mg/l	Cd mg/l	As mg/l	Total Coliform MPN/100ml	Faecal Coliform MPN/100ml
Test Method / Reference No	APHA 4500H+B	APHA 2510 B	APHA 2130 B	APHA 2550 B	APHA 5220 B	APHA 5210 B	APHA 2540 D	APHA 3111 B	APHA 3111 B	APHA 3111 B	APHA 3111 B	APHA 3125 B	APHA 9221 B	APHA 9221 E
580/18/LS	**6.4**	3.77	0.1	30	**26**	7	19	<0.01	<0.01	<0.01	<0.01	<0.001	**78**	**45**
581/18/LS	6.6	2.23	1.1	29	**12**	8	12	<0.01	<0.01	<0.01	<0.01	<0.001	**790**	**330**
582/18/LS	6.6	0.38	0.9	28	8	6	1	<0.01	<0.01	<0.01	<0.01	<0.001	**20**	Absent
583/18/LS	7.0	6.67	**24.7**	29	**696**	34	69	<0.01	**3.66**	<0.01	<0.01	0.002	**>16000**	**9200**
584/18/LS	6.8	3.41	**2.2**	30	**33**	22	27	<0.01	<0.01	<0.01	<0.01	<0.001	**9200**	**5400**
SLS 614:2013 Requirement mg/l	**6.5-8.5 max**	**Not specified**	**2 max**	**Not specified**	**10 max**	**Not specified**	**Not specified**	**0.01 max**	**0.3 max**	**0.05 max**	**0.003 max**	**0.01 max**	**3 max**	**Absent**

Abbreviations
COD: Chemical Oxygen Demand
EC : Electrical Conductivity
BOD: Biological Oxygen Demand
TURB : Turbidity
TSS: Total Suspended Solids
TEMP: Temperature
Pb Dissolved Lead
Cr: Dissolved Chromium
Fe: Iron
Cd: Cadmium
As: Arsenic

** Site measurements
This report refers specifically to the sample tested.

2018/09/03

JICA Project
2018/09/03

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TEST REPORT

Report No: WQL/2018/195

Issued Date: 2018/09/03

Name and Address of the Industry

Boreholes of
Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala

Report No : WQL/2018/195

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
585/18/LS	Turbid sample	Borehole No.1	00830042N 00428573 E
586/18/LS	Clear sample	Borehole No.2	00830059N 00428589 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)
Chethika Ambalangodage (SLA)

Witnessed by : B.D.Nuwan Chathuranga
(Assistant Health Administrative Officer)

Date of sample collected : 2018.08.08

Date(s) of test performed : 2018.08.08-2018.08.29

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

2018/09/03

JICA Project
2018/09/03

LABORATORY
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TEST REPORT

Report No: WQL/2018/196

Issued Date: 2018/09/03

Name and Address of the Industry

Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala

Report No : WQL/2018/195

ANALYTICAL RESULTS

Parameter	Units	Test Method	Results	
			Ref No 585/18/LS	Ref No 586/18/LS
pH at ambient temperature **		APHA 4500 H^+ B	6.9	6.7
Electrical Conductivity (EC) **	mS/cm	APHA 2510 B	3.88	3.29
Temperature of discharge **	^{0}C	APHA 2550 B	30	32
Turbidity **	NTU	APHA 2130 B	1000	8
Chemical Oxygen Demand (COD)	mg/l	APHA 5220 B	98	49
Biological Oxygen Demand (BOD_5) in 5 days at 20 ^{0}C	mg/l	APHA 5210 B	16	26
Total Suspended Solids (TSS)	mg/l	APHA 2540 D	1352	67
Total Coliform	MPN/ 100ml	APHA 9221 B	5400	3500
Fecal Coliform	MPN/ 100ml	APHA 9221 E	3500	3500
Lead as Pb	mg/l	APHA 3111 B	0.04	<0.01
Chromium as Cr	mg/l	APHA 3111 B	<0.01	<0.01
Iron as Fe	mg/l	APHA 3111 B	63.46	32.83
Cadmium as Cd	mg/l	APHA 3111 B	<0.01	<0.01
Arsenic as As	mg/l	APHA 3125 B	<0.001	<0.001

** Site measurements

This report refers specifically to the sample tested.

Remarks :

Conclusion:

Signature
Name
Director (Laboratory Services)
Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority
2018/09/03

Signature
Name Aruna Wijesinghe
Technical Manager

Report No : WQL/2018/196

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
587/18/LS	Turbid sample	Leachate inside the facility	00832228 N 00428598 E
588/18/LS	Turbid sample	Untreated wastewater from the inlet of the Treatment plant	00830126 N 00428571 E
589/18/LS	Slightly turbid sample	Treated wastewater from the outlet of the treatment plant	00830156 N 00428566 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)

Chethika Ambalangodage (SLA)

Witnessed by : B.D.Nuwan Chathuranga
(Assistant Health Administrative Officer)

Date of sample collected : 2018.08.08

Date(s) of test performed : 2018.08.08-2018.08.29

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

2018/09/03

Report No : WQL/2018/196

ANALYTICAL RESULTS

Parameter	Units	Test Method	Results		
			Ref No 587/18/LS	Ref No 588/18/LS	Ref No 589/18/LS
pH at ambient temperature **		APHA 4500 H⁺ B	8.0	Not Done	9.6
Electrical Conductivity (EC) **	mS/cm	APHA 2510 B	20.6		1.17
Temperature of discharge **	^{0}C	APHA 2550 B	29		30
Turbidity **	NTU	APHA 2130 B	180		76
Chemical Oxygen Demand (COD)	mg/l	APHA 5220 B	6002	38376	148
Biological Oxygen Demand (BOD_5) in 5 days at 20 ^{0}C	mg/l	APHA 5210 B	194	835	20
Total Suspended Solids (TSS)	mg/l	APHA 2540 D	254	3400	63
Total Coliform	MPN/ 100ml	APHA 9221 B	>16000	>16000	9200
Faecal Coliform	MPN/ 100ml	APHA 9221 E	16000	9200	5400

** Site measurements

This report refers specifically to the sample tested.

Remarks : Ref No.588/18/LS contains untreated wastewater from the inlet of the treatment plant. Its site measurements could not be performed due to high viscosity.

Conclusion:

Signature 2018/09/03
Name
Director (Laboratory Services)
Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name Aruna Wijesinghe
Technical Manager

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2018/11/08

TEST REPORT

Report No: WQL 2018/282

Issued Date: 2018/11/08

Name and Address of the Industry

Boreholes of
Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala

Report No : WQL 2018/282

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
857/18/LS	Slightly turbid sample	Borehole No.1	00830042N 00428573 E
858/18/LS	Slightly turbid sample	Borehole No.2	00830059N 00428589 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)
Chethika Ambalangodage (SLA)

Witnessed by : B.D.Nuwan Chathuranga (Sub Administrator)

Date of sample collected : 2018.10.08

Date(s) of test performed : 2018.10.08-2018.11.07

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

And/or

USEPA-United States Environmental Protection Agency

2018/11/08

Report No : WQL 2018/282

ANALYTICAL RESULTS

Parameter	Units	Test Method	Results	
			Ref No 857/18/LS	Ref No 858/18/LS
pH at ambient temperature **		APHA 4500 H⁺ B	6.7	6.7
Electrical Conductivity (EC) **	mS/cm	APHA 2510 B	4.52	4.16
Temperature of discharge **	⁰C	APHA 2550 B	30	31
Turbidity **	NTU	APHA 2130 B	113	157
Chemical Oxygen Demand (COD)	mg/l	APHA 5220 B	64	44
Biological Oxygen Demand (BOD_5) in 5 days at 20 ⁰C	mg/l	APHA 5210 B	25	16
Total Suspended Solids (TSS)	mg/l	APHA 2540 D	235	547
Total Coliform	MPN/ 100ml	APHA 9221 B	>16000	>16000
Fecal Coliform	MPN/ 100ml	APHA 9221 E	16000	9200
Lead as Pb	mg/l	APHA 3111 B	<0.01	<0.01
Chromium as Cr	mg/l	APHA 3111 B	<0.01	<0.01
Iron as Fe	mg/l	APHA 3111 B	0.33	1.09
Cadmium as Cd	mg/l	APHA 3111 B	<0.01	<0.01
Arsenic as As	mg/l	USEPA 200.8	<0.001	<0.001

** Site measurements

This report refers specifically to the sample tested.

Remarks : Sampling was carried out under rainy condition.

Conclusion:

Signature 2018/11/08
Name
Director (Laboratory Services)

Signature
Name Aruna Wijesinghe
Technical Manager

Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control
Central Environmental Authority

JICA
2018/11/08

LABORATORY

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TEST REPORT

Report No: WQL 2018/283

Issued Date: 2018/11/08

Name and Address of the Industry

Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala

Report No : WQL 2018/283

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
859/18/LS	Turbid sample	Leachate inside the facility	00832228 N 00428598 E
860/18/LS	Turbid sample	Untreated wastewater from the inlet of the treatment plant	00830126 N 00428571 E
861/18/LS	Slightly turbid yellowish colour sample	Treated wastewater from the outlet of the treatment plant	00830156 N 00428566 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)

Chethika Ambalangodage (SLA)

Witnessed by : B.D.Nuwan Chathuranga (Sub Administrator)

Date of sample collected : 2018.10.08

Date(s) of test performed : 2018.10.08-2018.11.07

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

2018/11/08

Report No : WQL 2018/283

ANALYTICAL RESULTS

Parameter	Units	Test Method	Results		
			Ref No 859/18/LS	Ref No 860/18/LS	Ref No 861/18/LS
pH at ambient temperature **		APHA 4500 H⁺ B	7.2	5.7	8.1
Electrical Conductivity (EC) **	mS/cm	APHA 2510 B	4.81	1.73	1.87
Temperature of discharge **	⁰C	APHA 2550 B	29	28	28
Turbidity **	NTU	APHA 2130 B	132	660	164
Chemical Oxygen Demand (COD)	mg/l	APHA 5220 B	9178	9764	98
Biological Oxygen Demand (BOD_5) in 5 days at 20 ⁰C	mg/l	APHA 5210 B	241	271	10
Total Suspended Solids (TSS)	mg/l	APHA 2540 D	936	9188	88
Total Coliform	MPN/ 100ml	APHA 9221 B	>16000	>16000	>16000
Fecal Coliform	MPN/ 100ml	APHA 9221 E	16000	4300	9200

** Site measurements

This report refers specifically to the sample tested.

Remarks : Sampling was carried out under rainy condition.

Conclusion:

Signature 2018/11/08
Name
Director (Laboratory Services)

Signature
Name Aruna Wijesinghe
Technical Manager

Mrs. T. W. A. Wasantha W
Director (Laboratory S
Environment Pollution Contr
Central Environmental Aut

JICA
2018/11/08

LABORATORY
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TEST REPORT

Report No: WQL 2018/281

Issued Date: 2018/11/08

Name and Address of Surface water

Well water samples around
Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala

Report No : WQL 2018/281

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
852/18/LS	Clear sample	Well (Mr.Subramaniyam)	00830049N 00428555E
853/18/LS	Clear sample	Well (Mr.Ruhmal)	00829974N 00428524E
854/18/LS	Clear sample	Well (Mrs.Rodrigo)	00829885 N 00428558 E
855/18/LS	Clear sample	Existing Well No.2 inside the facility	00830087 N 00428559 E
856/18/LS	Slightly turbid sample	Existing Well No.1 inside the facility near leachate tank	00832228 N 00428598 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)
Chethika Ambalangodage (SLA)

Witnessed by : B.D.Nuwan Chathuranga (Sub Administrator)

Date of sample collected : 2018.10.08

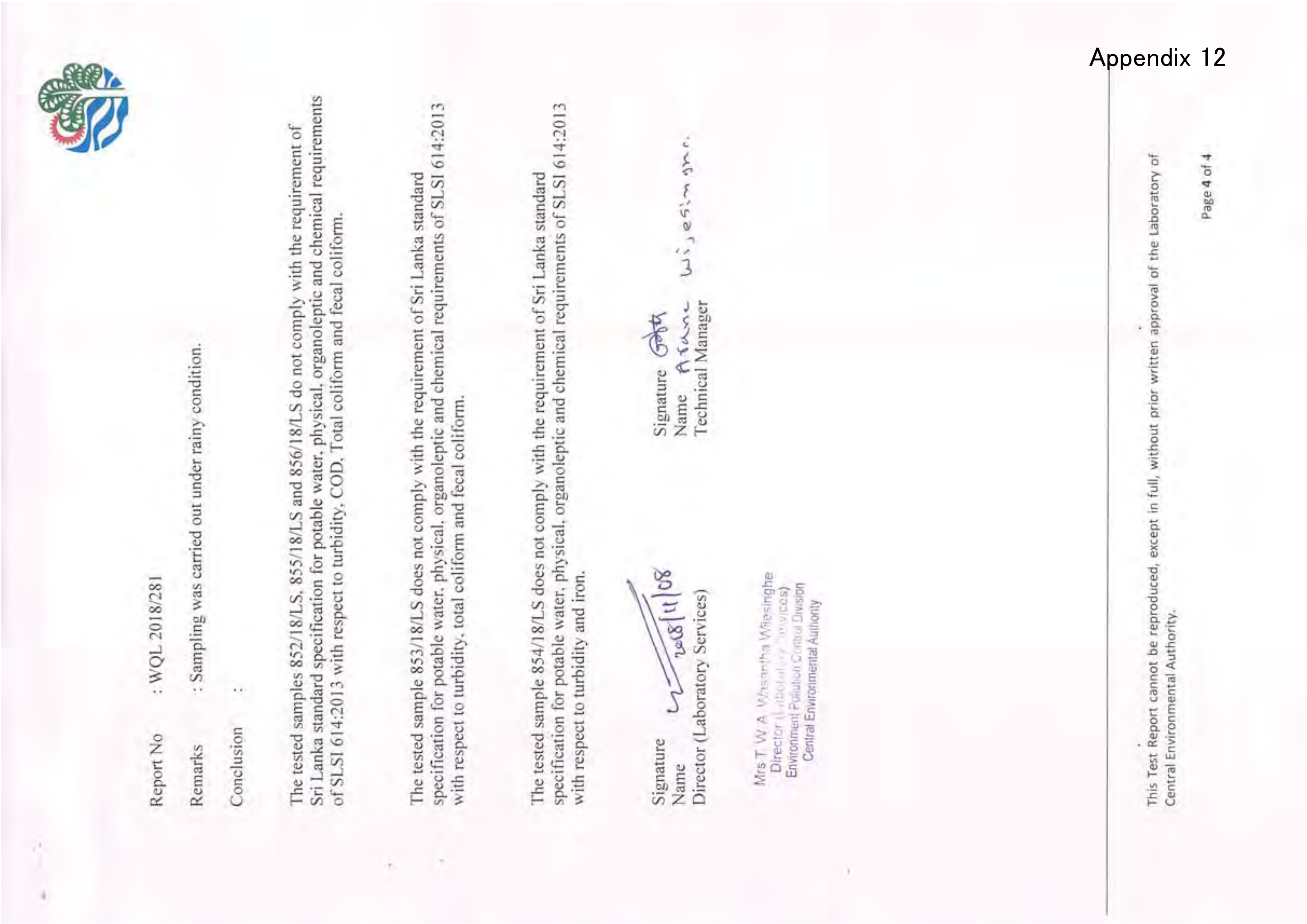
Date(s) of test performed : 2018.10.08-2018.11.07

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

And/or

USEPA-United States Environmental Protection Agency

2018/11/08



Report No : WQL 2018/281

Remarks : Sampling was carried out under rainy condition.

Conclusion :

The tested samples 852/18/LS, 855/18/LS and 856/18/LS do not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to turbidity, COD, Total coliform and fecal coliform.

The tested sample 853/18/LS does not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to turbidity, total coliform and fecal coliform.

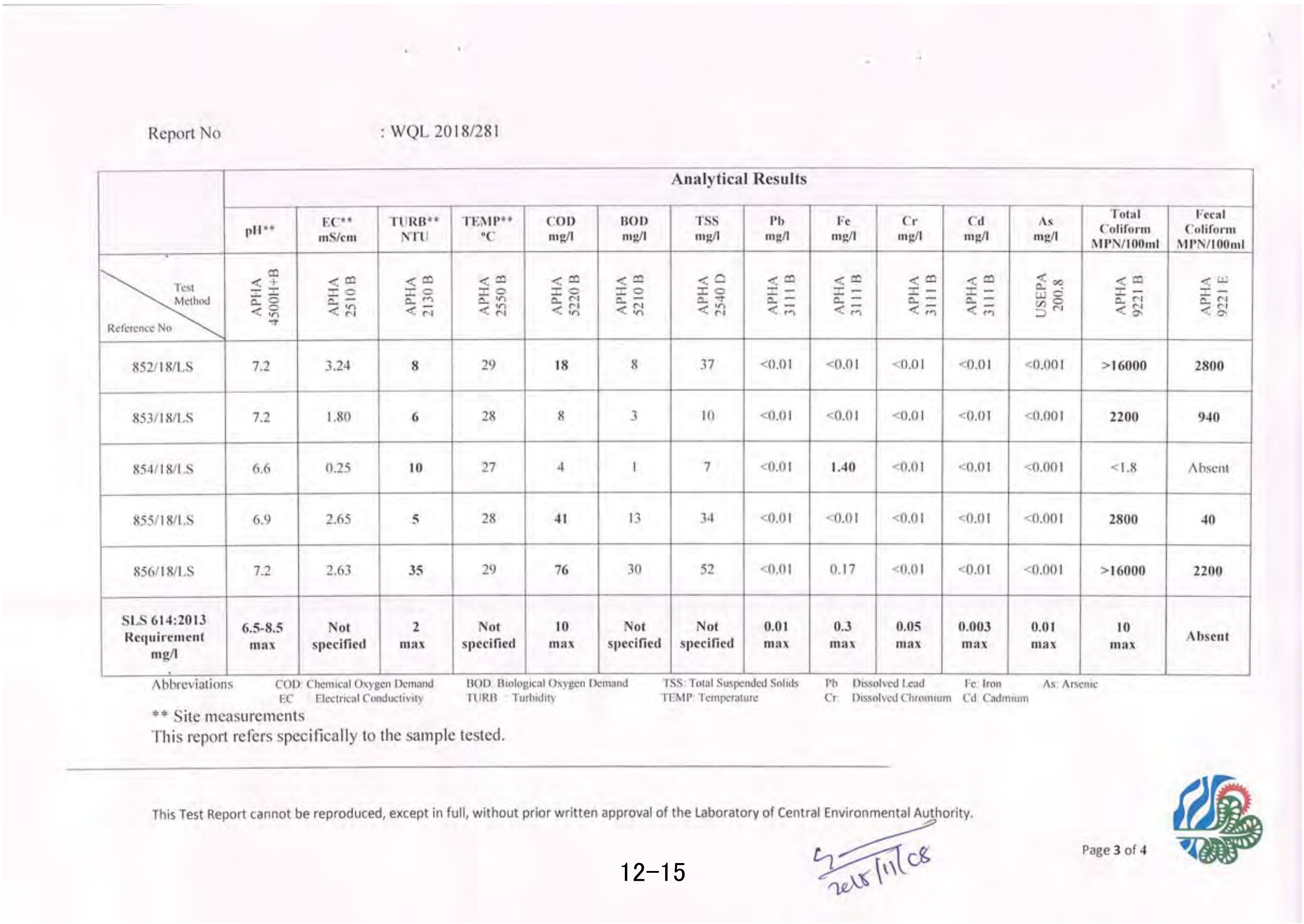
The tested sample 854/18/LS does not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to turbidity and iron.

Signature
Name
Director (Laboratory Services)

2018/11/08

Mrs T W A Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name Asanka Wijesinghe
Technical Manager



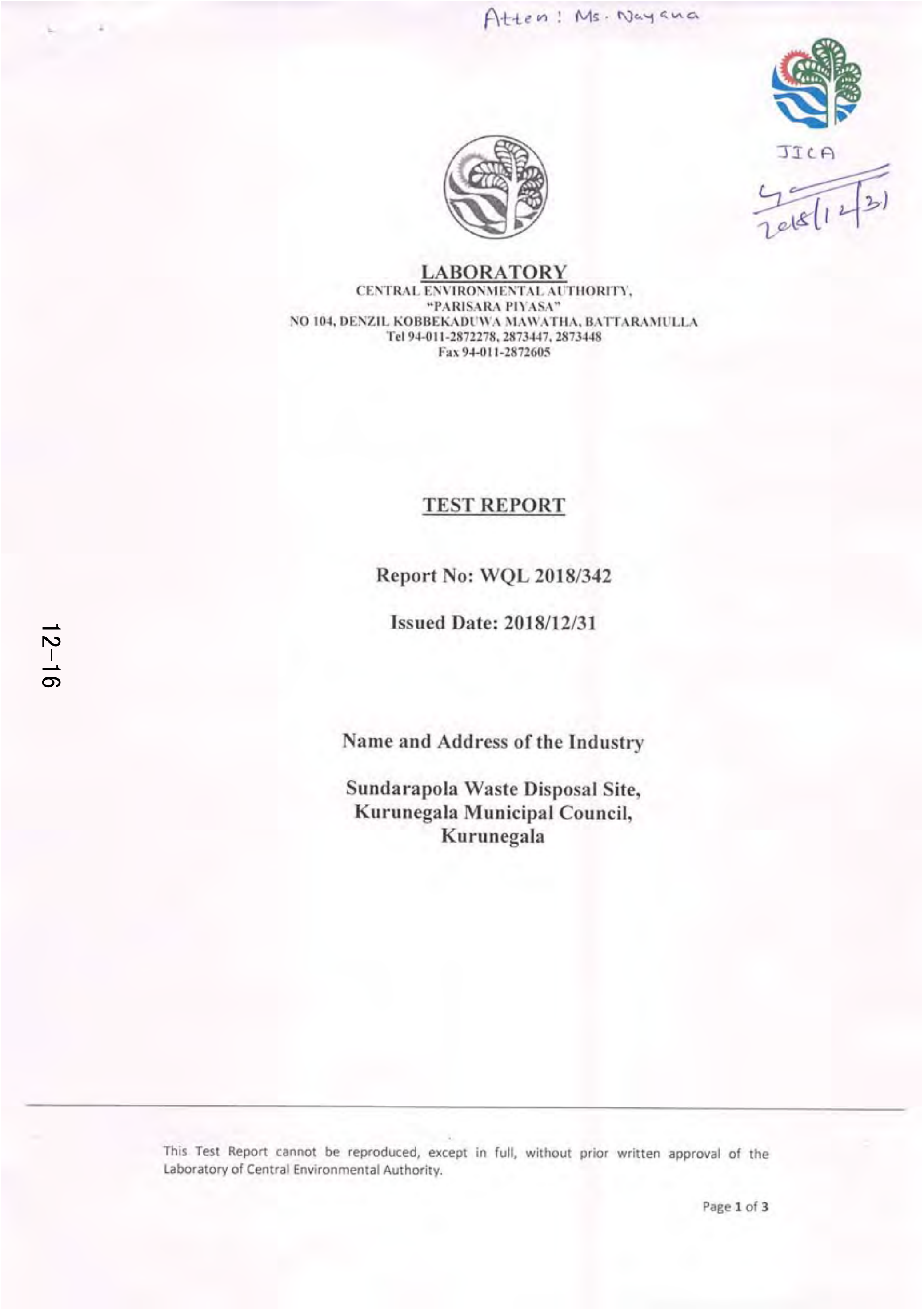
Report No : WQL 2018/281

Test Method / Reference No	pH**	EC** mS/cm	TURB** NTU	TEMP** °C	COD mg/l	BOD mg/l	TSS mg/l	Pb mg/l	Fe mg/l	Cr mg/l	Cd mg/l	As mg/l	Total Coliform MPN/100ml	Fecal Coliform MPN/100ml
	APHA 4500H+B	APHA 2510 B	APHA 2130 B	APHA 2550 B	APHA 5220 B	APHA 5210 B	APHA 2540 D	APHA 3111 B	APHA 3111 B	APHA 3111 B	APHA 3111 B	USEPA 200.8	APHA 9221 B	APHA 9221 E
852/18/LS	7.2	3.24	**8**	29	**18**	8	37	<0.01	<0.01	<0.01	<0.01	<0.001	**>16000**	**2800**
853/18/LS	7.2	1.80	**6**	28	8	3	10	<0.01	<0.01	<0.01	<0.01	<0.001	**2200**	**940**
854/18/LS	6.6	0.25	**10**	27	4	1	7	<0.01	**1.40**	<0.01	<0.01	<0.001	<1.8	Absent
855/18/LS	6.9	2.65	**5**	28	**41**	13	34	<0.01	<0.01	<0.01	<0.01	<0.001	**2800**	**40**
856/18/LS	7.2	2.63	**35**	29	**76**	30	52	<0.01	0.17	<0.01	<0.01	<0.001	**>16000**	**2200**
SLS 614:2013 Requirement mg/l	**6.5-8.5 max**	**Not specified**	**2 max**	**Not specified**	**10 max**	**Not specified**	**Not specified**	**0.01 max**	**0.3 max**	**0.05 max**	**0.003 max**	**0.01 max**	**10 max**	**Absent**

Abbreviations COD: Chemical Oxygen Demand BOD: Biological Oxygen Demand TSS: Total Suspended Solids Pb Dissolved Lead Fe: Iron As: Arsenic
EC Electrical Conductivity TURB Turbidity TEMP: Temperature Cr: Dissolved Chromium Cd: Cadmium

** Site measurements
This report refers specifically to the sample tested.

2018/11/08



Atten ! Ms. Nayana

JICA
2018/12/31

LABORATORY

CENTRAL ENVIRONMENTAL AUTHORITY,
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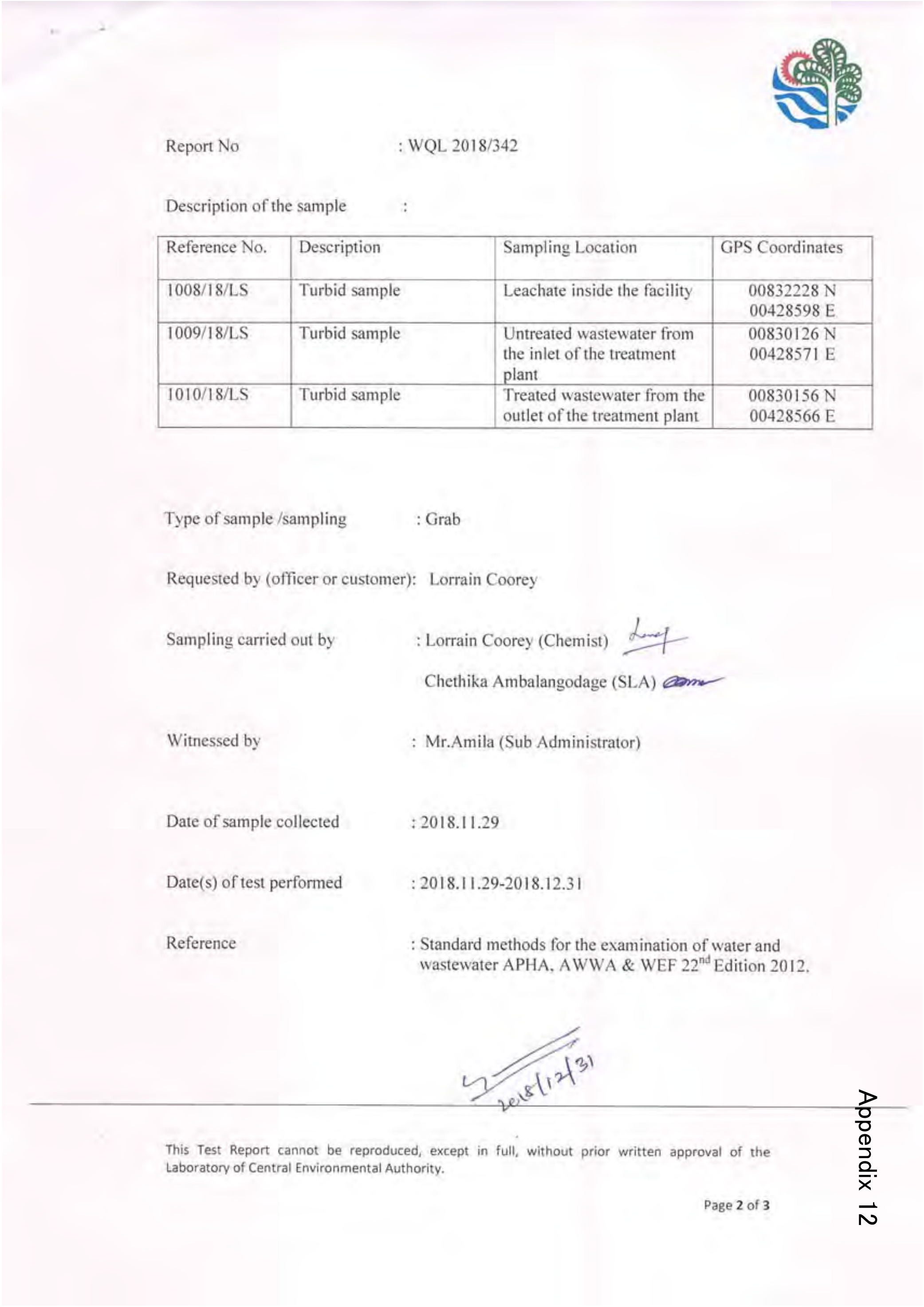
TEST REPORT

Report No: WQL 2018/342

Issued Date: 2018/12/31

Name and Address of the Industry

Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala



Report No : WQL 2018/342

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
1008/18/LS	Turbid sample	Leachate inside the facility	00832228 N 00428598 E
1009/18/LS	Turbid sample	Untreated wastewater from the inlet of the treatment plant	00830126 N 00428571 E
1010/18/LS	Turbid sample	Treated wastewater from the outlet of the treatment plant	00830156 N 00428566 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)
Chethika Ambalangodage (SLA)

Witnessed by : Mr.Amila (Sub Administrator)

Date of sample collected : 2018.11.29

Date(s) of test performed : 2018.11.29-2018.12.31

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

2018/12/31

Report No : WQL 2018/342

ANALYTICAL RESULTS

Parameter	Units	Test Method	Results		
			Ref No 1008/18/LS	Ref No 1009/18/LS	Ref No 1010/18/LS
pH at ambient temperature **		APHA 4500 H^+ B	8.0	7.6	8.2
Electrical Conductivity (EC) **	mS/cm	APHA 2510 B	10.10	2.45	2.43
Temperature of discharge **	^{0}C	APHA 2550 B	30	27	28
Turbidity **	NTU	APHA 2130 B	150	188	175
Chemical Oxygen Demand (COD)	mg/l	APHA 5220 B	1512	202	363
Biological Oxygen Demand (BOD_5) in 5 days at 20 ^{0}C	mg/l	APHA 5210 B	136	61	76
Total Suspended Solids (TSS)	mg/l	APHA 2540 D	276	104	158
Total Coliform	MPN/ 100ml	APHA 9221 B	>16000	>16000	>16000
Fecal Coliform	MPN/ 100ml	APHA 9221 E	16000	>16000	3500

** Site measurements

This report refers specifically to the sample tested.

Remarks :
Conclusion:

Signature 2018/12/31
Name
Director (Laboratory Services)

Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name Aruna Wijesinghe
Technical Manager

Atten : Ms. Nayano

JICA
2018/12/31

LABORATORY
CENTRAL ENVIRONMENTAL AUTHORITY,
"PARISARA PIYASA"
NO 104, DENZIL KOBBEKADUWA MAWATHA, BATTARAMULLA
Tel 94-011-2872278, 2873447, 2873448
Fax 94-011-2872605

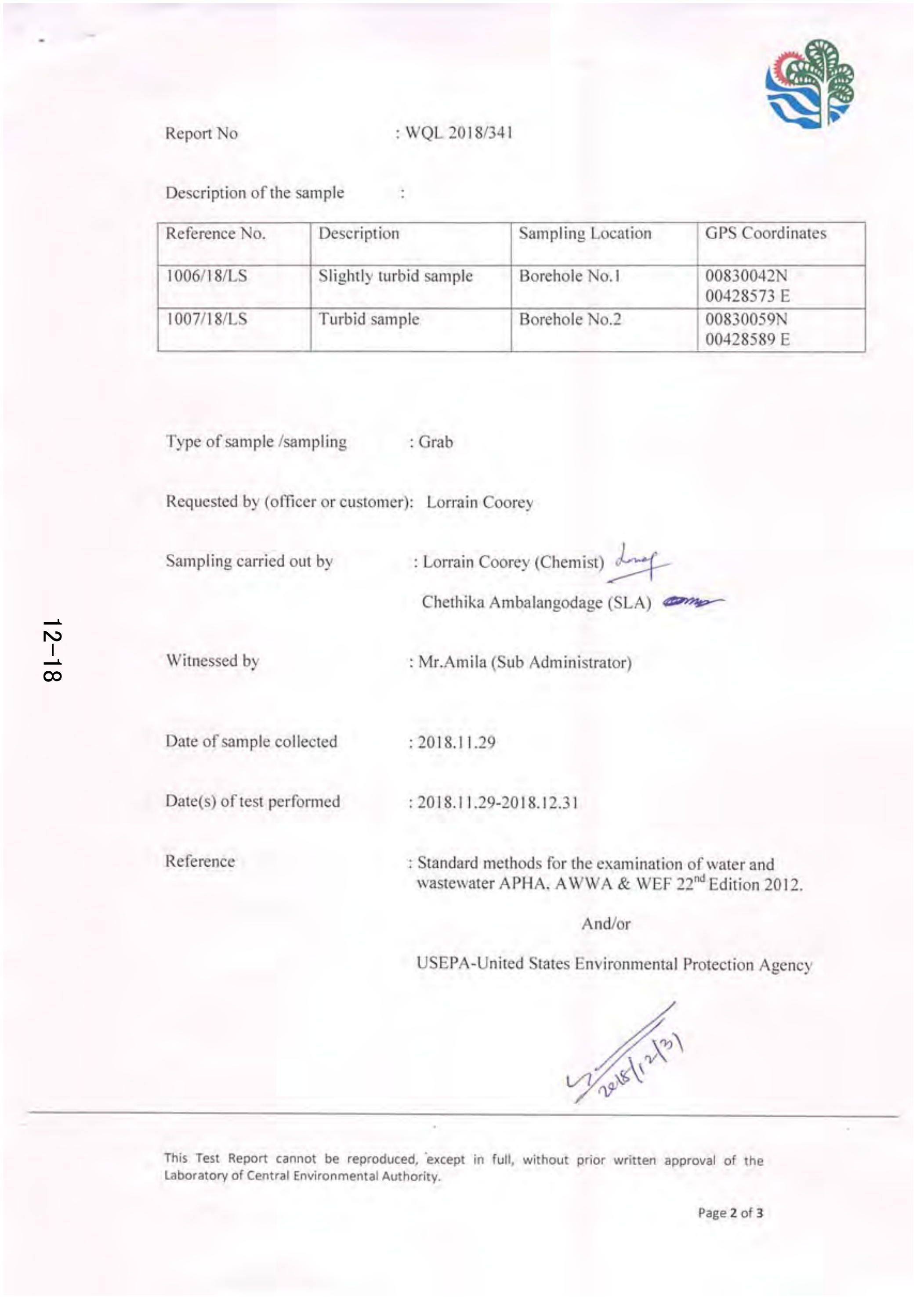
TEST REPORT

Report No: WQL 2018/341

Issued Date: 2018/12/31

Name and Address of the Industry

Boreholes of
Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala



Report No : WQL 2018/341

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
1006/18/LS	Slightly turbid sample	Borehole No.1	00830042N 00428573 E
1007/18/LS	Turbid sample	Borehole No.2	00830059N 00428589 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)

Chethika Ambalangodage (SLA)

Witnessed by : Mr.Amila (Sub Administrator)

Date of sample collected : 2018.11.29

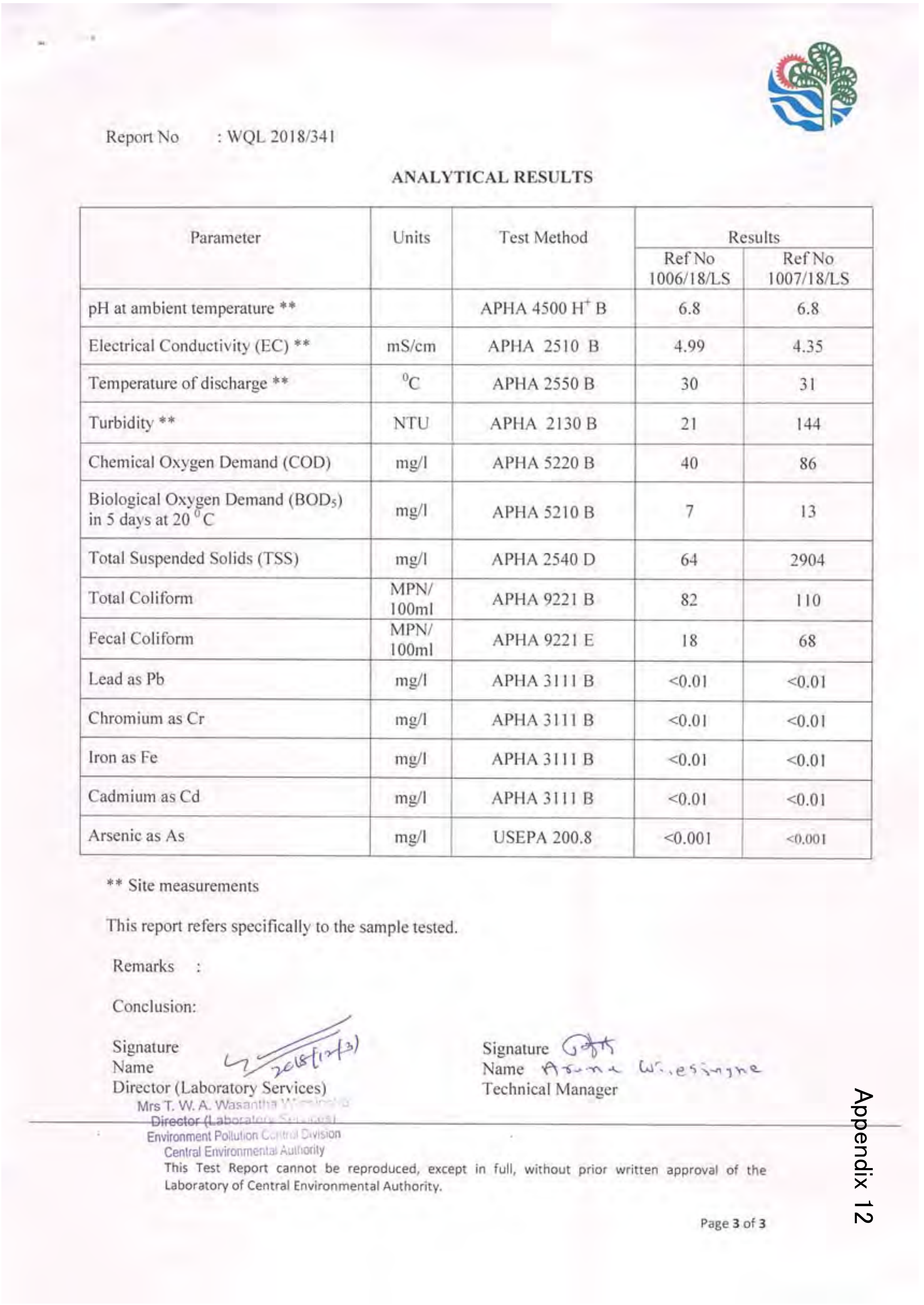
Date(s) of test performed : 2018.11.29-2018.12.31

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

And/or

USEPA-United States Environmental Protection Agency

2018/12/3



Report No : WQL 2018/341

ANALYTICAL RESULTS

Parameter	Units	Test Method	Results	
			Ref No 1006/18/LS	Ref No 1007/18/LS
pH at ambient temperature **		APHA 4500 H^+ B	6.8	6.8
Electrical Conductivity (EC) **	mS/cm	APHA 2510 B	4.99	4.35
Temperature of discharge **	^{0}C	APHA 2550 B	30	31
Turbidity **	NTU	APHA 2130 B	21	144
Chemical Oxygen Demand (COD)	mg/l	APHA 5220 B	40	86
Biological Oxygen Demand (BOD_5) in 5 days at 20 ^{0}C	mg/l	APHA 5210 B	7	13
Total Suspended Solids (TSS)	mg/l	APHA 2540 D	64	2904
Total Coliform	MPN/ 100ml	APHA 9221 B	82	110
Fecal Coliform	MPN/ 100ml	APHA 9221 E	18	68
Lead as Pb	mg/l	APHA 3111 B	<0.01	<0.01
Chromium as Cr	mg/l	APHA 3111 B	<0.01	<0.01
Iron as Fe	mg/l	APHA 3111 B	<0.01	<0.01
Cadmium as Cd	mg/l	APHA 3111 B	<0.01	<0.01
Arsenic as As	mg/l	USEPA 200.8	<0.001	<0.001

** Site measurements

This report refers specifically to the sample tested.

Remarks :

Conclusion:

Signature
Name 2018/12/3
Director (Laboratory Services)

Mrs T. W. A. Wasantha [illegible]
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name Aruna Wijesinghe
Technical Manager

Atten: Ms. Nayana

JICA
4
2018/12/31

LABORATORY
CENTRAL ENVIRONMENTAL AUTHORITY,
"PARISARA PIYASA"
NO 104, DENZIL KOBBEKADUWA MAWATHA, BATTARAMULLA
Tel 94-011-2872278, 2873447, 2873448
Fax 94-011-2872605

TEST REPORT

Report No: WQL 2018/340

Issued Date: 2018/12/31

Name and Address of Surface water

Well water samples around
Sundarapola Waste Disposal Site,
Kurunegala Municipal Council,
Kurunegala

Report No : WQL 2018/340

Description of the sample :

Reference No.	Description	Sampling Location	GPS Coordinates
1001/18/LS	Clear sample	Existing well No.3 (Mr.Subramaniyam)	00830049N 00428555E
1002/18/LS	Clear sample	Existing well No.4 (Mr.Ruhmal)	00829974N 00428524E
1003/18/LS	Clear sample	Existing well No.5 (Mrs.Rodrigo)	00829885 N 00428558 E
1004/18/LS	Clear sample	Existing Well No.2 inside the facility	00830087 N 00428559 E
1005/18/LS	Clear sample	Existing Well No.1 inside the facility near leachate tank	00832228 N 00428598 E

Type of sample /sampling : Grab

Requested by (officer or customer): Lorrain Coorey

Sampling carried out by : Lorrain Coorey (Chemist)

Chethika Ambalangodage (SLA)

Witnessed by : Mr.Amila (Sub Administrator)

Date of sample collected : 2018.11.29

Date(s) of test performed : 2018.11.29-2018.12.31

Reference : Standard methods for the examination of water and wastewater APHA, AWWA & WEF 22nd Edition 2012.

And/or

USEPA-United States Environmental Protection Agency

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2018/12/31

Report No : WQL 2018/340

Remarks :

Conclusion :

The tested sample 1001/18/LS does not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to turbidity, COD and total coliform.

The tested samples 1004/18/LS and 1005/18/LS do not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to turbidity, COD, total coliform and fecal coliform.

The tested sample 1002/18/LS does not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to total coliform.

The tested sample 1003/18/LS does not comply with the requirement of Sri Lanka standard specification for potable water, physical, organoleptic and chemical requirements of SLSI 614:2013 with respect to pH.

Signature 2018/12/31
Name
Director (Laboratory Services)

Mrs T. W. A. Wasantha Wijesinghe
Director (Laboratory Services)
Environment Pollution Control Division
Central Environmental Authority

Signature
Name Aruna Wijesinghe
Technical Manager

Report No : WQL 2018/340

	Analytical Results													
	pH**	EC** mS/cm	TURB** NTU	TEMP** °C	COD mg/l	BOD mg/l	TSS mg/l	Pb mg/l	Fe mg/l	Cr mg/l	Cd mg/l	As mg/l	Total Coliform MPN/100ml	Fecal Coliform MPN/100ml
Test Method / Reference No	APHA 4500H+B	APHA 2510 B	APHA 2130 B	APHA 2550 B	APHA 5220 B	APHA 5210 B	APHA 2540 D	APHA 3111 B	APHA 3111 B	APHA 3111 B	APHA 3111 B	USEPA 200.8	APHA 9221 B	APHA 9221 E
1001/18/LS	6.5	4.25	**4.5**	30	**19**	4	8	<0.01	<0.01	<0.01	<0.01	<0.001	**2400**	Absent
1002/18/LS	6.7	2.19	1.7	29	10	3	3	<0.01	<0.01	<0.01	<0.01	<0.001	**2400**	Absent
1003/18/LS	**6.2**	0.34	1.6	28	4	1	1	<0.01	<0.01	<0.01	<0.01	<0.001	<1.8	Absent
1004/18/LS	7.0	5.73	**3.8**	30	**94**	13	13	<0.01	<0.01	<0.01	<0.01	<0.001	**1100**	**20**
1005/18/LS	6.6	4.82	**4.9**	28	**46**	5	24	<0.01	<0.01	<0.01	<0.01	<0.001	**>16000**	**470**
SLS 614:2013 Requirement mg/l	**6.5-8.5 max**	**Not specified**	**2 max**	**Not specified**	**10 max**	**Not specified**	**Not specified**	**0.01 max**	**0.3 max**	**0.05 max**	**0.003 max**	**0.01 max**	**10 max**	**Absent**

Abbreviations COD: Chemical Oxygen Demand BOD: Biological Oxygen Demand TSS: Total Suspended Solids Pb Dissolved Lead Fe: Iron As: Arsenic
EC : Electrical Conductivity TURB : Turbidity TEMP: Temperature Cr: Dissolved Chromium Cd: Cadmium

** Site measurements

This report refers specifically to the sample tested.

2018/12/31

NBRO/ENV/26201/2017/166a
AQP/2017/166a

18th August 2017

Client: Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF BASELINE AMBIENT AIR QUALITY AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA

(JULY 2017)

1.0 SCOPE:

As per the letter dated on 30th May 2017, by the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, No. 104, Denzil Kobbekaduwa Mawatha, Battaramulla Ltd. to the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) was requested to monitor baseline ambient air quality levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions before start the project activities of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the air sampling programme on 13th & 14th July 2017.

Staff involved:

Mr. Manjula Dissanayake - Scientist - ESSD, NBRO
Mr. Prabath Liyanaarachchi - Scientist - ESSD, NBRO
Mr. W A Weerasinghe - Field Assistant - ESSD, NBRO

Witness: *Mr. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Naofumi Sato - EX Research Institute Ltd.

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor baseline air quality levels at the project area before staring the project activities.

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3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 MONITORING OF AMBIENT AIR QUALITY

4.1 SELECTION OF MONITORING LOCATIONS

Air samples were collected from three selected locations around the disposal site area as per the client's requirement. Location description is given in Table 1 and attached layout plan.

Table 01: Location description of air quality measurements

Location No.	Location Description	GPS Coordinates
L1	At a location, close to the north west boundary of the disposal site	07°30'55.0"N 080°21'13.3"E
L2	At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.	07°30'50.2"N 080°21'16.0"E
L3	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.	07°30'45.8"N 080°21'16.9"E

4.2 SAMPLING AND ANALYTICAL CONDITIONS:

Air samples were collected from the selected locations as per the methods stipulated in National Ambient Air Quality Standards on one (01) hour basis for the analysis of Carbon Monoxide (CO), Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) on 24-hours and three (3) hours basis for the analysis of TSPM. The sampling receiver height was about 3 m from the ground level and sampling rates were 0.5 l/min for SO_2 and NO_2, 1.0 l/min for CO analysis and sampling rate for PM_{10} and TSPM analysis was 1.0 m^3/min and at 16 l/min for $PM_{2.5}$. One hour average CO levels were taken as onsite measurements. Samples collected for the analysis of SO_2 and NO_2 were stored in a cooling box and PM_{10} & $PM_{2.5}$ samples were stored in filter cassettes and sent to the NBRO laboratory for the analysis.

The laboratory received samples on 14th July 2017 in satisfactory condition. They were analysed on the same day for the NO_2 & SO_2. PM_{10}, $PM_{2.5}$ and TSPM were analysed on 18th July 2017 after drying to a constant weight in a desiccator. Sampling and analytical method used are given in Table 2.

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4.3 SAMPLING AND ANALYTICAL METHODOLOGY:

Table 02: Description of the Sampling & Analytical methods used for each parameter

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
SO_2	ASTM D 2914 - 78, 1987 West-Gaek & Pararosaniline Spectrometric method	4 μg/m^3 (0.0015 ppm)	Pararosaniline method or equivalent (pulsed fluorescent method)	*Standard Personal Air Samplers * UV-Visible Spectrophotometer
NO_2	ASTM D 1607 - 76, 1987, Griess – Saltzman Reaction Method	4 μg/m^3 (0.002 ppm)	Colorimetric using Saltzman method or equivalent (gas phase Chemiluminescence)	*Standard Personal Air Samplers * UV – Visible Spectrophotometer
TSPM	ASTM D 4096 - 82, 1997 High - Volume Sampling and Gravimetric Analysis	2 μg/m^3	Hi - volume sampling, and Gravimetric	* High Volume Sampler * Sartorius analytical balance
CO	Non - dispersive infrared Spectrometric method	1 ppm (1140 μg/m^3)	Non - dispersive infrared(IR) spectroscopy	*REAIAQ analyser
PM10 & PM2.5	ASTM D 4096 - 82, 1997 High - Volume Sampling and Gravimetric Analysis	2 μg/m3	Hi - volume sampling, and Gravimetric	* High Volume Sampler with size selective sample inlet * Sartorius analytical balance

4.4 AMBIENT AIR QUALITY MONITORING RESULTS:

Table 03: Concentration of each parameter for ambient air quality monitoring locations

Parameter	Date of Sampling	Date of Analysis	Time Average	Units	Concentrations at each locations		
					L1	L2	L3
SO_2	14/07/2017	14/07/2017	1 hr	μg/m^3	14	16	18
NO_2	14/07/2017	14/07/2017	1 hr	μg/m^3	35	40	31
CO	14/07/2017	14/07/2017	1 hr	μg/m^3	<1000	<1000	<1000
TSPM	14/07/2017	14/07/2017	3 hrs	μg/m^3	192	160	162
PM_{10}	13-14/07/2017	18/07/2017	24 hrs	μg/m^3	55	36	37
$PM_{2.5}$	13-14/07/2017	18/07/2017	24 hrs	μg/m^3	30	20	20

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4.5 AMBIENT AIR QUALITY STANDARDS

Table 04a: Ambient Air Quality Standards stipulated under the Extraordinary Gazette, No. 1562/22 – August 15, 2008, by the Ministry of Environment and Natural Resources of Sri Lanka

POLLUTANT	TIMEAVERAGE	CONCENTRATION (μg/m^3)
SO_2	1 hr	200
NO_2	1 hr	250
CO	1 hr	30,000
PM_{10}	24 hr	100
$PM_{2.5}$	24 hr	50

Table 04b: The Interim fugitive dust emission standards levels for TSPM between two simultaneous 3 hours measurement at upwind and downwind stipulated by the Central Environmental Authority of Sri Lanka

Pollutant	Average Time	Concentration (μg/m^3)
TSPM	3 hour	450

5.0 CONCLUSIONS:

Measured ambient air quality levels with respect to measured parameters at all locations were lower than the Ambient Air Quality Standards stipulated by the Ministry of Environment & Natural Resources of Sri Lanka (Extraordinary Gazette No. 1562/22, August 15, 2008).

Total Suspended Particulate Matter level in downwind direction of the project area itself was well below the Interim Source Emission Standard levels for TSPM level (450 μg/Nm^3) stipulated by the Central Environmental Authority of Sri Lanka.

……………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

……………………..
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Ambient Air Quality monitoring locations

L1- At a location, close to the north west boundary of the disposal site

L2- At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

L3-At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2017/166a
AQP/2017/166a

4th September 2018

Client:
Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON THE MONITORING OF AMBIENT AIR QUALITY AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA

(CONSTRCUTION STAGE - AUGUST 2018)

1.0 SCOPE:

As per the letter dated 30th May 2017 the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor ambient air quality levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions of the project area during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the air sampling programme on 08th & 09th August 2018.

Staff involved:

Mr. D R Rathnayaka	*- Technical Officer*	*- ESSD, NBRO*
Mr. N Krishnamoorthy	*- Field Assistant*	*- ESSD, NBRO*
Mr. Ranil Jayawardhana	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Nuwan – Site Supervisor

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor air quality levels at the project area during the construction stage.

Cont.....2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 MONITORING OF AMBIENT AIR QUALITY

4.1 SELECTION OF MONITORING LOCATIONS

Air samples were collected from three selected locations around the disposal site area as per the client's requirement. Location description is given in Table 1 and attached layout plan.

Table 01: Location description of air quality measurements

Location	GPS Coordinates	Location Description
L1	07°30'55.0"N 080°21'13.3"E	At a location, close to the north west boundary of the disposal site
L2	07°30'31"N 080°21'9"E	At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
L3	07°30'45.8"N 080°21'16.9"E	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

4.2 SAMPLING AND ANALYTICAL CONDITIONS:

Air samples were collected from the selected locations as per the methods stipulated in National Ambient Air Quality Standards on one (01) hour basis for the analysis of Carbon Monoxide (CO), Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) on 24-hours and three (3) hours basis for the analysis of TSPM. The sampling receiver height was about 3 m from the ground level and sampling rates were 0.5 l/min for SO_2 and NO_2, 1.0 l/min for CO analysis and sampling rate for PM_{10} and TSPM analysis was 1.0 m^3/min and at 16 l/min for $PM_{2.5}$. One-hour average CO levels were taken as onsite measurements. Samples collected for the analysis of SO_2 and NO_2 were stored in a cooling box and PM_{10} & $PM_{2.5}$ samples were stored in filter cassettes and sent to the NBRO laboratory for the analysis. During the sampling period, the factory was functioning at its normal working conditions.

The laboratory received samples on 09th August 2018 in satisfactory condition. They were analysed on the same day for the NO_2 & SO_2. PM_{10}, $PM_{2.5}$ and TSPM were analysed on 13th August 2018 after drying to a constant weight in a desiccator. Sampling and analytical method used are given in Table 2.

Cont......3

4.3 SAMPLING AND ANALYTICAL METHODOLOGY:

Table 02: Description of the Sampling & Analytical methods used for each parameter

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
SO_2	ASTM D 2914 – 95, 2015 West-Geake & Pararosaniline Spectrometric method	4 µg/m^3 (0.0015 ppm)	Pararosaniline method or equivalent (pulsed fluorescent method)	*Standard Personal Air Samplers * UV-Visible Spectrophotometer
NO_2	ASTM D 1607 - 91, 2011, Griess – Saltzman Reaction Method	4 µg/m^3 (0.002 ppm)	Colorimetric using Saltzman method or equivalent (gas phase Chemiluminescence)	*Standard Personal Air Samplers * UV – Visible Spectrophotometer
CO	ASTM D 3162 – 12, 2012 Non - dispersive infrared Spectrometric method	1.0 mg/m^3 (1 ppm)	Non - dispersive infrared(IR) spectroscopy	Riken Keiki CO Detector Model - CO-7
PM10 & PM2.5	ASTM D 4096 - 82, 2017 High - Volume Sampling and Gravimetric Analysis	2 µg/m^3	Hi - volume sampling, and Gravimetric	* High Volume Sampler with size selective sample inlet * Sartorius analytical balance
TSPM	ASTM D 4096-17, 2017 High-Volume Sampler method and Gravimetric Analysis	0.002 mg/m^3	Hi-volume sampling and gravimetric	High volume sampler Sartorius analytical balance

4.4 AMBIENT AIR QUALITY MONITORING RESULTS:

Table 03: Concentration of each parameter for ambient air quality monitoring locations

Parameter	Date of Sampling	Date of Analysis	Time Average	Units	Concentrations at each location		
					L1	L2	L3
SO_2	09/08/2018	09/08/2018	1 hr	µg/m^3	14	13	10
NO_2	09/08/2018	09/08/2018	1 hr	µg/m^3	26	28	22
CO	09/08/2018	09/08/2018	1 hr	µg/m^3	<1000	<1000	<1000
TSPM	09/08/2018	13/08/2018	3 hrs	µg/m^3	32	28	27
PM_{10}	08-09/08/2018	13/08/2018	24 hrs	µg/m^3	16	13	29
$PM_{2.5}$	08-09/08/2018	13/08/2018	24 hrs	µg/m^3	19	17	16

Cont......4

4.5 AMBIENT AIR QUALITY STANDARDS

Table 04a: Ambient Air Quality Standards stipulated under the Extraordinary Gazette, No. 1562/22 – August 15, 2008, by the Ministry of Environment and Natural Resources of Sri Lanka

POLLUTANT	TIMEAVERAGE	CONCENTRATION (µg/m^3)
SO_2	1 hr	200
NO_2	1 hr	250
CO	1 hr	30,000
PM_{10}	24 hr	100
$PM_{2.5}$	24 hr	50

Table 04b: The Interim fugitive dust emission standards levels for TSPM between two simultaneous 3 hours measurement at upwind and downwind stipulated by the Central Environmental Authority of Sri Lanka

Pollutant	Average Time	Concentration (µg/m^3)
TSPM	3 hour	450

5.0 CONCLUSIONS:

Measured ambient air quality levels with respect to measured parameters at all locations were lower than the Ambient Air Quality Standards stipulated by the Ministry of Environment & Natural Resources of Sri Lanka (Extraordinary Gazette No. 1562/22, August 15, 2008).

Total Suspended Particulate Matter level in downwind direction of the project area itself was well below the Interim Source Emission Standard levels for TSPM level (450 µg/Nm^3) stipulated by the Central Environmental Authority of Sri Lanka.

…………………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

…………………………
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Ambient Air Quality monitoring locations

L1- At a location, close to the north west boundary of the disposal site

L2- At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.

L3- At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2018/319a
AQP/2018/319a

12th December 2018

Client:
Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF AMBIENT AIR QUALITY AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA

(CONSTRCUTION STAGE – NOVEMBER 2018)

1.0 SCOPE:

As per the letter dated 30th May 2017 the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor ambient air quality levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions of the project area during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the air sampling programme on 28th & 29thNovember 2018.

Staff involved:

Mr. Nilanka Ranaweera	*- Technical Officer*	*- ESSD, NBRO*
Mr. W A Weerasinghe	*- Field Assistant*	*- ESSD, NBRO*
Mr. Ranil Jayawardhana	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Nuwan – Site Supervisor

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor air quality levels at the project area during the construction stage.

Cont.....2

NBRO/ENV/26201/2018/319a
AQP/2018/319a

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 MONITORING OF AMBIENT AIR QUALITY

4.1 SELECTION OF MONITORING LOCATIONS

Air samples were collected from three selected locations around the disposal site area as per the client's requirement. Location description is given in Table 1 and attached layout plan.

Table 01: Location description of air quality measurements

Location	GPS Coordinates	Location Description
L1	07°30'55.0"N 080°21'13.3"E	At a location, close to the north west boundary of the disposal site
L2	07°30'31"N 080°21'9"E	At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
L3	07°30'45.8"N 080°21'16.9"E	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

4.2 SAMPLING AND ANALYTICAL CONDITIONS:

Air samples were collected from the selected locations as per the methods stipulated in National Ambient Air Quality Standards on one (01) hour basis for the analysis of Carbon Monoxide (CO), Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) on 24-hours and three (3) hours basis for the analysis of TSPM. The sampling receiver height was about 3 m from the ground level and sampling rates were 0.5 l/min for SO_2 and NO_2, 1.0 l/min for CO analysis and sampling rate for PM_{10} and TSPM analysis was 1.0 m^3/min and at 16 l/min for $PM_{2.5}$. One-hour average CO levels were taken as onsite measurements. Samples collected for the analysis of SO_2 and NO_2 were stored in a cooling box and PM_{10} & $PM_{2.5}$ samples were stored in filter cassettes and sent to the NBRO laboratory for the analysis. During the sampling period, the factory was functioning at its normal working conditions.

The laboratory received samples on 29th November 2018 in satisfactory condition. They were analysed on the same day for the NO_2 & SO_2. PM_{10}, $PM_{2.5}$ and TSPM were analysed on 3rd December 2018 after drying to a constant weight in a desiccator. Sampling and analytical method used are given in Table 2.

Cont......3

4.3 SAMPLING AND ANALYTICAL METHODOLOGY:

Table 02: Description of the Sampling & Analytical methods used for each parameter

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
SO_2	ASTM D 2914 – 95, 2015 West-Geake & Pararosaniline Spectrometric method	4 µg/m^3 (0.0015 ppm)	Pararosaniline method or equivalent (pulsed fluorescent method)	*Standard Personal Air Samplers * UV-Visible Spectrophotometer
NO_2	ASTM D 1607 - 91, 2011, Griess – Saltzman Reaction Method	4 µg/m^3 (0.002 ppm)	Colorimetric using Saltzman method or equivalent (gas phase Chemiluminescence)	*Standard Personal Air Samplers * UV – Visible Spectrophotometer
CO	ASTM D 3162 – 12, 2012 Non - dispersive infrared Spectrometric method	1.0 mg/m^3 (1 ppm)	Non - dispersive infrared(IR) spectroscopy	Riken Keiki CO Detector Model - CO-7
PM_{10} & $PM_{2.5}$	ASTM D 4096 - 82, 2017 High - Volume Sampling and Gravimetric Analysis	2 µg/m^3	Hi - volume sampling, and Gravimetric	* High Volume Sampler with size selective sample inlet * Sartorius analytical balance
TSPM	ASTM D 4096-17, 2017 High-Volume Sampler method and Gravimetric Analysis	0.002 mg/m^3	Hi-volume sampling and gravimetric	High volume sampler Sartorius analytical balance

4.4 AMBIENT AIR QUALITY MONITORING RESULTS:

Table 03: Concentration of each parameter for ambient air quality monitoring locations

Parameter	Date of Sampling	Date of Analysis	Time Average	Units	Concentrations at each location		
					L1	L2	L3
SO_2	29/11/2018	29/11/2018	1 hr	µg/m^3	10	12	14
NO_2	29/11/2018	29/11/2018	1 hr	µg/m^3	21	29	27
CO	29/11/2018	29/11/2018	1 hr	µg/m^3	<1000	<1000	<1000
TSPM	29/11/2018	03/12/2018	3 hrs	µg/m^3	37	42	72
PM_{10}	28-29/11/2018	03/12/2018	24 hrs	µg/m^3	22	25	43
$PM_{2.5}$	28-29/11/2018	03/12/2018	24 hrs	µg/m^3	12	14	23

Cont......4

4.5 AMBIENT AIR QUALITY STANDARDS

Table 04a: Ambient Air Quality Standards stipulated under the Extraordinary Gazette, No. 1562/22 – August 15, 2008, by the Ministry of Environment and Natural Resources of Sri Lanka

POLLUTANT	TIMEAVERAGE	CONCENTRATION (µg/m^3)
SO_2	1 hr	200
NO_2	1 hr	250
CO	1 hr	30,000
PM_{10}	24 hr	100
$PM_{2.5}$	24 hr	50

Table 04b: The Interim fugitive dust emission standards levels for TSPM between two simultaneous 3 hours measurement at upwind and downwind stipulated by the Central Environmental Authority of Sri Lanka

Pollutant	Average Time	Concentration (µg/m^3)
TSPM	3 hour	450

5.0 CONCLUSIONS:

Measured ambient air quality levels with respect to measured parameters at all locations were lower than the Ambient Air Quality Standards stipulated by the Ministry of Environment & Natural Resources of Sri Lanka (Extraordinary Gazette No. 1562/22, August 15, 2008).

Total Suspended Particulate Matter level in downwind direction of the project area itself was well below the Interim Source Emission Standard levels for TSPM level (450 µg/Nm^3) stipulated by the Central Environmental Authority of Sri Lanka.

…………………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

…………………………
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Ambient Air Quality monitoring locations

	
L1- At a location, close to the north west boundary of the disposal site	**L2**- At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
	**L3**- At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2017/275a
AQP/2017/275a

30th January 2018

Client: Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF BASELINE AMBIENT AIR QUALITY AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA

(DECEMBER 2017)

1.0 SCOPE:

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, No. 104, Denzil Kobbekaduwa Mawatha, Battaramulla requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor baseline ambient air quality levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions before start the project activities of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the air sampling programme on 20h & 21st December 2017.

Staff involved:

Mr. Prabath Liyanaarachchi	*- Scientist*	*- ESSD, NBRO*
Mr. D R Rathnayake	*- Technical Officer*	*- ESSD, NBRO*
Mr. A S Premarathne	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor baseline air quality levels at the project area before staring the project activities.

Cont…..2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 MONITORING OF AMBIENT AIR QUALITY

4.1 SELECTION OF MONITORING LOCATIONS

Air samples were collected from one (01) selected location around the disposal site area as per the client's requirement. Location description is given in Table 1 and attached layout plan.

Table 01: Location description of air quality measurements

Location No.	Location Description	GPS Coordinates
L1	At a location, close to the front boundary of the disposal site, near to the fence	6^0 22' 13.99" N 81^0 18' 23.86" E

4.2 SAMPLING AND ANALYTICAL CONDITIONS:

Air samples were collected from a selected location as per the methods stipulated in National Ambient Air Quality Standards on one (01) hour basis for the analysis of Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) on 24-hours and Total Suspended Particulate Matter (TSPM) on three (03) hour basis. The sampling receiver height was about 3 m from the ground level and sampling rates were 0.5 l/min for SO_2 and NO_2, 1.0 l/min for CO analysis and sampling rate for PM_{10} and TSPM analysis was 1.0 m^3/min and at 16 l/min for $PM_{2.5}$. One-hour average CO levels were taken as onsite measurements. Samples collected for the analysis of SO_2 and NO_2 were stored in a cooling box and PM_{10} & $PM_{2.5}$ and TSPM samples were stored in filter cassettes and sent to the NBRO laboratory for the analysis. During the sampling period, the factory was functioning at its normal working conditions.

The laboratory received samples on 21st December 2017 in satisfactory condition. They were analysed on the same day for the NO_2 & SO_2. PM_{10}, $PM_{2.5}$ and TSPM were analysed on 26th December 2017 after drying to a constant weight in a desiccator. Sampling and analytical method used are given in Table 2.

4.3 SAMPLING AND ANALYTICAL METHODOLOGY:

Table 02: Description of the Sampling & Analytical methods used for each parameter

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
SO_2	ASTM D 2914 - 78, 1987 West-Gaek & Pararosaniline Spectrometric method	4 μg/m^3 (0.0015 ppm)	Pararosaniline method or equivalent (pulsed fluorescent method)	*Standard Personal Air Samplers * UV-Visible Spectrophotometer
NO_2	ASTM D 1607 - 76, 1987, Griess – Saltzman Reaction Method	4 μg/m^3 (0.002 ppm)	Colorimetric using Saltzman method or equivalent (gas phase Chemiluminescence)	*Standard Personal Air Samplers * UV – Visible Spectrophotometer
TSPM	ASTM D 4096 - 82, 1997 High - Volume Sampling and Gravimetric Analysis	2 μg/m^3	Hi - volume sampling, and Gravimetric	* High Volume Sampler * Sartorius analytical balance
CO	Non - dispersive infrared Spectrometric method	1 ppm (1140 μg/m^3)	Non - dispersive infrared(IR) spectroscopy	*REAIAQ analyser
PM10 & PM2.5	ASTM D 4096 - 82, 1997 High - Volume Sampling and Gravimetric Analysis	2 μg/m^3	Hi - volume sampling, and Gravimetric	* High Volume Sampler with size selective sample inlet * Sartorius analytical balance

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Table 02: Cont…

4.4 AMBIENT AIR QUALITY MONITORING RESULTS:

Table 03: Concentration of each parameter for ambient air quality monitoring locations

Parameter	Date of Sampling	Date of Analysis	Time Average	Units	Concentrations at each location L1
SO_2	21/12/2017	21/12/2017	1 hr	μg/m^3	14
NO_2	21/12/2017	21/12/2017	1 hr	μg/m^3	35
CO	21/12/2017	21/12/2017	1 hr	μg/m^3	<1000
TSPM	21/12/2017	26/12/2017	3 hrs	μg/m^3	42
PM_{10}	20-21/12/2017	26/12/2017	24 hrs	μg/m^3	25
$PM_{2.5}$	20-21/12/2017	26/12/2017	24 hrs	μg/m^3	14

Cont......4

4.5 AMBIENT AIR QUALITY STANDARDS

Table 04a: Ambient Air Quality Standards stipulated under the Extraordinary Gazette, No. 1562/22 – August 15, 2008, by the Ministry of Environment and Natural Resources of Sri Lanka

POLLUTANT	TIMEAVERAGE	CONCENTRATION (µg/m^3)
SO_2	1 hr	200
NO_2	1 hr	250
CO	1 hr	30,000
PM_{10}	24 hr	100
$PM_{2.5}$	24 hr	50

Table 04b: The Interim fugitive dust emission standards levels for TSPM between two simultaneous 3 hours measurement at upwind and downwind stipulated by the Central Environmental Authority of Sri Lanka

Pollutant	Average Time	Concentration (µg/m^3)
TSPM	3 hour	450

5.0 CONCLUSIONS:

Measured ambient air quality levels with respect to measured parameters at all locations were lower than the Ambient Air Quality Standards stipulated by the Ministry of Environment & Natural Resources of Sri Lanka (Extraordinary Gazette No. 1562/22, August 15, 2008).

Total Suspended Particulate Matter level in downwind direction of the project area itself was well below the Interim Source Emission Standard levels for TSPM level (450 µg/Nm^3) stipulated by the Central Environmental Authority of Sri Lanka.

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H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

……………………..
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Ambient Air Quality monitoring locations

L1- At a location, close to the front boundary of the disposal site, near to the fence

NBRO/ENV/26201/2017/275a
AQP/2017/275a

28th June 2018

Client:

Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF AMBIENT AIR QUALITY LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA

(CONSTRUCTION STAGE - JUNE 2018)

1.0 SCOPE:

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor ambient air quality levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the air sampling programme on 04th & 05th June 2018.

Staff involved:

Mr. Prabath Liyanaarachchi - Scientist - ESSD, NBRO
Mr. N Krishnamoorthy - Field Assistant - ESSD, NBRO
Mr. A S Premarathne - Field Assistant - ESSD, NBRO
Mr. Gayan Indika - Field Assistant - ESSD, NBRO

***Witness**: Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor the ambient air quality levels during the construction stage.

Cont……2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 MONITORING OF AMBIENT AIR QUALITY

4.1 SELECTION OF MONITORING LOCATIONS

Air samples were collected from one (01) selected location around the disposal site area as per the client's requirement. Location description is given in Table 1 and attached layout plan.

Table 01: Location description of air quality measurements

Location No.	Location Description	GPS Coordinates
L1	At a location, close to the front boundary of the disposal site, near to the fence	6^0 22′ 13.99″ N 81^0 18′ 23.86″ E

4.2 SAMPLING AND ANALYTICAL CONDITIONS:

Air samples were collected from a selected location as per the methods stipulated in National Ambient Air Quality Standards on one (01) hour basis for the analysis of Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) on 24-hours and Total Suspended Particulate Matter (TSPM) on three (03) hour basis. The sampling receiver height was about 3 m from the ground level and sampling rates were 0.5 l/min for SO_2 and NO_2, 1.0 l/min for CO analysis and sampling rate for PM_{10} and TSPM analysis was 1.0 m^3/min and at 16 l/min for $PM_{2.5}$. One-hour average CO levels were taken as onsite measurements. Samples collected for the analysis of SO_2 and NO_2 were stored in a cooling box and PM_{10} & $PM_{2.5}$ and TSPM samples were stored in filter cassettes and sent to the NBRO laboratory for the analysis. During the sampling period, the factory was functioning at its normal working conditions.

The laboratory received samples on 05th June 2018 in satisfactory condition. They were analysed on the same day for the NO_2 & SO_2. PM_{10}, $PM_{2.5}$ and TSPM were analysed on 8th June 2018 after drying to a constant weight in a desiccator. Sampling and analytical method used are given in Table 2.

4.3 SAMPLING AND ANALYTICAL METHODOLOGY:

Table 02: Description of the Sampling & Analytical methods used for each parameter

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
SO_2	ASTM D 2914 – 95, 2015 West-Geake & Pararosaniline Spectrometric method	4 µg/m^3 (0.0015 ppm)	Pararosaniline method or equivalent (pulsed fluorescent method)	*Standard Personal Air Samplers * UV-Visible Spectrophotometer

Cont……3

Table 02: Cont…

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
NO_2	ASTM D 1607 - 91, 2011, Griess – Saltzman Reaction Method	4 µg/m^3 (0.002 ppm)	Colorimetric using Saltzman method or equivalent (gas phase Chemiluminescence)	*Standard Personal Air Samplers * UV – Visible Spectrophotometer
CO	ASTM D 3162 – 12, 2012 Non - dispersive infrared Spectrometric method	1.0 mg/m^3 (1 ppm)	Non - dispersive infrared(IR) spectroscopy	Riken Keiki CO Detector Model - CO-7
TSPM	ASTM D 4096-17, 2017 High-Volume Sampler method and Gravimetric Analysis	0.002 mg/m^3	Hi-volume sampling and gravimetric	High volume sampler Sartorius analytical balance
PM_{10} & $PM_{2.5}$	ASTM D 4096 - 82, 2017 High - Volume Sampling and Gravimetric Analysis	2 µg/m^3	Hi - volume sampling, and Gravimetric	* High Volume Sampler with size selective sample inlet * Sartorius analytical balance

4.4 AMBIENT AIR QUALITY MONITORING RESULTS:

Table 03: Concentration of each parameter for ambient air quality monitoring location

Parameter	Date of Sampling	Date of Analysis	Time Average	Units	Concentrations at location L1
SO_2	05/06/2018	05/06/2018	1 hr	µg/m^3	21
NO_2	05/06/2018	05/06/2018	1 hr	µg/m^3	30
CO	05/06/2018	05/06/2018	1 hr	µg/m^3	<1000
TSPM	05/06/2018	07/06/2018	3 hrs	µg/m^3	47
PM_{10}	04-05/06/2018	08/06/2018	24 hrs	µg/m^3	28
$PM_{2.5}$	04-05/06/2018	08/06/2018	24 hrs	µg/m^3	15

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4.5 AMBIENT AIR QUALITY STANDARDS

Table 04a: Ambient Air Quality Standards stipulated under the Extraordinary Gazette, No. 1562/22 – August 15, 2008, by the Ministry of Environment and Natural Resources of Sri Lanka

POLLUTANT	TIMEAVERAGE	CONCENTRATION (µg/m^3)
SO_2	1 hr	200
NO_2	1 hr	250
CO	1 hr	30,000
PM_{10}	24 hr	100
$PM_{2.5}$	24 hr	50

Table 04b: The Interim fugitive dust emission standards levels for TSPM between two simultaneous 3 hours measurement at upwind and downwind stipulated by the Central Environmental Authority of Sri Lanka

Pollutant	Average Time	Concentration (µg/m^3)
TSPM	3 hours	450

5.0 CONCLUSIONS:

Measured ambient air quality levels with respect to measured parameters at location L1 were lower than the Ambient Air Quality Standards stipulated by the Ministry of Environment & Natural Resources of Sri Lanka (Extraordinary Gazette No. 1562/22, August 15, 2008).

Total Suspended Particulate Matter level in downwind direction of the project area itself was well below the Interim Source Emission Standard levels for TSPM level (450 µg/Nm^3) stipulated by the Central Environmental Authority of Sri Lanka.

……………………………….
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

………………………………….
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

NBRO/ENV/26201/2017/275a
AQP/2017/275a

Ambient Air Quality monitoring locations

L1- At a location, close to the front boundary of the disposal site, near to the fence

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NBRO/ENV/26201/2018/320a
AQP/2018/320a

12th December 2018

Client: Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF AMBIENT AIR QUALITY LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA

(CONSTRUCTION STAGE - NOVEMBER 2018)

1.0 SCOPE:

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor ambient air quality levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the air sampling programme on 26th & 27th November 2018.

Staff involved:

Mr. Viran Daniel	*- Technical Assistant*	*- ESSD, NBRO*
Mr. W A Weerasinghe	*- Field Assistant*	*- ESSD, NBRO*
Mr. A S Premarathne	*- Field Assistant*	*- ESSD, NBRO*

***Witness**: Mr. Layan Gunasekara – Coordinator - ReEB Waste treatment Project*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor the ambient air quality levels during the construction stage.

Cont……2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 MONITORING OF AMBIENT AIR QUALITY

4.1 SELECTION OF MONITORING LOCATIONS

Air samples were collected from one (01) selected location around the disposal site area as per the client’s requirement. Location description is given in Table 1 and attached layout plan.

Table 01: Location description of air quality measurements

Location No.	Location Description	GPS Coordinates
L1	At a location, close to the front boundary of the disposal site, near to the fence	6^0 22’ 13.99” N 81^0 18’ 23.86” E

4.2 SAMPLING AND ANALYTICAL CONDITIONS:

Air samples were collected from a selected location as per the methods stipulated in National Ambient Air Quality Standards on one (01) hour basis for the analysis of Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Particulate Matter (PM_{10} & $PM_{2.5}$) on 24-hours and Total Suspended Particulate Matter (TSPM) on three (03) hour basis. The sampling receiver height was about 3 m from the ground level and sampling rates were 0.5 l/min for SO_2 and NO_2, 1.0 l/min for CO analysis and sampling rate for PM_{10} and TSPM analysis was 1.0 m^3/min and at 16 l/min for $PM_{2.5}$. One-hour average CO levels were taken as onsite measurements. Samples collected for the analysis of SO_2 and NO_2 were stored in a cooling box and PM_{10} & $PM_{2.5}$ and TSPM samples were stored in filter cassettes and sent to the NBRO laboratory for the analysis. During the sampling period, the factory was functioning at its normal working conditions.

The laboratory received samples on 27th November 2018 in satisfactory condition. They were analysed on the same day for the NO_2 & SO_2. PM_{10}, $PM_{2.5}$ and TSPM were analysed on 30th November 2018 after drying to a constant weight in a desiccator. Sampling and analytical method used are given in Table 2.

4.3 SAMPLING AND ANALYTICAL METHODOLOGY:

Table 02: Description of the Sampling & Analytical methods used for each parameter

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
SO_2	ASTM D 2914 – 95, 2015 West-Geake & Pararosaniline Spectrometric method	4 µg/m^3 (0.0015 ppm)	Pararosaniline method or equivalent (pulsed fluorescent method)	*Standard Personal Air Samplers * UV-Visible Spectrophotometer

Cont......3

Table 02: Cont…

Parameter	Testing Method	Minimum Detection Limits	CEA Recommended method	Instrumentation
NO_2	ASTM D 1607 - 91, 2011, Griess – Saltzman Reaction Method	4 µg/m^3 (0.002 ppm)	Colorimetric using Saltzman method or equivalent (gas phase Chemiluminescence)	*Standard Personal Air Samplers * UV – Visible Spectrophotometer
CO	ASTM D 3162 – 12, 2012 Non - dispersive infrared Spectrometric method	1.0 mg/m^3 (1 ppm)	Non - dispersive infrared(IR) spectroscopy	Riken Keiki CO Detector Model - CO-7
TSPM	ASTM D 4096-17, 2017 High-Volume Sampler method and Gravimetric Analysis	0.002 mg/m^3	Hi-volume sampling and gravimetric	High volume sampler Sartorius analytical balance
PM_{10} & $PM_{2.5}$	ASTM D 4096 - 82, 2017 High - Volume Sampling and Gravimetric Analysis	2 µg/m^3	Hi - volume sampling, and Gravimetric	* High Volume Sampler with size selective sample inlet * Sartorius analytical balance

4.4 AMBIENT AIR QUALITY MONITORING RESULTS:

Table 03: Concentration of each parameter for ambient air quality monitoring location

Parameter	Date of Sampling	Date of Analysis	Time Average	Units	Concentrations at location L1
SO_2	26/11/2018	26/11/2018	1 hr	µg/m^3	11
NO_2	26/11/2018	26/11/2018	1 hr	µg/m^3	20
CO	26/11/2018	26/11/2018	1 hr	µg/m^3	<1000
TSPM	26/11/2018	26/11/2018	3 hrs	µg/m^3	107
PM_{10}	25-26/11/2018	30/11/2018	24 hrs	µg/m^3	64
$PM_{2.5}$	25-26/11/2018	30/11/2018	24 hrs	µg/m^3	35

Cont......4

4.5 AMBIENT AIR QUALITY STANDARDS

Table 04a: Ambient Air Quality Standards stipulated under the Extraordinary Gazette, No. 1562/22 – August 15, 2008, by the Ministry of Environment and Natural Resources of Sri Lanka

POLLUTANT	TIMEAVERAGE	CONCENTRATION (μg/m^3)
SO_2	1 hr	200
NO_2	1 hr	250
CO	1 hr	30,000
PM_{10}	24 hr	100
$PM_{2.5}$	24 hr	50

Table 04b: The Interim fugitive dust emission standards levels for TSPM between two simultaneous 3 hours measurement at upwind and downwind stipulated by the Central Environmental Authority of Sri Lanka

Pollutant	Average Time	Concentration (μg/m^3)
TSPM	3 hours	450

5.0 CONCLUSIONS:

Measured ambient air quality levels with respect to measured parameters at location L1 were lower than the Ambient Air Quality Standards stipulated by the Ministry of Environment & Natural Resources of Sri Lanka (Extraordinary Gazette No. 1562/22, August 15, 2008).

Total Suspended Particulate Matter level in downwind direction of the project area itself was well below the Interim Source Emission Standard levels for TSPM level (450 μg/Nm^3) stipulated by the Central Environmental Authority of Sri Lanka.

…………………………….
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

…………………………………
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Ambient Air Quality monitoring locations

L1- At a location, close to the front boundary of the disposal site, near to the fence

NBRO/ENV/26201/2017/166c
AQP/2017/166c

18th August 2017

Client: Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF BASELINE VIBRATION LEVELS AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA

(JULY 2017)

1.0 SCOPE

As per the letter dated on 30th May 2017, by the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, No. 104, Denzil Kobbekaduwa Mawatha, Battaramulla Ltd. to the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) was requested to monitor baseline vibration levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions before start the project activities of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the vibration monitoring program on 13th July 2017.

Staff involved:

Mr. Manjula Dissanayake	*- Scientist*	*- ESSD, NBRO*
Mr. Prabath Liyanaarachchi	*- Scientist*	*- ESSD, NBRO*
Mr. W A Weerasinghe	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Mr. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Naofumi Sato - EX Research Institute Ltd.

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor baseline vibration levels at the project area before staring the project activities.

Cont.......2

3.0 VIBRATION MEASUREMENTS

4.1 DESCRIPTION OF MEASURING LOCATIONS

Three locations within the study area were selected as per the client's requirement. The measuring location description is given in Table 1 and refer attached figure for more information. Structures at all selected locations can be categorized as type 3 structures as per the interim vibration levels stipulated by the Central Environmental Authority of Sri Lanka.

3.2 METHOD OF MEASUREMENTS

Continuous vibration levels were recorded at selected locations in accordance with the methods laid down in International Organisation for Standardization - ISO - 4966: 1990E, as stipulated in the interim vibration standard stipulated by the Central Environmental Authority of Sri Lanka.

3.3 MEASURING INSTRUMENTS

Vibration meter	: Instantel BlastMate III
Calibration due	: December 2017
Minimum Detection Limit	: PPV of 0.07 mm/s

3.4 MEASURING CONDITIONS

Continuous 5 minutes vibration levels (peak particulate velocity levels) were recorded selected locations within the selected area. The recording time of the instrument is 30 sec. at 1024 sps in continuous mode and at geo range of 254 mm/s.

3.5 VIBRATION MONITORING LOCATIONS

Table 01: Details of Vibration Monitoring Locations

Location No.	Location Description	GPS Coordinates
V1	At a location, close to the north west boundary of the disposal site	07°30'55.0"N 080°21'13.3"E
V2	At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.	07°30'50.2"N 080°21'16.0"E
V3	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.	07°30'45.8"N 080°21'16.9"E

Cont....3

3.5 VIBRATION MOINTORING RESULTS :

Table 02: Maximum Vibration levels at each measuring location

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V_1	Transgenic	0.063	0.141	10-50
	Vertical	0.102		
	Longitude	0.110		
V_2	Transgenic	0.063	0.158	10-50
	Vertical	0.126		
	Longitude	0.126		
V_2	Transgenic	0.166	0.235	10-50
	Vertical	0.205		
	Longitude	0.150		

4.6 MAXIMUM PERMISSIBLE VALUES

Table 03. The interim standard on vibration for the Machinery, Construction Activities and Vehicular Movements stipulated by the Central Environmental Authority of Sri Lanka for different type of structures summaries below.

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 1 structures – Multi story buildings of reinforced concrete or structural steel, with filling panels of block work, brick work or precast units not designed to resist earthquakes	Continuous	0 - 10	5.0
		10 - 50	7.5
		Over 50	15.0
	Intermittent	0 - 10	10.0
		10 - 50	15.0
		Over 50	30.0
Type 2 structures – Two-storey domestic houses and buildings constructed of made of reinforced block work, precast units, and reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.	Continuous	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
	Intermittent	0 - 10	4.0
		10 - 50	8.0
		Over 50	16.0
Type 3 structures – Single and two storey houses and buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.	Continuous	0 - 10	1.0
		10 - 50	2.0
		Over 50	4.0
	Intermittent	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
Type 4 structures – Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3, & declared as archeologically preserved structures by the Department of Archaeology	Continuous	0 - 10	0.25
		10 - 50	0.5
		Over 50	1.0
	Intermittent	0 - 10	0.5
		10 - 50	1.0
		Over 50	2.0

Cont....4

5.0 CONCLUSION:

The measured baseline vibration levels at the frequency range given in table 2, were lower than the vibration levels stipulated for any type of structures in the Interim Vibration Standard stipulated by the Central Environmental Authority of Sri Lanka.

……………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

……………………..
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

NBRO/ENV/26201/2017/166c
AQP/2017/166c

Vibration monitoring locations

	
V1- At a location, close to the north west boundary of the disposal site	**V2-** At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.
	**V3-** At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2017/166c
AQP/2017/166c

4th September 2018

Client:
Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF VIBRATION LEVELS AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA

(AUGUST2018)

1.0 SCOPE

As per the letter dated 30th May 2017 the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor vibration levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions of the project area during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the vibration monitoring program on 08th August 2018.

Staff involved:

Mr. D R Rathnayaka	*- Technical Officer*	*- ESSD, NBRO*
Mr. N Krishnamoorthy	*- Field Assistant*	*- ESSD, NBRO*
Mr. Ranil Jayawardhana	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Nuwan – Site Supervisor

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor vibration levels at the project area during the construction stage.

Cont.......2

3.0 VIBRATION MEASUREMENTS

4.1 DESCRIPTION OF MEASURING LOCATIONS

Three locations within the study area were selected as per the client's requirement. The measuring location description is given in Table 1 and refer attached figure for more information. Structures at all selected locations can be categorized as type 3 structures as per the interim vibration levels stipulated by the Central Environmental Authority of Sri Lanka.

3.2 METHOD OF MEASUREMENTS

Continuous vibration levels were recorded at selected locations in accordance with the methods laid down in International Organisation for Standardization - ISO - 4966: 1990E, as stipulated in the interim vibration standard stipulated by the Central Environmental Authority of Sri Lanka.

3.3 MEASURING INSTRUMENTS

Vibration meter	: Micromate ISEE Base unit
Model	: Instantel Part No. 721A2501
Serial No	: UM10585
Calibration due	: December 2018
Minimum Detection Limit	: PPV of 0.07 mm

3.4 MEASURING CONDITIONS

Continuous 5 minutes vibration levels (peak particulate velocity levels) were recorded selected locations within the selected area. The recording time of the instrument is 30 sec. at 1024 sps in continuous mode and at geo range of 254 mm/s.

3.5 VIBRATION MONITORING LOCATIONS

Table 01: Details of Vibration Monitoring Locations

Location	GPS Coordinates	Location Description
V1	07°30'55.0"N 080°21'13.3"E	At a location, close to the north west boundary of the disposal site
V2	07°30'31"N 080°21'9"E	At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
V3	07°30'45.8"N 080°21'16.9"E	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

Cont....3

3.5 VIBRATION MOINTORING RESULTS:

Table 02: Maximum Vibration levels at each measuring location

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V$_1$	Transgenic	0.166	0.225	10-50
	Vertical	0.189		
	Longitude	0.205		
V$_2$	Transgenic	0.118	0.239	10-50
	Vertical	0.221		
	Longitude	0.134		
V$_2$	Transgenic	0.063	0.135	10-50
	Vertical	0.126		
	Longitude	0.102		

4.6 MAXIMUM PERMISSIBLE VALUES

Table 03. The interim standard on vibration for the Machinery, Construction Activities and Vehicular Movements stipulated by the Central Environmental Authority of Sri Lanka for different type of structures summaries below.

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 1 structures – Multi story buildings of reinforced concrete or structural steel, with filling panels of block work, brick work or precast units not designed to resist earthquakes	Continuous	0 - 10	5.0
		10 - 50	7.5
		Over 50	15.0
	Intermittent	0 - 10	10.0
		10 - 50	15.0
		Over 50	30.0
Type 2 structures – Two-storey domestic houses and buildings constructed of made of reinforced block work, precast units, and reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.	Continuous	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
	Intermittent	0 - 10	4.0
		10 - 50	8.0
		Over 50	16.0
Type 3 structures – Single and two storey houses and buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.	Continuous	0 - 10	1.0
		10 - 50	2.0
		Over 50	4.0
	Intermittent	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0

Cont....4

Table 03. Cont………

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 4 structures – Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3, & declared as archeologically preserved structures by the Department of Archaeology	Continuous	0 - 10	0.25
		10 - 50	0.5
		Over 50	1.0
	Intermittent	0 - 10	0.5
		10 - 50	1.0
		Over 50	2.0

5.0 CONCLUSION:

The measured vibration levels at the frequency range given in table 2, were lower than the vibration levels stipulated for any type of structures in the Interim Vibration Standard stipulated by the Central Environmental Authority of Sri Lanka.

………………………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

………………………………………
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Vibration monitoring locations

V1- At a location, close to the north west boundary of the disposal site

V2- At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

V3- At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

Appendix 14

NBRO/ENV/26201/2017/166c
AQP/2017/166c

4th September 2018

Client: Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON THE MONITORING OF VIBRATION LEVELS AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA

(AUGUST2018)

1.0 SCOPE

As per the letter dated 30th May 2017 the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor vibration levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions of the project area during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the vibration monitoring program on 08th August 2018.

Staff involved:

Mr. D R Rathnayaka	*- Technical Officer*	*- ESSD, NBRO*
Mr. N Krishnamoorthy	*- Field Assistant*	*- ESSD, NBRO*
Mr. Ranil Jayawardhana	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Nuwan – Site Supervisor

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor vibration levels at the project area during the construction stage.

Cont.......2

3.0 VIBRATION MEASUREMENTS

4.1 DESCRIPTION OF MEASURING LOCATIONS

Three locations within the study area were selected as per the client's requirement. The measuring location description is given in Table 1 and refer attached figure for more information. Structures at all selected locations can be categorized as type 3 structures as per the interim vibration levels stipulated by the Central Environmental Authority of Sri Lanka.

3.2 METHOD OF MEASUREMENTS

Continuous vibration levels were recorded at selected locations in accordance with the methods laid down in International Organisation for Standardization - ISO - 4966: 1990E, as stipulated in the interim vibration standard stipulated by the Central Environmental Authority of Sri Lanka.

3.3 MEASURING INSTRUMENTS

Vibration meter	: Micromate ISEE Base unit
Model	: Instantel Part No. 721A2501
Serial No	: UM10585
Calibration due	: December 2018
Minimum Detection Limit	: PPV of 0.07 mm

3.4 MEASURING CONDITIONS

Continuous 5 minutes vibration levels (peak particulate velocity levels) were recorded selected locations within the selected area. The recording time of the instrument is 30 sec. at 1024 sps in continuous mode and at geo range of 254 mm/s.

3.5 VIBRATION MONITORING LOCATIONS

Table 01: Details of Vibration Monitoring Locations

Location	GPS Coordinates	Location Description
V1	07°30'55.0"N 080°21'13.3"E	At a location, close to the north west boundary of the disposal site
V2	07°30'31"N 080°21'9"E	At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
V3	07°30'45.8"N 080°21'16.9"E	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

Cont....3

3.5 VIBRATION MOINTORING RESULTS:

Table 02: Maximum Vibration levels at each measuring location

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V_1	Transgenic	0.166	0.225	10-50
	Vertical	0.189		
	Longitude	0.205		
V_2	Transgenic	0.118	0.239	10-50
	Vertical	0.221		
	Longitude	0.134		
V_2	Transgenic	0.063	0.135	10-50
	Vertical	0.126		
	Longitude	0.102		

4.6 MAXIMUM PERMISSIBLE VALUES

Table 03. The interim standard on vibration for the Machinery, Construction Activities and Vehicular Movements stipulated by the Central Environmental Authority of Sri Lanka for different type of structures summaries below.

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 1 structures – Multi story buildings of reinforced concrete or structural steel, with filling panels of block work, brick work or precast units not designed to resist earthquakes	Continuous	0 - 10	5.0
		10 - 50	7.5
		Over 50	15.0
	Intermittent	0 - 10	10.0
		10 - 50	15.0
		Over 50	30.0
Type 2 structures – Two-storey domestic houses and buildings constructed of made of reinforced block work, precast units, and reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.	Continuous	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
	Intermittent	0 - 10	4.0
		10 - 50	8.0
		Over 50	16.0
Type 3 structures – Single and two storey houses and buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.	Continuous	0 - 10	1.0
		10 - 50	2.0
		Over 50	4.0
	Intermittent	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0

Cont....4

Table 03. Cont.........

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 4 structures – Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3, & declared as archeologically preserved structures by the Department of Archaeology	Continuous	0 - 10	0.25
		10 - 50	0.5
		Over 50	1.0
	Intermittent	0 - 10	0.5
		10 - 50	1.0
		Over 50	2.0

5.0 CONCLUSION:

The measured vibration levels at the frequency range given in table 2, were lower than the vibration levels stipulated for any type of structures in the Interim Vibration Standard stipulated by the Central Environmental Authority of Sri Lanka.

……………………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

……………………………
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

NBRO/ENV/26201/2017/166c
AQP/2017/166c

Vibration monitoring locations

	
V1- At a location, close to the north west boundary of the disposal site	**V2-** At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.
	**V3-** At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2018/319c
AQP/2018/319c

12th December 2018

Client: Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF VIBRATION LEVELS AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA
(CONSTRCUTION STAGE - NOVEMBER 2018)

1.0 SCOPE

As per the letter dated 30th May 2017 the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor vibration levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions of the project area during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the vibration monitoring program on 28th November 2018.

Staff involved:

Mr. Nilanka Ranaweera - Technical Officer - ESSD, NBRO
Mr. W A Weerasinghe - Field Assistant - ESSD, NBRO
Mr. Ranil Jayawardhana - Field Assistant - ESSD, NBRO

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Nuwan – Site Supervisor

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor vibration levels at the project area during the construction stage.

Cont.......2

3.0 VIBRATION MEASUREMENTS

3.1 DESCRIPTION OF MEASURING LOCATIONS

Three locations within the study area were selected as per the client's requirement. The measuring location description is given in Table 1 and refer attached figure for more information. Structures at all selected locations can be categorized as type 3 structures as per the interim vibration levels stipulated by the Central Environmental Authority of Sri Lanka.

3.2 METHOD OF MEASUREMENTS

Continuous vibration levels were recorded at selected locations in accordance with the methods laid down in International Organisation for Standardization - ISO - 4966: 1990E, as stipulated in the interim vibration standard stipulated by the Central Environmental Authority of Sri Lanka.

3.3 MEASURING INSTRUMENTS

Vibration meter	: Micromate ISEE Base unit
Model	: Instantel Part No. 721A2501
Serial No	: UM10585
Calibration due	: December 2018
Minimum Detection Limit	: PPV of 0.07 mm

3.4 MEASURING CONDITIONS

Continuous 5 minutes vibration levels (peak particulate velocity levels) were recorded selected locations within the selected area. The recording time of the instrument is 30 sec. at 1024 sps in continuous mode and at geo range of 254 mm/s.

3.5 VIBRATION MONITORING LOCATIONS

Table 01: Details of Vibration Monitoring Locations

Location	GPS Coordinates	Location Description
V1	07°30'55.0"N 80°21'13.3"E	At a location, close to the north west boundary of the disposal site
V2	07°30'31"N 80°21'09"E	At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
V3	07°30'45.8"N 080°21'16.9"E	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

Cont....3

3.5 VIBRATION MOINTORING RESULTS:

Table 02: Maximum Vibration levels at each measuring location

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V1	Transgenic	0.142	0.182	10-50
	Vertical	0.087		
	Longitude	0.110		
V2	Transgenic	0.150	0.175	10-50
	Vertical	0.087		
	Longitude	0.102		
V2	Transgenic	0.104	0.154	10-50
	Vertical	0.095		
	Longitude	0.118		

4.6 MAXIMUM PERMISSIBLE VALUES

Table 03. The interim standard on vibration for the Machinery, Construction Activities and Vehicular Movements stipulated by the Central Environmental Authority of Sri Lanka for different type of structures summaries below.

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 1 structures – Multi story buildings of reinforced concrete or structural steel, with filling panels of block work, brick work or precast units not designed to resist earthquakes	Continuous	0 - 10	5.0
		10 - 50	7.5
		Over 50	15.0
	Intermittent	0 - 10	10.0
		10 - 50	15.0
		Over 50	30.0
Type 2 structures – Two-storey domestic houses and buildings constructed of made of reinforced block work, precast units, and reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.	Continuous	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
	Intermittent	0 - 10	4.0
		10 - 50	8.0
		Over 50	16.0
Type 3 structures – Single and two storey houses and buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.	Continuous	0 - 10	1.0
		10 - 50	2.0
		Over 50	4.0
	Intermittent	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0

Cont....4

14–10

Table 03. Cont………

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 4 structures – Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3, & declared as archeologically preserved structures by the Department of Archaeology	Continuous	0 - 10	0.25
		10 - 50	0.5
		Over 50	1.0
	Intermittent	0 - 10	0.5
		10 - 50	1.0
		Over 50	2.0

5.0 CONCLUSION:

The measured vibration levels at the frequency range given in table 2, were lower than the vibration levels stipulated for any type of structures in the Interim Vibration Standard stipulated by the Central Environmental Authority of Sri Lanka.

………………………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

……………………………………
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Vibration monitoring locations

	
V1- At a location, close to the north west boundary of the disposal site	**V2-** At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.
	**V3-** At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

Appendix14

NBRO/ENV/26201/2017/275c
AQP/2017/275c

30th January 2017

Client: Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF BASELINE VIBRATION LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA
(DECEMBER 2017)

1.0 SCOPE

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, No. 104, Denzil Kobbekaduwa Mawatha, Battaramulla requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor baseline vibration levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions before start the project activities of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the vibration monitoring program on 21st December 2017.

Staff involved:

Mr. Prabath Liyanaarachchi	*- Scientist*	*- ESSD, NBRO*
Mr. D R Rathnayake	*- Technical Officer*	*- ESSD, NBRO*
Mr. W A Weerasinghe	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated.This monitoring programme is scheduled to monitor baseline vibration levels at the project area before staring the project activities.

Cont.......2

NBRO/ENV/26201/2017/275c
AQP/2017/275c

3.0 VIBRATION MEASUREMENTS

3.1 DESCRIPTION OF MEASURING LOCATIONS

Four locations within the study area were selected as per the client’s requirement. The measuring location description is given in Table 1 and refer attached figure for more information. Structures at all selected locations can be categorized as type 3 structures as per the interim vibration levels stipulated by the Central Environmental Authority of Sri Lanka.

3.2 METHOD OF MEASUREMENTS

Continuous vibration levels were recorded at selected locations in accordance with the methods laid down in International Organisation for Standardization - ISO - 4966: 1990E, as stipulated in the interim vibration standard stipulated by the Central Environmental Authority of Sri Lanka.

3.3 MEASURING INSTRUMENTS

Vibration meter	: Instantel BlastMate III
Calibration due	: June 2018
Minimum Detection Limit	: PPV of 0.07 mm/s

3.4 MEASURING CONDITIONS

Continuous 5 minutes vibration levels (peak particulate velocity levels) were recorded selected locations within the selected area. The recording time of the instrument is 30 sec. at 1024 sps in continuous mode and at geo range of 254 mm/s.

3.5 VIBRATION MONITORING LOCATIONS

Table 01: Details of Vibration Monitoring Locations

Location No.	Location Description	GPS Coordinates
V1	At a location, close to the entrance of the compost production site	6^0 23’ 13.35” N 81^0 18’ 23.40” E
V2	At a location, close to the existing waste disposal site	6^0 23’ 23.69” N 81^0 17’ 57.73” E
V3	At a location, close to the proposed waste disposal site	6^0 23’ 24.46” N 81^0 17’ 35.28” E
V4	At a location, close to the staff dressing room at waste disposal site	6^0 23’ 13.90” N 81^0 18’ 24.32” E

3.6 VIBRATION MOINTORING RESULTS :

Table 02: Maximum Vibration levels at each measuring location

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V_1	Transgenic	0.079	0.104	10-50
	Vertical	0.055		
	Longitude	0.087		

Cont....3

Table 02: Cont……

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V_2	Transgenic	0.102	0.224	10-50
	Vertical	0.102		
	Longitude	0.213		
V_3	Transgenic	0.063	0.209	10-50
	Vertical	0.158		
	Longitude	0.158		
V_4	Transgenic	0.110	0.145	10-50
	Vertical	0.110		
	Longitude	0.142		

3.7 MAXIMUM PERMISSIBLE VALUES

Table 03. The interim standard on vibration for the Machinery, Construction Activities and Vehicular Movements stipulated by the Central Environmental Authority of Sri Lanka for different type of structures summaries below.

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 1 structures – Multi story buildings of reinforced concrete or structural steel, with filling panels of block work, brick work or precast units not designed to resist earthquakes	Continuous	0 - 10	5.0
		10 - 50	7.5
		Over 50	15.0
	Intermittent	0 - 10	10.0
		10 - 50	15.0
		Over 50	30.0
Type 2 structures – Two-storey domestic houses and buildings constructed of made of reinforced block work, precast units, and reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.	Continuous	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
	Intermittent	0 - 10	4.0
		10 - 50	8.0
		Over 50	16.0
Type 3 structures – Single and two storey houses and buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.	Continuous	0 - 10	1.0
		10 - 50	2.0
		Over 50	4.0
	Intermittent	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
Type 4 structures – Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3, & declared as archeologically preserved structures by the Department of Archaeology	Continuous	0 - 10	0.25
		10 - 50	0.5
		Over 50	1.0
	Intermittent	0 - 10	0.5
		10 - 50	1.0
		Over 50	2.0

Cont....4

4.0 CONCLUSION:

The measured baseline vibration levels at the frequency range given in table 2, were lower than the vibration levels stipulated for any type of structures in the Interim Vibration Standard stipulated by the Central Environmental Authority of Sri Lanka.

……………………	……………………..
H.D.S. Premasiri	S.V. Dias
Coordinator / Air Quality	Director
Environmental Studies & Services Division	Environmental Studies & Services Division
National Building Research Organization	National Building Research Organization

Vibration monitoring locations

	
V1- At a location, close to the entrance of the compost production site	**V2**-At a location, close to the existing waste disposal site
	
V3- At a location, close to the proposed waste disposal site	**V4**-At a location, close to the staff dressing room at waste disposal site

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NBRO/ENV/26201/2017/275c
AQP/2017/275c

28th June 2018

Client: Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF VIBRATION LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA
(CONSTRUCTION STAGE - JUNE 2018)

1.0 SCOPE

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor vibration levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the vibration monitoring program on 05th June 2018.

Staff involved:

Mr. Prabath Liyanaarachchi - Scientist - ESSD, NBRO
Mr. N Krishnamoorthy - Field Assistant - ESSD, NBRO
Mr. A S Premarathne - Field Assistant - ESSD, NBRO
Mr. Gayan Indika - Field Assistant - ESSD, NBRO

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated.This monitoring programme is scheduled to monitor vibration levels at the project area during the construction stage.

Cont.....2

3.0 VIBRATION MEASUREMENTS

3.1 DESCRIPTION OF MEASURING LOCATIONS

Four locations within the study area were selected as per the client’s requirement. The measuring location description is given in Table 1 and refer attached figure for more information. Structures at all selected locations can be categorized as type 3 structures as per the interim vibration levels stipulated by the Central Environmental Authority of Sri Lanka.

3.2 METHOD OF MEASUREMENTS

Continuous vibration levels were recorded at selected locations in accordance with the methods laid down in International Organisation for Standardization - ISO - 4966: 1990E, as stipulated in the interim vibration standard stipulated by the Central Environmental Authority of Sri Lanka.

3.3 MEASURING INSTRUMENTS

Vibration meter : Micromate ISEE Base unit
Model : Instantel Part No. 721A2501
Serial No : UM10585
Calibration due : December 2018
Minimum Detection Limit : PPV of 0.07 mm/s

3.4 MEASURING CONDITIONS

Continuous 5 minutes vibration levels (peak particulate velocity levels) were recorded selected locations within the selected area. The recording time of the instrument is 30 sec. at 1024 sps in continuous mode and at geo range of 254 mm/s. It was noticed that construction activities such as heavy vehicle movements were on going during the monitoring period.

It was noticed that construction activities such as heavy vehicle movements were on going during the monitoring period.

3.5 VIBRATION MONITORING LOCATIONS

Table 01: Details of Vibration Monitoring Locations

Location No.	GPS Coordinates	Location Description
V1	6^0 23’ 13.35” N 81^0 18’ 23.40” E	At a location, close to the entrance of the compost production site
V2	6^0 23’ 23.69” N 81^0 17’ 57.73” E	At a location, close to the existing waste disposal site
V3	6^0 23’ 24.46” N 81^0 17’ 35.28” E	At a location, close to the proposed waste disposal site
V4	6^0 23’ 13.90” N 81^0 18’ 24.32” E	At a location, close to the staff dressing room at waste disposal site

Cont....3

Table 02: Maximum Vibration levels at each measuring location

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V_1	Transgenic	0.166	0.198	10-50
	Vertical	0.173		
	Longitude	0.102		
V_2	Transgenic	0.126	0.146	10-50
	Vertical	0.079		
	Longitude	0.087		
V_3	Transgenic	0.142	0.180	10-50
	Vertical	0.079		
	Longitude	0.110		
V_4	Transgenic	1.332	1.807	10-50
	Vertical	0.607		
	Longitude	1.230		

3.7 MAXIMUM PERMISSIBLE VALUES

Table 03. The interim standard on vibration for the Machinery, Construction Activities and Vehicular Movements stipulated by the Central Environmental Authority of Sri Lanka for different type of structures summaries below.

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 1 structures – Multi story buildings of reinforced concrete or structural steel, with filling panels of block work, brick work or precast units not designed to resist earthquakes	Continuous	0 - 10	5.0
		10 - 50	7.5
		Over 50	15.0
	Intermittent	0 - 10	10.0
		10 - 50	15.0
		Over 50	30.0
Type 2 structures – Two-storey domestic houses and buildings constructed of made of reinforced block work, precast units, and reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.	Continuous	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
	Intermittent	0 - 10	4.0
		10 - 50	8.0
		Over 50	16.0
Type 3 structures – Single and two storey houses and buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.	Continuous	0 - 10	1.0
		10 - 50	2.0
		Over 50	4.0
	Intermittent	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0

Cont....4

Table 03: Cont……….

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 4 structures – Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3, & declared as archeologically preserved structures by the Department of Archaeology	Continuous	0 - 10	0.25
		10 - 50	0.5
		Over 50	1.0
	Intermittent	0 - 10	0.5
		10 - 50	1.0
		Over 50	2.0

4.0 CONCLUSION:

The measured ground vibration levels at all locations were lower than the vibration levels stipulated for type 3 structures in the Interim Vibration Standard stipulated by the Central Environmental Authority of Sri Lanka.

…………………………	……………………..
H.D.S. Premasiri	S.V. Dias
Coordinator / Air Quality	Director
Environmental Studies & Services Division	Environmental Studies & Services Division
National Building Research Organization	National Building Research Organization

Vibration monitoring locations

	
V1- At a location, close to the entrance of the compost production site	**V2**-At a location, close to the existing waste disposal site
	
V3- At a location, close to the proposed waste disposal site	**V4**-At a location, close to the staff dressing room at waste disposal site

NBRO/ENV/26201/2018/320c
AQP/2018/320c

12th December 2018

Client:
Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF VIBRATION LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA
(CONSTRUCTION STAGE - NOVEMBER 2018)

1.0 SCOPE

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor vibration levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the vibration monitoring program on 26th November 2018.

Staff involved:

Mr. Viran Daniel	*- Technical Assistant*	*- ESSD, NBRO*
Mr. W A Weerasinghe	*- Field Assistant*	*- ESSD, NBRO*
Mr. A S Premarathne	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Mr. Layan Gunasekara – Coordinator - ReEB Waste treatment Project*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated.This monitoring programme is scheduled to monitor vibration levels at the project area during the construction stage.

Cont.....2

3.0 VIBRATION MEASUREMENTS

3.1 DESCRIPTION OF MEASURING LOCATIONS

Four locations within the study area were selected as per the client's requirement. The measuring location description is given in Table 1 and refer attached figure for more information. Structures at all selected locations can be categorized as type 3 structures as per the interim vibration levels stipulated by the Central Environmental Authority of Sri Lanka.

3.2 METHOD OF MEASUREMENTS

Continuous vibration levels were recorded at selected locations in accordance with the methods laid down in International Organisation for Standardization - ISO - 4966: 1990E, as stipulated in the interim vibration standard stipulated by the Central Environmental Authority of Sri Lanka.

3.3 MEASURING INSTRUMENTS

Vibration meter : Micromate ISEE Base unit
Model : Instantel Part No. 721A2501
Serial No : UM10585
Calibration due : December 2018
Minimum Detection Limit : PPV of 0.07 mm/s

3.4 MEASURING CONDITIONS

Continuous 5 minutes vibration levels (peak particulate velocity levels) were recorded selected locations within the selected area. The recording time of the instrument is 30 sec. at 1024 sps in continuous mode and at geo range of 254 mm/s. It was noticed that construction activities such as heavy vehicle movements were on going during the monitoring period.

It was noticed that construction activities such as heavy vehicle movements were on going during the monitoring period.

3.5 VIBRATION MONITORING LOCATIONS

Table 01: Details of Vibration Monitoring Locations

Location No.	GPS Coordinates	Location Description
V1	6^0 23’ 13.35” N 81^0 18’ 23.40” E	At a location, close to the entrance of the compost production site
V2	6^0 23’ 23.69” N 81^0 17’ 57.73” E	At a location, close to the existing waste disposal site
V3	6^0 23’ 24.46” N 81^0 17’ 35.28” E	At a location, close to the proposed waste disposal site
V4	6^0 23’ 13.90” N 81^0 18’ 24.32” E	At a location, close to the staff dressing room at waste disposal site

Cont....3

Table 02: Maximum Vibration levels at each measuring location

Location No.	Vibration Axis	Vibration Levels ppv (mm/sec)	Maximum Vibration in ppv (mm/sec)	Frequency Range (Hz)
V1	Transgenic	0.158	0.198	10-50
	Vertical	0.110		
	Longitude	0.118		
V2	Transgenic	0.150	0.163	10-50
	Vertical	0.095		
	Longitude	0.110		
V3	Transgenic	0.134	0.154	10-50
	Vertical	0.095		
	Longitude	0.118		
V4	Transgenic	0.110	0.165	10-50
	Vertical	0.142		
	Longitude	0.071		

3.7 MAXIMUM PERMISSIBLE VALUES

Table 03. The interim standard on vibration for the Machinery, Construction Activities and Vehicular Movements stipulated by the Central Environmental Authority of Sri Lanka for different type of structures summaries below.

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 1 structures – Multi story buildings of reinforced concrete or structural steel, with filling panels of block work, brick work or precast units not designed to resist earthquakes	Continuous	0 - 10	5.0
		10 - 50	7.5
		Over 50	15.0
	Intermittent	0 - 10	10.0
		10 - 50	15.0
		Over 50	30.0
Type 2 structures – Two-storey domestic houses and buildings constructed of made of reinforced block work, precast units, and reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.	Continuous	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0
	Intermittent	0 - 10	4.0
		10 - 50	8.0
		Over 50	16.0
Type 3 structures – Single and two storey houses and buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.	Continuous	0 - 10	1.0
		10 - 50	2.0
		Over 50	4.0
	Intermittent	0 - 10	2.0
		10 - 50	4.0
		Over 50	8.0

Cont....4

Table 03: Cont...........

Structure Type	Type of Vibration	Frequency of Vibration (Hz)	Vibration in ppv (mm/sec)
Type 4 structures – Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3, & declared as archeologically preserved structures by the Department of Archaeology	Continuous	0 - 10	0.25
		10 - 50	0.5
		Over 50	1.0
	Intermittent	0 - 10	0.5
		10 - 50	1.0
		Over 50	2.0

4.0 CONCLUSION:

The measured ground vibration levels at all locations were lower than the vibration levels stipulated for type 3 structures in the Interim Vibration Standard stipulated by the Central Environmental Authority of Sri Lanka.

…………………………
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

……………………..
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

NBRO/ENV/26201/2018/320c
AQP/2018/320c

Vibration monitoring locations

V1- At a location, close to the entrance of the compost production site

V2-At a location, close to the existing waste disposal site

V3- At a location, close to the proposed waste disposal site

V4-At a location, close to the staff dressing room at waste disposal site

NBRO/ENV/26201/2017/166b
AQP/2017/166b

18th August 2017

Client:
Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON THE MONITORING OF BASELINE NOISE LEVELS AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA

(JULY 2017)

1.0 SCOPE

As per the letter dated on 30th May 2017, by the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, No. 104, Denzil Kobbekaduwa Mawatha, Battaramulla Ltd. to the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) was requested to monitor baseline noise levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions before start the project activities of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the noise monitoring program on 13th July 2017.

Staff involved:

Mr. Manjula Dissanayake	*- Scientist*	*- ESSD, NBRO*
Mr. Prabath Liyanaarachchi	*- Scientist*	*- ESSD, NBRO*
Mr. W A Weerasinghe	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Mr. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Naofumi Sato - EX Research Institute Ltd.

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor baseline noise levels at the project area before staring the project activities.

Cont.......2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 NOISE LEVEL MEASUREMENTS

4.1 MEASURINGINSTRUMENTS

Sound Level meter : RION NL 52
Calibrator : RION NC 74 – IEC 60942 (JIS C 1515), Class 1
Calibration due : December 2017

The sound level meter conforms to the requirements of both IEC 61672-12002 class 1 and JIS C 1509-1:2005 class 1

4.2 METHOD OF MEASUREMENTS

The sound level measurements were carried out in accordance with the methods laid down in International Organisation for Standardization (ISO) 1996 (part 1,2,3) and BS 4142; 1990, as stipulated in National Environmental Noise Control Regulations.

The equivalent continuous A weighted sound pressure level (Leq,T) was measured for a periods of T (1 hour) with the integrated time of one (1.0) second in the fast selection mode of the meter.

4.3 MEASURING CONDITIONS

Sets of 1 hour continuous time integrated noise levels were taken at selected locations during day time around the proposed site to assess the baseline noise levels in the area. The noise level receiver height was about 1.5 m from the ground level for the measurement.

4.4 MEASURING LOCATIONS

Three locations were selected as per the client's requirement for the monitoring of noise levels. The locations description is given in Table 1.

Table 01: Noise Monitoring Location Description

Location No.	Location Description	GPS Coordinates
N1	At a location, close to the north west boundary of the disposal site	07°30'55.0"N 080°21'13.3"E
N2	At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.	07°30'50.2"N 080°21'16.0"E
N3	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.	07°30'45.8"N 080°21'16.9"E

Cont….3

4.5 NOISE MEASURING RESULTS

Table 02: Noise Levels at each monitoring location on 13th July 2017

Location	Time	Hourly Averaged Noise Level Leq (dB)	Background Noise level L90 dB(A)
N_1	Day	58	50
N_2	Day	62	54
N_3	Day	59	49

Where;

- Measured Noise Level (L_{eq}):- The equivalent continuous baseline noise level over the measuring period.
- Background Noise Level (L_{90}):- The noise level that exceeded 90% of the measuring periods.

4.6 MAXIMUM PERMISSIBLE NOISE LEVELS

The maximum permissible noise levels that to be maintained at the construction period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities are as follows.

- 75 dB Leq(A) during Day time
- 50 dBLeq(A) during Night time

The maximum permissible noise levels that to be maintained at the operation period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the activities are as follows.

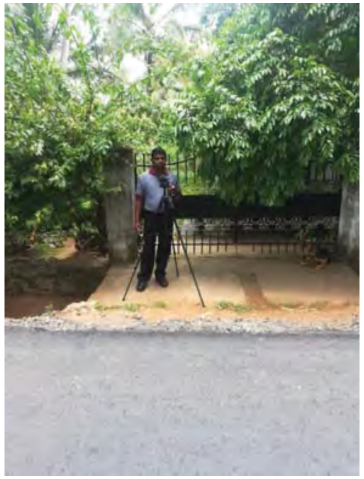
- 65 dB Leq(A) during Day time
- 50 dBLeq(A) during Night time

5.0 CONCLUSIONS

The measured day time baseline noise levels were lower than the maximum permissible noise levels stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities.

……………………	……………………..
H.D.S. Premasiri	S.V. Dias
Coordinator / Air Quality	Director
Environmental Studies & Services Division	Environmental Studies & Services Division
National Building Research Organization	National Building Research Organization

Noise monitoring locations



N1- At a location, close to the north west boundary of the disposal site

N2- At the premises of Ms. Buddhika Sudharma, No. 101, Sooriyawatte, 2nd stage, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

N3- At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2017/166b
AQP/2017/166b

4th September 2018

Client: Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF NOISE LEVELS AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA
(AUGUST 2018)

1.0 SCOPE

As per the letter dated 30th May 2017 the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor noise levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions of the project area during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the noise monitoring program on 08th August 2018.

Staff involved:

Mr. D R Rathnayaka	*- Technical Officer*	*- ESSD, NBRO*
Mr. N Krishnamoorthy	*- Field Assistant*	*- ESSD, NBRO*
Mr. Ranil Jayawardhana	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Nuwan – Site Supervisor

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor noise levels at the project area during the construction stage.

Cont.......2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 NOISE LEVEL MEASUREMENTS

4.1 MEASURINGINSTRUMENTS

Sound Level meter	: RION NL 52
Calibrator	: RION NC 74 – IEC 60942 (JIS C 1515), Class 1
Calibration due	: December 2018

The sound level meter conforms to the requirements of both IEC 61672-12002 class 1 and JIS C 1509-1:2005 class 1

4.2 METHOD OF MEASUREMENTS

The sound level measurements were carried out in accordance with the methods laid down in International Organisation for Standardization (ISO) 1996 (part 1,2,3) and BS 4142; 1990, as stipulated in National Environmental Noise Control Regulations.

The equivalent continuous A weighted sound pressure level (Leq,T) was measured for a periods of T (5 minutes) with the integrated time of one (1.0) second in the fast selection mode of the meter.

4.3 MEASURING CONDITIONS

Sets of 5 minutes continuous time integrated noise levels were taken at selected locations during day time around the proposed site to assess the noise levels in the area. The noise level receiver height was about 1.5 m from the ground level for the measurement.

4.4 MEASURING LOCATIONS

Three locations were selected as per the client's requirement for the monitoring of noise levels. The locations description is given in Table 1.

Table 01: Noise Monitoring Location Description

Location	GPS Coordinates	Location Description
N1	07°30'55.0"N 080°21'13.3"E	At a location, close to the north west boundary of the disposal site
N2	07°30'31"N 080°21'9"E	At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
N3	07°30'45.8"N 080°21'16.9"E	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

Cont....3

4.5 NOISE MEASURING RESULTS

Table 02: Noise Levels at each monitoring location on 8th August 2018

Location	Time	Run time (min)	Measured Noise Level Leq (dB)	Residual noise level Leq dB(A)	Corrected Noise Level
N1	Day	05	60	58	*
N2	Day	05	66	62	64
N3	Day	05	59	59	*

Where;

• Measured Noise Level (Leq):-	The equivalent continuous noise level when the construction activities of the project are going on over a period of measurement.
• Residual Noise Level (Leq):-	The equivalent continuous noise levels measured on during baseline noise survey.
• Corrected Noise Level: -	The continuous noise level generated due to the construction activities of the project, calculated in accordance to BS: 4142; 1997.

*Corrected noise levels cannot be estimated in accordance to BS: 4142; 1997 since the measured noise levels and residual noise levels were very closed to each other.

4.6 MAXIMUM PERMISSIBLE NOISE LEVELS

The maximum permissible noise levels that to be maintained at the construction period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities are as follows.

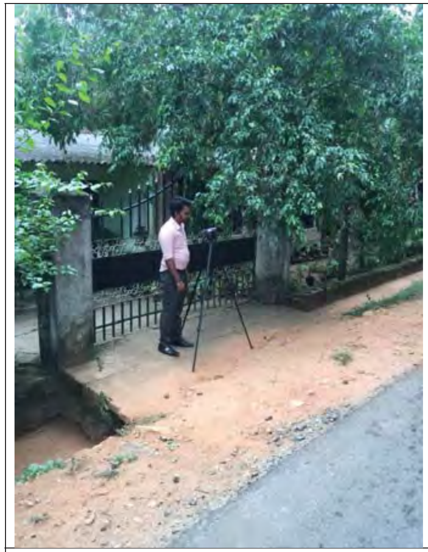
- 75 dB Leq(A) during Day time
- 50 dB Leq(A) during Night time

5.0 CONCLUSIONS

The corrected day time noise levels at locations N1 & N3 cannot be estimated since the measured noise level and residual noise levels are closer (<2dB) to each other. Therefore, additional noise contribution by the construction activities to the residual noise level is insignificant at those locations. Whereas, the corrected day time noise level at location N2 was lower than the maximum permissible noise levels stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities.

…………………………	……………………………
H.D.S. Premasiri	S.V. Dias
Coordinator / Air Quality	Director
Environmental Studies & Services Division	Environmental Studies & Services Division
National Building Research Organization	National Building Research Organization

Noise monitoring locations



N1- At a location, close to the north west boundary of the disposal site

N2- At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.

N3 - At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2018/319b
AQP/2018/319b

12th December 2018

Client:
Mr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF NOISE LEVELS AT SUNDARAPOLA DISPOSAL SITE, KURUNEGALA
(CONSTRCUTION STAGE - NOVEMBER 2018)

1.0 SCOPE

As per the letter dated 30th May 2017 the client, Mr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor noise levels at the Sudarapola Disposal Site, located in Kurunegala to assess the environmental conditions of the project area during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the noise monitoring program on 28th November 2018.

Staff involved:

Mr. Nilanka Ranaweera - Technical Officer - ESSD, NBRO
Mr. W A Weerasinghe - Field Assistant - ESSD, NBRO
Mr. Ranil Jayawardhana - Field Assistant - ESSD, NBRO

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*
Mr. Nuwan – Site Supervisor

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kurunegala Municipal council area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting dispoasl site area is about 12.5 acres and about 50 – 55 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor noise levels at the project area during the construction stage.

Cont.......2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 NOISE LEVEL MEASUREMENTS

4.1 MEASURINGINSTRUMENTS

Sound Level meter : RION NL 52
Calibrator : RION NC 74 – IEC 60942 (JIS C 1515), Class 1
Calibration due : December 2018

The sound level meter conforms to the requirements of both IEC 61672-12002 class 1 and JIS C 1509-1:2005 class 1

4.2 METHOD OF MEASUREMENTS

The sound level measurements were carried out in accordance with the methods laid down in International Organisation for Standardization (ISO) 1996 (part 1,2,3) and BS 4142; 1990, as stipulated in National Environmental Noise Control Regulations.

The equivalent continuous A weighted sound pressure level (Leq,T) was measured for a periods of T (5 minutes) with the integrated time of one (1.0) second in the fast selection mode of the meter.

4.3 MEASURING CONDITIONS

Sets of 5 minutes continuous time integrated noise levels were taken at selected locations during day time around the proposed site to assess the noise levels in the area. The noise level receiver height was about 1.5 m from the ground level for the measurement.

4.4 MEASURING LOCATIONS

Three locations were selected as per the client's requirement for the monitoring of noise levels. The locations description is given in Table 1.

Table 01: Noise Monitoring Location Description

Location	GPS Coordinates	Location Description
N1	07°30'55.0"N 80°21'13.3"E	At a location, close to the north west boundary of the disposal site
N2	07°30'31"N 80°21'09"E	At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.
N3	07°30'45.8"N 80°21'16.9"E	At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

Cont....3

4.5 NOISE MEASURING RESULTS

Table 02: Noise Levels at each monitoring location on 28th November 2018

Location	Time	Run time (min)	Measured Noise Level Leq (dB)	Residual noise level Leq dB(A)	Corrected Noise Level
N1	Day	05	60	58	*
N2	Day	05	62	62	*
N3	Day	05	59	59	*

Where;

• Measured Noise Level (Leq):-	The equivalent continuous noise level when the construction activities of the project are going on over a period of measurement.
• Residual Noise Level (Leq):-	The equivalent continuous noise levels measured on during baseline noise survey.
• Corrected Noise Level: -	The continuous noise level generated due to the construction activities of the project, calculated in accordance to BS: 4142; 1997.

*Corrected noise levels cannot be estimated in accordance to BS: 4142; 1997 since the measured noise levels and residual noise levels were very closed to each other.

4.6 MAXIMUM PERMISSIBLE NOISE LEVELS

The maximum permissible noise levels that to be maintained at the construction period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities are as follows.

- 75 dB Leq(A) during Day time
- 50 dB Leq(A) during Night time

5.0 CONCLUSIONS

The corrected day time noise levels at all locations cannot be estimated since the measured noise level and residual noise levels are closer (<2dB) to each other. Therefore, additional noise contribution by the construction activities to the residual noise level is insignificant at those locations.

………………………….	…………………………….
H.D.S. Premasiri	S.V. Dias
Coordinator / Air Quality	Director
Environmental Studies & Services Division	Environmental Studies & Services Division
National Building Research Organization	National Building Research Organization

Noise monitoring locations

N1- At a location, close to the north west boundary of the disposal site

N2- At the premises of Mr.Subramanium., No. 102, 2nd stage, Sundarapola Road, Sooriyawatte, close to the western boundary of the disposal site.

N3 - At the premises of Mr. A Nadaraja, No. 96, Sooriyawatte, Yanthampalawa, Kurunegala, close to the western boundary of the disposal site.

NBRO/ENV/26201/2017/275b
AQP/2017/275b

30th January 2018

Client: Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON THE MONITORING OF BASELINE NOISE LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA

(DECEMBER 2017)

1.0 SCOPE

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, No. 104, Denzil Kobbekaduwa Mawatha, Battaramulla requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor baseline noise levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions before start the project activities of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the noise monitoring program on 21st December 2017.

Staff involved:

Mr. Prabath Liyanaarachchi - Scientist - ESSD, NBRO
Mr D R Rathnayake - Technical Officer - ESSD, NBRO
Mr.W A Weerasinghe - Field Assistant - ESSD, NBRO

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor baseline noise levels at the project area before staring the project activities.

Cont.......2

NBRO/ENV/26201/2017/275b
AQP/2017/275b

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 NOISE LEVEL MEASUREMENTS

4.1 MEASURINGINSTRUMENTS

Sound Level meter : RION NL 52
Calibrator : RION NC 74 – IEC 60942 (JIS C 1515), Class 1
Calibration due : June 2018

The sound level meter conforms to the requirements of both IEC 61672-12002 class 1 and JIS C 1509-1:2005 class 1

4.2 METHOD OF MEASUREMENTS

The sound level measurements were carried out in accordance with the methods laid down in International Organisation for Standardization (ISO) 1996 (part 1,2,3) and BS 4142; 1990, as stipulated in National Environmental Noise Control Regulations.

The equivalent continuous A weighted sound pressure level (Leq,T) was measured for a periods of T (1 hour) with the integrated time of one (1.0) second in the fast selection mode of the meter.

4.3 MEASURING CONDITIONS

Sets of 1 hour continuous time integrated noise levels were taken at selected locations during day time around the proposed site to assess the baseline noise levels in the area. The noise level receiver height was about 1.5 m from the ground level for the measurement.

It was noticed that localised noise such as noises of dogs, birds and breeze etc. were contribute to measured noise levels.

4.4 MEASURING LOCATIONS

Four locations were selected as per the client’s requirement for the monitoring of noise levels. The locations description is given in Table 1.

Table 01: Noise Monitoring Location Description

Location No.	Location Description	GPS Coordinates
N1	At a location, close to the entrance of the compost production site	6^0 23’ 12.70” N 81^0 18’ 23.91” E
N2	At a location, close to the existing waste disposal site	6^0 23’ 23.69” N 81^0 17’ 57.73” E
N3	At a location, close to the proposed waste disposal site	6^0 23’ 24.46” N 81^0 17’ 35.28” E
N4	At a location, close to the back fence of the compost production site	6^0 23’ 13.20” N 81^0 18’ 22.69” E

Cont….3

4.5 NOISE MEASURING RESULTS

Table 02: Noise Levels at each monitoring location on 21st December 2017

Location	Time	Hourly Averaged Noise Level Leq (dB)	Background Noise level L90 dB(A)
N_1	Day	54	47
N_2	Day	47	39
N_3	Day	47	39
N_4	Day	50	42

Where;

- Measured Noise Level (L_{eq}):- The equivalent continuous baseline noise level over the measuring period.
- Background Noise Level (L_{90}):- The noise level that exceeded 90% of the measuring periods.

4.6 MAXIMUM PERMISSIBLE NOISE LEVELS

The maximum permissible noise levels that to be maintained at the construction period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities are as follows.

- 75 dB Leq(A) during Day time
- 50 dBLeq(A) during Night time

The maximum permissible noise levels that to be maintained at the operation period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the activities are as follows.

- 55 dB Leq(A) during Day time
- 45 dBLeq(A) during Night time

5.0 CONCLUSIONS

The measured day time baseline noise levels were in the range of 47-54dB and below the maximum permissible noise levels stipulated for low noise area under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka. It should apply measures to maintained noise levels below 75dB during the day time of the construction stage.

……………………	……………………..
H.D.S. Premasiri	S.V. Dias
Coordinator / Air Quality	Director
Environmental Studies & Services Division	Environmental Studies & Services Division
National Building Research Organization	National Building Research Organization

Noise monitoring locations

	
N1- At a location, close to the entrance of the compost production site	**N2-**At a location, close to the existing waste disposal site
	
N3- At a location, close to the proposed waste disposal site	**N4-** At a location, close to the back fence of the compost production site

NBRO/ENV/26201/2017/275b 28th June 2018
AQP/2017/275b

Client: Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF NOISE LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA

(CONSTRUCTION STAGE - JUNE 2018)

1.0 SCOPE

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor noise levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the noise monitoring program on 05th June 2018.

Staff involved:

Mr. Prabath Liyanaarachchi	*- Scientist*	*- ESSD, NBRO*
Mr. N Krishnamoorthy	*- Field Assistant*	*- ESSD, NBRO*
Mr. A S Premarathne	*- Field Assistant*	*- ESSD, NBRO*
Mr. Gayan Indika	*- Field Assistant*	*- ESSD, NBRO*

Witness: *Ms. Nayana Samaraweera – Local Consultant/ Project Coordinator*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor noise levels at the project area during the construction stage.

Cont.......2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 NOISE LEVEL MEASUREMENTS

4.1 MEASURINGINSTRUMENTS

Sound Level meter	: RION NL 52
Calibrator	: RION NC 74 – IEC 60942 (JIS C 1515), Class 1
Calibration due	: December 2018

The sound level meter conforms to the requirements of both IEC 61672-12002 class 1 and JIS C 1509-1:2005 class 1

4.2 METHOD OF MEASUREMENTS

The sound level measurements were carried out in accordance with the methods laid down in International Organisation for Standardization (ISO) 1996 (part 1,2,3) and BS 4142; 1990, as stipulated in National Environmental Noise Control Regulations.

The equivalent continuous A weighted sound pressure level (Leq,T) was measured for a periods of T (5 min) with the integrated time of one (1.0) second in the fast selection mode of the meter.

4.3 MEASURING CONDITIONS

Sets of 5 min continuous time integrated noise levels were taken at selected locations during day time around the proposed site to assess the baseline noise levels in the area. The noise level receiver height was about 1.5 m from the ground level for the measurement.

It was noticed that construction activities such as heavy vehicle movements were on going during the monitoring period.

4.4 MEASURING LOCATIONS

Four locations were selected as per the client's requirement for the monitoring of noise levels. The locations description is given in Table 1.

Table 01: Noise Monitoring Location Description

Location No.	Location Description	GPS Coordinates
N1	At a location, close to the entrance of the compost production site	6^0 23' 12.70" N 81^0 18' 23.91" E
N2	At a location, close to the existing waste disposal site	6^0 23' 23.69" N 81^0 17' 57.73" E
N3	At a location, close to the proposed waste disposal site	6^0 23' 24.46" N 81^0 17' 35.28" E
N4	At a location, close to the back fence of the compost production site	6^0 23' 13.20" N 81^0 18' 22.69" E

Cont….3

4.5 NOISE MEASURING RESULTS

Table 02: Noise Levels at each monitoring location on 05th June 2018

Location	Time	Run time (min)	Measured Noise Level Leq (dB)	Residual noise level Leq dB(A)	Corrected Noise Level
N1	Day	5	54	54	*
N2	Day	5	52	47	50
N3	Day	5	58	47	58
N4	Day	5	55	50	53

Where;

• Measured Noise Level (Leq):-	The equivalent continuous noise level when the construction activities of the project are going on over a period of measurement.
• Residual Noise Level (Leq):-	The equivalent continuous noise levels measured on during baseline noise survey.
• Corrected Noise Level: -	The continuous noise level generated due to the construction activities of the project, calculated in accordance to BS: 4142; 1997.

*Corrected noise levels cannot be estimated in accordance to BS: 4142; 1997 since the measured noise levels and residual noise levels were very closed to each other.

4.6 MAXIMUM PERMISSIBLE NOISE LEVELS

The maximum permissible noise levels that to be maintained at the construction period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities are as follows.

- 75 dB Leq(A) during Day time
- 50 dB Leq(A) during Night time

5.0 CONCLUSIONS

The corrected day time noise levels at location N1 cannot be estimated since the measured noise level and residual noise levels are closer (<2dB) to each other. Therefore, additional noise contribution by the construction activities to the residual noise level is insignificant at this location. Whereas, the corrected day time noise levels at locations N2, N3 & N4 were lower than the maximum permissible noise levels stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities.

…………………………………	……………………………..
H.D.S. Premasiri	S.V. Dias
Coordinator / Air Quality	Director
Environmental Studies & Services Division	Environmental Studies & Services Division
National Building Research Organization	National Building Research Organization

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Noise monitoring locations

	
N1- At a location, close to the entrance of the compost production site	**N2**-At a location, close to the existing waste disposal site
	
N3- At a location, close to the proposed waste disposal site	**N4**- At a location, close to the back fence of the compost production site

NBRO/ENV/26201/2018/320b
AQP/2018/320b

12th December 2018

Client:

Dr. Naofumi Sato
EX Research Institute Ltd.
Central Environmental Authority - Waste Management Unit
No. 104, Denzil Kobbekaduwa Mawatha
Battaramulla

REPORT ON
THE MONITORING OF NOISE LEVELS AT GALAPITAGALAYAYA DISPOSAL SITE, KATARAGAMA

(CONSTRUCTION STAGE - NOVEMBER 2018)

1.0 SCOPE

As per the letter dated 11th October 2017 the client, Dr. Naofumi Sato, EX Research Institute, Central Environmental Authority - Waste Management Unit, requested the Environmental Studies and Services Division (ESSD) of the National Building Research Organisation (NBRO) to monitor noise levels at the Galapitagalayaya Disposal Site, located in Kataragama to assess the environmental conditions during the construction stage of the disposal site.

In this regard, following officers of the Environmental Studies and Services Division of NBRO were carried out the noise monitoring program on 26th November 2018.

Staff involved:

Mr. Viran Daniel	*- Technical Assistant*	*- ESSD, NBRO*
Mr. W A Weerasinghe	*- Field Assistant*	*- ESSD, NBRO*
Mr. A S Premarathne	*- Field Assistant*	*- ESSD, NBRO*

***Witness**: Mr. Layan Gunasekara – Coordinator - ReEB Waste treatment Project*

2.0 DESCRIPTION OF THE PREMISES:

Pollution Control and Reduction of Environmental Burden in Solid Waste Management Project site is at exsisting disposal site and the compost plant within the Kataragama Pradeshiya Sabha area. The project aims rehabilitation of exsiting disposal sites and improvement of compost plants. The exsisting disposal site area is about 3.5 acres and about 6 tons of segregated municipal solid waste are received to the site in each day. The organic waste are processing through a composting process to produce fertilizers and recycable parts are recycled. The swerage waste receive to the site are stored in two tanks and treated. This monitoring programme is scheduled to monitor noise levels at the project area during the construction stage.

Cont.......2

3.0 WEATHER CONDITION

Dry weather with scattered wind prevailed during the sampling period.

4.0 NOISE LEVEL MEASUREMENTS

4.1 MEASURINGINSTRUMENTS

Sound Level meter : RION NL 52
Calibrator : RION NC 74 – IEC 60942 (JIS C 1515), Class 1
Calibration due : December 2018

The sound level meter conforms to the requirements of both IEC 61672-12002 class 1 and JIS C 1509-1:2005 class 1

4.2 METHOD OF MEASUREMENTS

The sound level measurements were carried out in accordance with the methods laid down in International Organisation for Standardization (ISO) 1996 (part 1,2,3) and BS 4142; 1990, as stipulated in National Environmental Noise Control Regulations.

The equivalent continuous A weighted sound pressure level (Leq,T) was measured for a periods of T (5 min) with the integrated time of one (1.0) second in the fast selection mode of the meter.

4.3 MEASURING CONDITIONS

Sets of 5 min continuous time integrated noise levels were taken at selected locations during day time around the proposed site to assess the baseline noise levels in the area. The noise level receiver height was about 1.5 m from the ground level for the measurement.

It was noticed that construction activities such as heavy vehicle movements were on going during the monitoring period.

4.4 MEASURING LOCATIONS

Four locations were selected as per the client's requirement for the monitoring of noise levels. The locations description is given in Table 1.

Table 01: Noise Monitoring Location Description

Location No.	Location Description	GPS Coordinates
N1	At a location, close to the entrance of the compost production site	06^0 23' 12.70" N 81^0 18' 23.91" E
N2	At a location, close to the existing waste disposal site	06^0 23' 23.69" N 81^0 17' 57.73" E
N3	At a location, close to the proposed waste disposal site	06^0 23' 24.46" N 81^0 17' 35.28" E
N4	At a location, close to the back fence of the compost production site	06^0 23' 13.20" N 81^0 18' 22.69" E

Cont.......3

4.5 NOISE MEASURING RESULTS

Table 02: Noise Levels at each monitoring location on 26th November 2018

Location	Time	Run time (min)	Measured Noise Level Leq (dB)	Residual noise level Leq dB(A)	Corrected Noise Level
N1	Day	5	54	54	*
N2	Day	5	47	47	*
N3	Day	5	48	47	*
N4	Day	5	50	50	*

Where;

- Measured Noise Level (Leq):- The equivalent continuous noise level when the construction activities of the project are going on over a period of measurement.
- Residual Noise Level (Leq):- The equivalent continuous noise levels measured on during baseline noise survey.
- Corrected Noise Level: - The continuous noise level generated due to the construction activities of the project, calculated in accordance to BS: 4142; 1997.

*Corrected noise levels cannot be estimated in accordance to BS: 4142; 1997 since the measured noise levels and residual noise levels were very closed to each other.

4.6 MAXIMUM PERMISSIBLE NOISE LEVELS

The maximum permissible noise levels that to be maintained at the construction period, stipulated under the Extraordinary Gazette No. 924/12- Thursday, May 23, 1996 by the Central Environmental Authority (CEA) of Sri Lanka for the construction activities are as follows.

- 75 dB Leq(A) during Day time
- 50 dB Leq(A) during Night time

5.0 CONCLUSIONS

The corrected day time noise levels at all locations cannot be estimated since the measured noise level and residual noise levels are closer (<2dB) to each other. Therefore, additional noise contribution by the construction activities to the residual noise level is insignificant at these locations.

……………………………….
H.D.S. Premasiri
Coordinator / Air Quality
Environmental Studies & Services Division
National Building Research Organization

…………………………….
S.V. Dias
Director
Environmental Studies & Services Division
National Building Research Organization

Noise monitoring locations

	
N1- At a location, close to the entrance of the compost production site	**N2**-At a location, close to the existing waste disposal site
	
N3- At a location, close to the proposed waste disposal site	**N4**- At a location, close to the back fence of the compost production site

Appendix 16

Approval letter of Kurunegala MC

කුරුණෑගල
මහ නගර සභාව
නාගරික කොමසාරිස්,
කුරුණෑගල.

KURUNEGALA
MUNICIPAL COUNCIL
Municipal – Commissioner
Kurunegala.

My No :- HD/2/1/5

Your No :-
Date - 2017.11.22

Project
27 NOV 2017

Mrs. Nayana - JICA Project
Fwd pl
27/11/2017

නියෝජ්‍ය අධ්‍යක්ෂ ජනරාල්,
(අපද්‍රව්‍ය කළමනාකරණය),
මධ්‍යම පරිසර අධිකාරිය,
බත්තරමුල්ල.

<u>සුන්දරාපොල කොම්පෝස්ට් අංගනයේ අපජලය පිරිපහදු කිරීමේ බැම්ම</u>

<u>(P.R.B.) ඉදිකිරීම.</u>

ජයිකා ආයතනය මගින් සුන්දරාපොල කොම්පෝස්ට් අංගනයේ ඉදිකිරීමට අපේක්ෂිත අප ජල පිරිපහදු කිරීමේ භූගත බැම්ම ඉදිකිරීමේ සැලැස්ම,සැලසුම් කමිටුව නිර්දේශ කර ඇත.

02. ඒ අනුව එම ඉදිකිරීම සඳහා අනුමැතිය ලබාදෙන බැව් කාරුණිකව දන්වමි.

නාගරික කොමසාරිස්,
මහා නගර සභාව,
කුරුණෑගල.

ප්‍රදීප් තිලකරත්න
නාගරික කොමසාරිස්
මහ නගර සභාව
කුරුණෑගල.

Appendix 17

Approval letter of Katharagama PS

"සහජීවනයේ වන්දනීය රම්‍ය පුරවරය"

කතරගම ප්‍රාදේශීය සභාව
கதிர்காமம் பிரதேச சபை
KATHARAGAMA PRADESHIYA SABHA

නව නගරය, කතරගම / புதிய நகர் கதிர்காமம். / New Town, Katharagama.

කිප්‍රාස/ක.ක.රැස්/2018 2018.01.17

මගේ අංකය / என து இல / My Ref.
ඔබේ අංකය / உமது இல / Your Ref.
දිනය / திகதி / Date

ආචාර්ය නඹුම් සාටෝ මහතා,

JICA.ReEB waste ඝන අපද්‍රව්‍ය කළමණාකරන ව්‍යාපෘතිය.

මධ්‍යම පරිසර අධිකාරිය,

කොළඹ.

ගලපිටගලයාය කසළ බැහැරලන මධ්‍යස්ථානය සංවර්ධනය කිරීම- JICA.ReEB waste ඝන අපද්‍රව්‍ය කළමණාකරන ව්‍යාපෘතිය.

2017.12.26 වන දින කතරගම ප්‍රාදේශීය සභාවේ සභා ලේකම් තීරණ අංක 19 හි උද්ධෘතයක් පහත දක්වමි.

02.ජපන් ජාත්‍යන්තර සහයෝගිතා ඒජන්සිය (JICA) හා මධ්‍යම පරිසර අධිකාරිය යටතේ කතරගම ප්‍රාදේශිය සභා බල ප්‍රදේශයේ ඝන අපද්‍රව්‍ය කළමණාකරන වැඩසටහනට අනුව කඳසූරිදුගම වසමෙ ගලපිටගලයාය රක්ෂිතයේ වන සංරක්ෂණ දෙපාර්තමේන්තුවට අයත් කතරගම ප්‍රාදේශිය සභාව මගින් බදු පදනම මත නිදහස් කර ගන්නා ලද අක්කර 3 1/2 ක ඉඩම තුල (දැනට කසල බැහැර කරන)සනීපාරක්ෂක බිම් පිරවීම සදහා සකස් කිරීමට ඉහත ව්‍යාපෘතිය මගින් සැලසුම් සකස් කර ඇති අක්කර 3 ½ ට වටා පස්වලින් බැම්මක් ඉදි කිරීමටත්, ඒ තුළ අප දියර පිටතට ගෙන ජලය පිරිසිදු කර මුදා හැරීමට අවශ්‍ය ඊට අදාළ ඉදිකිරීම් ඉදිකිරීමටත්, මුරකුටියක් ඇතුළු පහසුකම් සහිත ගොඩනැගිල්ලක් ඉදිකිරීමටත්, ඊට අදාල ප්‍රවේශ මාර්ග සංවර්ධනය කිරීමටත් එම මාර්ගයේ ඇති ආර හරහා කෝස්වුවක් ඉදි කිරීමටත්, දැනට කාබනික පොහොර මධ්‍යස්ථානයේ වැසිකිළි අපදියර පිරිසිදු කිරීමේ පද්ධතියක් ඉදි කිරීමටත් ඊට අමතරව කසළ පිළිබදව දත්ත තොරතුරු පවත්වාගෙන යාම සදහා අවශ්‍ය බර කිරීම් සදහා අවශ්‍ය වාහන තරාදියක් ඉදි කිරීමටත් ඉහත ව්‍යාපෘතියේ මූල්‍යමය දායකත්වය සහ සැලසුම් අනුව එම ව්‍යාපෘතිය මගින් ඉහත ඉදි කිරීම් කිරීම සදහා අවශ්‍ය අනුමැතිය ලබා දීමට මම තීරණය කරමි.

ලේකම්,
ප්‍රාදේශීය සභාව,
කතරගම,

ජේ.එල්.ඒ.එල්.ජයතිලක
සභා ලේකම් (වැ.බ.)
ප්‍රාදේශීය සභාව
කතරගම

පිටපත:-

01. පළාත් පාලන කොමසාරිස්- බදුල්ල -කා.දැ.ගැ.ස
02. සහකාර පළාත් පාලන කොමසාරිස්,මොනරාගල -කා.දැ.ගැ.ස
03. විගණන අධිකාරි , මොනරාගල -කා.දැ.ගැ.ස

දුරකථනය/ෆැක්ස්/தொலைபேசி / பெக்ஸ்/Telephone/Fax : 047-2235275
E-mail - Chairman-chairmankag@sltnet.lk office - kag2235275@sltadsl.lk

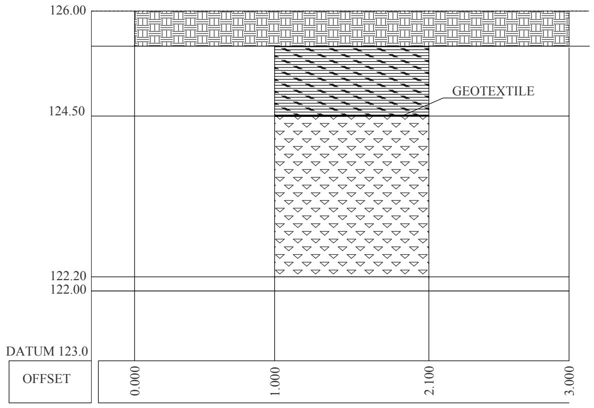
CONSTRUCTION OF PERMEABLE REACTIVE BARRIER AND ASSOCIATED FACILITIES AT SUNDARAPOLA DISPOSAL SITE IN KURUNEGALA MUNICIPAL COUNCIL

AS BUILT DRAWING OF PRB

CONTRACTOR:

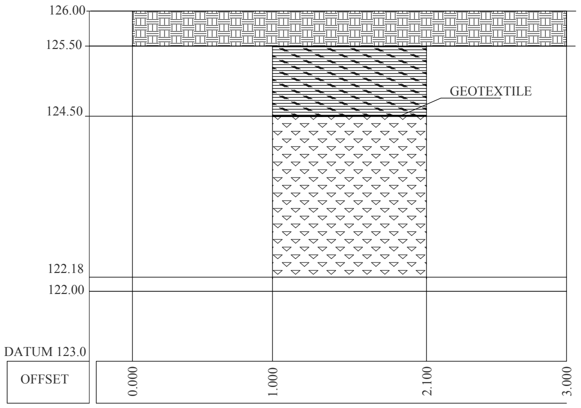
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,
SEEDUWA.

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.53
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+006

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.55
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+003

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+003
SECTION : 0+006

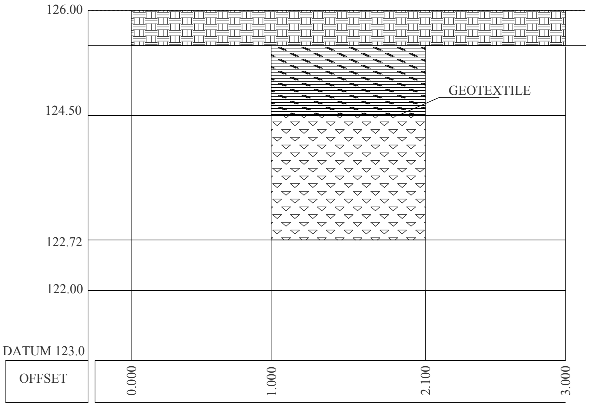
SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY:	APPROVED BY:	DATE:
INDIKA	PRANEETH	2018.08.10

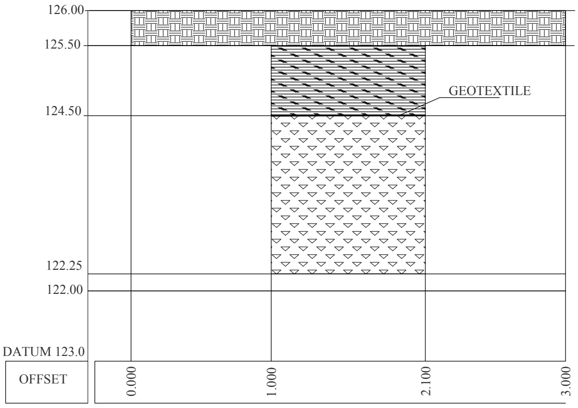
DRAWING NO: PRB 001

Description	Unit	Symbole	value
PRB Material	m^2	▽	1.96
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.53
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+0012



Chanage : 0+009

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+009
SECTION : 0+012

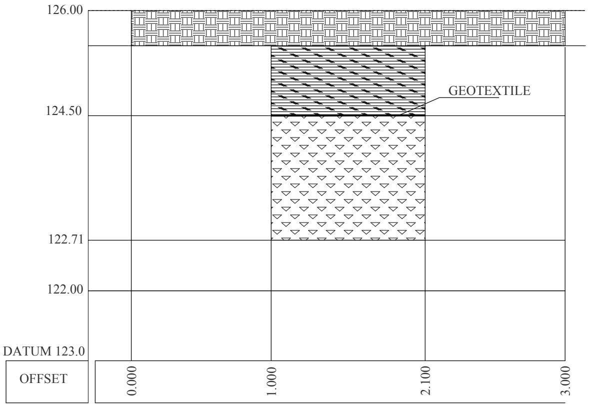
SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY: INDIKA
APPROVED BY: PRANEETH
DATE: 2018.08.10

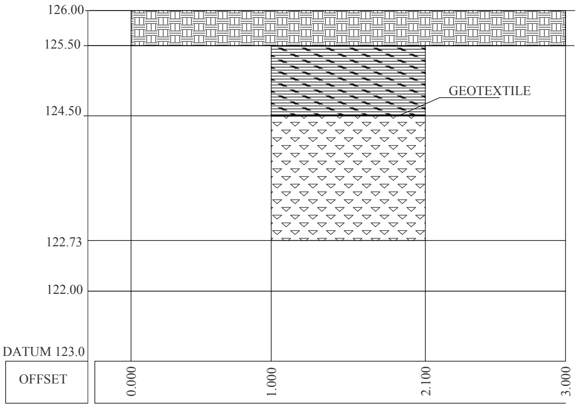
DRAWING NO: PRB 002

Description	Unit	Symbole	value
PRB Material	m^2	▽	1.97
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55

Description	Unit	Symbole	value
PRB Material	m^2	▽	1.96
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+018



Chanage : 0+015

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+015
SECTION : 0+018

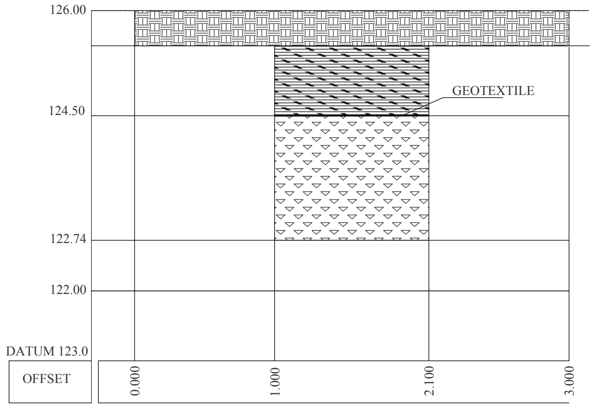
SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY: INDIKA
APPROVED BY: PRANEETH
DATE: 2018.08.10

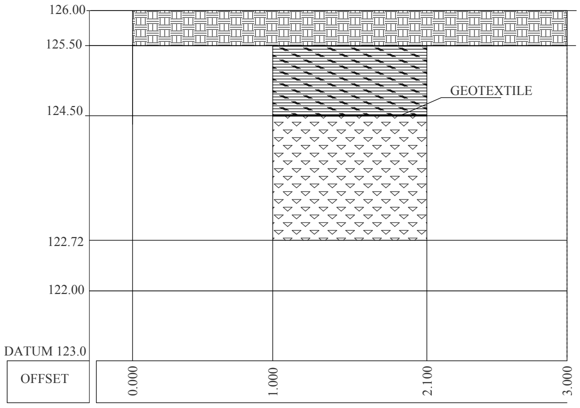
DRAWING NO: PRB 003

Description	Unit	Symbole	value
PRB Material	m^2	▽	1.94
Earth filling	m^2	▤	1.10
Top layer Earth filling	m^2	▦	1.55

Description	Unit	Symbole	value
PRB Material	m^2	▽	1.97
Earth filling	m^2	▤	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+024



Chanage : 0+021

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+021
SECTION : 0+024

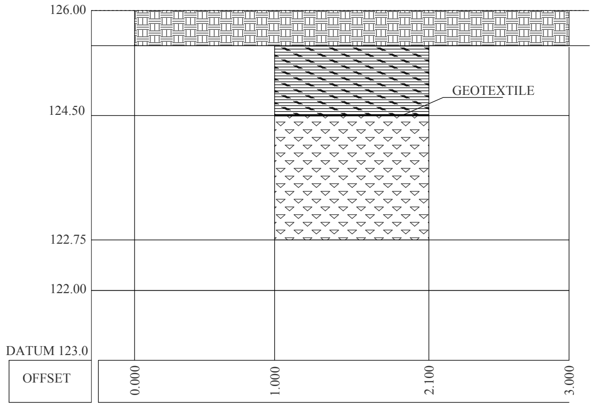
SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY:	APPROVED BY:	DATE:
INDIKA	PRANEETH	2018.08.10

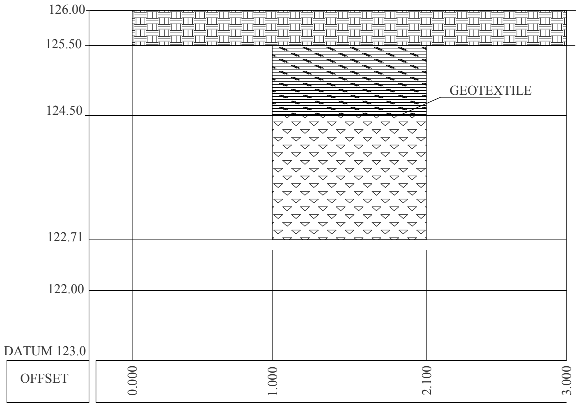
DRAWING NO: PRB 004

Description	Unit	Symbole	value
PRB Material	m^2	▽	1.94
Earth filling	m^2	▤	1.10
Top layer Earth filling	m^2	▦	1.55

Description	Unit	Symbole	value
PRB Material	m^2	▽	1.97
Earth filling	m^2	▤	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+027



Chanage : 0+030

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

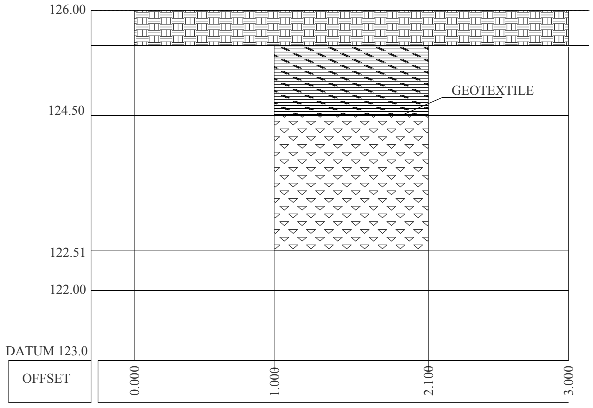
TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+027
SECTION : 0+030

SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY:	APPROVED BY:	DATE:
INDIKA	PRANEETH	2018.08.10

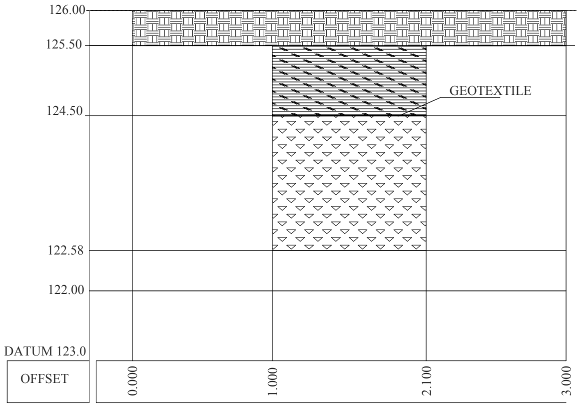
DRAWING NO: PRB 005

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.19
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+036

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.12
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+033

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

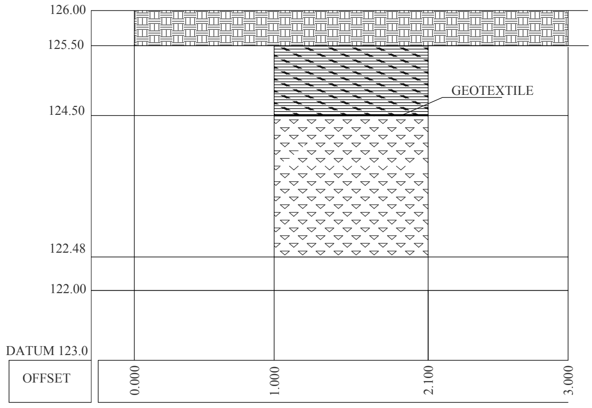
TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+033
SECTION : 0+036

SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY:	APPROVED BY:	DATE:
INDIKA	PRANEETH	2018.08.10

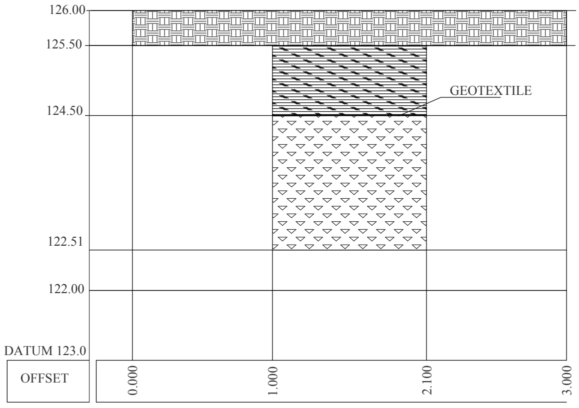
DRAWING NO: PRB 006

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.22
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+042

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.19
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+039

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+039
SECTION : 0+042

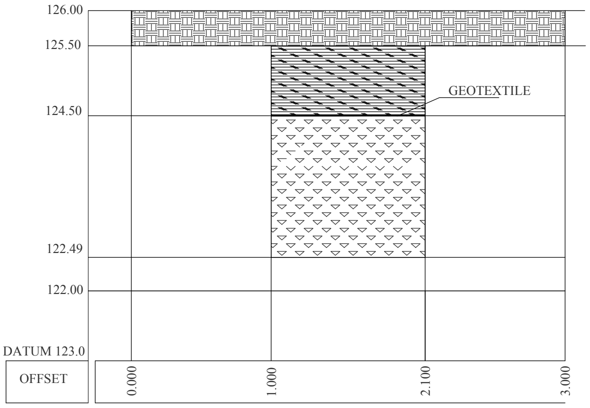
SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY:	APPROVED BY:	DATE:
INDIKA	PRANEETH	2018.08.10

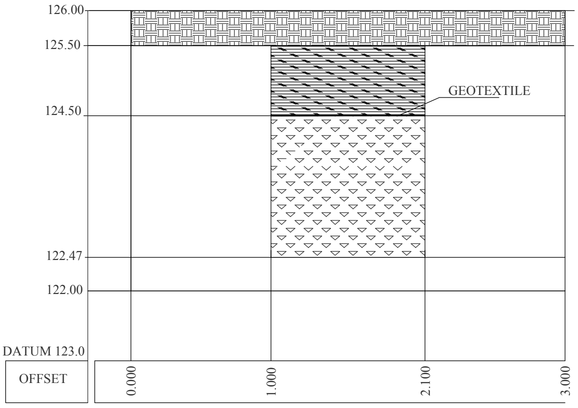
DRAWING NO: PRB 007

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.22
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.22
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+048



Chanage : 0+045

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

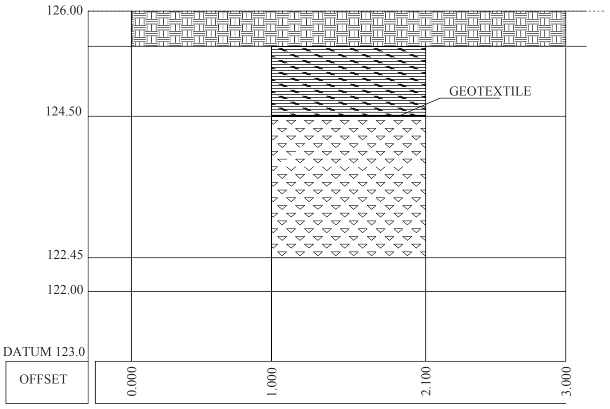
TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+045
SECTION : 0+048

SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY:	APPROVED BY:	DATE:
INDIKA	PRANEETH	2018.08.10

DRAWING NO: PRB 008

Description	Unit	Symbole	value
PRB Material	m^2	▽	2.25
Earth filling	m^2	▨	1.10
Top layer Earth filling	m^2	▦	1.55



Chanage : 0+051

EMPLOYER:
EX RESEARCH INSTITUTE LTD

CONSULTANT:
WASTE TO ENERGY TECHNOLOGIES LIMITED

CONTRACTOR:
T N CONSTRUCTIONS
NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA.
TELEPHONE : 0114962324
FAX: 0112259012

FUNDING AGENCY:
JAPAN INTERNATIONAL COOPERATION AGENCY

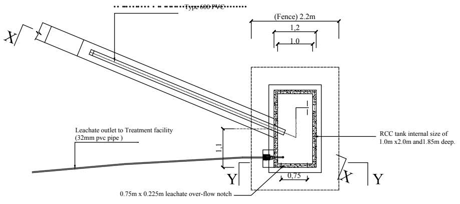
PROJECT :
CONSTURCTION OF PERMEABLE REACTIVE
BARRIER AND ASSOCIATED FACILITIES
AT SUNDARAPOLA DISPOSAL SITE
IN KURUNEGALA MUNICIPAL COUNCIL

TITLE :
AS BUILT DRAWING OF PRB
SECTION : 0+051

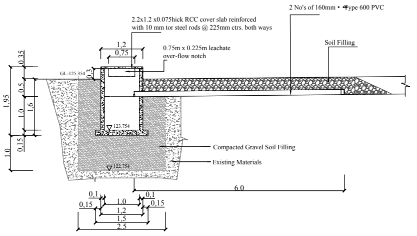
SCALE - Hor. - 1:25
Ver. - 1:50

DRAWN BY:	APPROVED BY:	DATE:
INDIKA	PRANEETH	2018.08.10

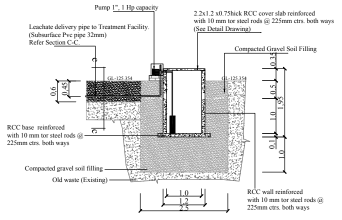
DRAWING NO: PRB 009



P L A N



SECTION X - X



SECTION Y-Y

NOTES

01. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

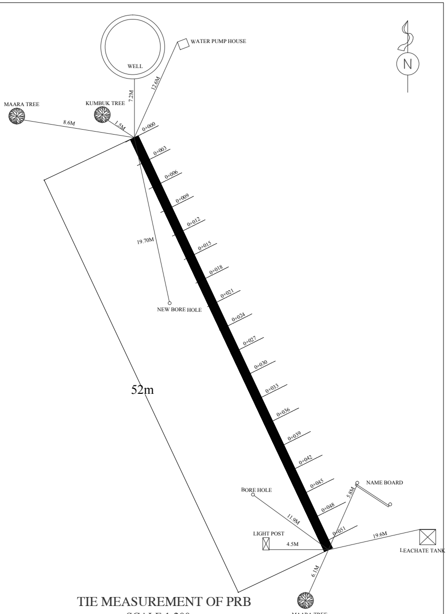
02. CONCRETE TO BE GRADE 20 UNLESS OTHERWISE SPECIFIED.

03. CLEAR COVER TO REINFORCEMENT

05. CHARACTERISTIC STRENGTH OF REINFORCEMENTS
(T) - TOR STEEL - 460 N/sq.mm
(R) - MILD STEEL - 250 N/sq.mm

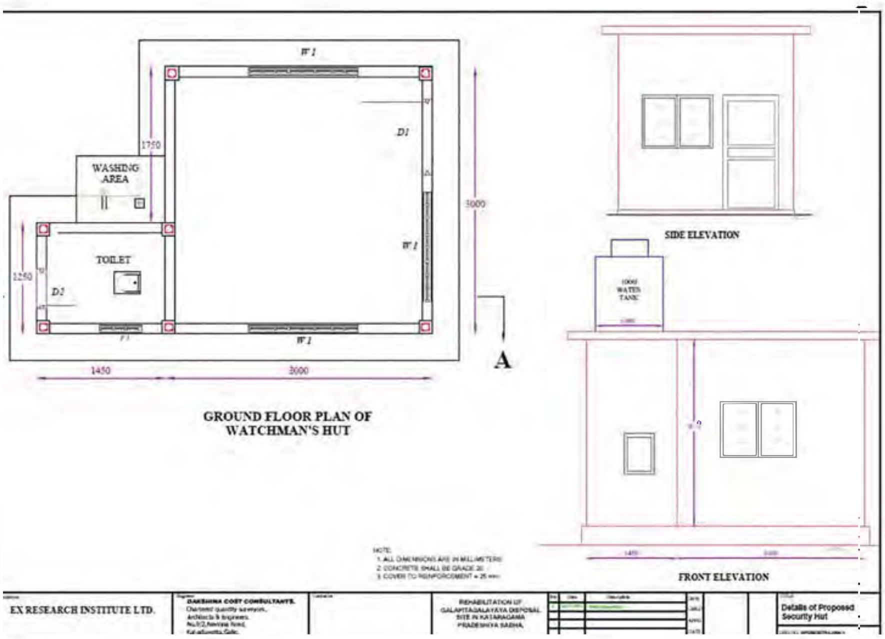
08. DRAWINGS SHOULD NOT BE SCALED.

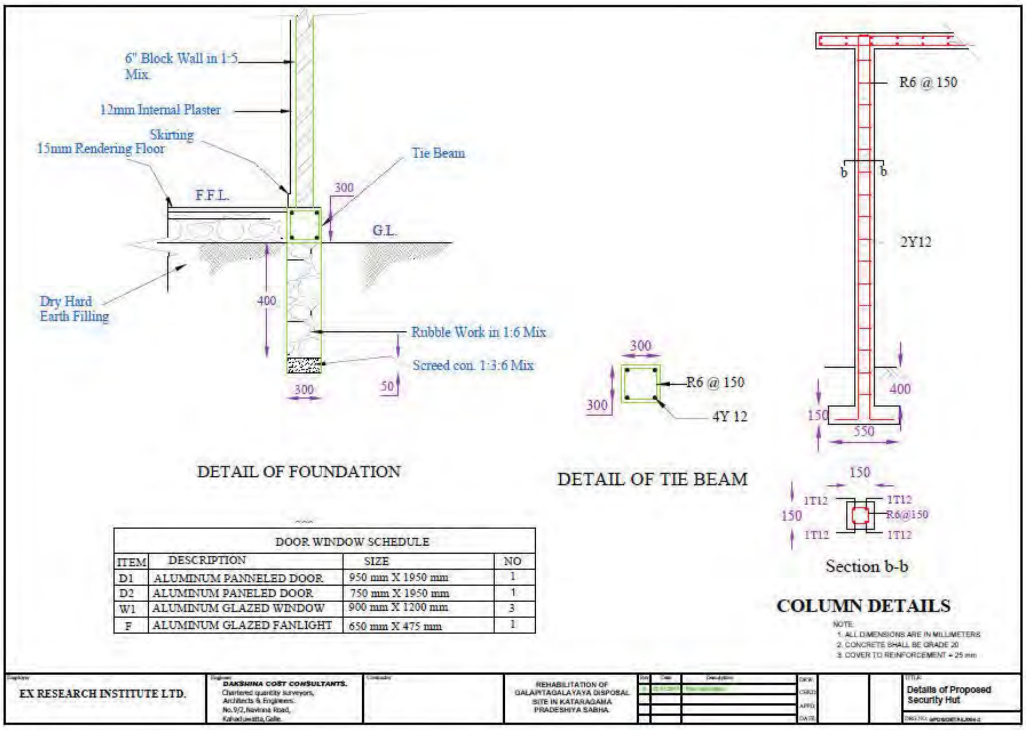
EMPLOYER: EX RESEARCH INSTITUTE LTD	CONTRACTOR: T N CONSTRUCTIONS NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA. TELEPHONE : 0114962324 FAX: 0112259012	PROJECT : CONSTURCTION OF PERMEABLE REACTIVE BARRIER AND ASSOCIATED FACILITIES AT SUNDARAPOLA DISPOSAL SITE IN KURUNEGALA MUNICIPAL COUNCIL	TITLE : LEACHATE COLLECTION AND DELIVERY SYSTEM	SCALE - NOT TO SCALE DRAWN BY: INDIKA APPROVED BY: PRANEETH DATE: 2018.08.10 DRAWING NO: PRB 009
CONSULTANT: WASTE TO ENERGY TECHNOLOGIES LIMITED	FUNDING AGENCY: JAPAN INTERNATIONAL COOPERATION AGENCY			



TIE MEASUREMENT OF PRB
SCALE 1:200

EMPLOYER: EX RESEARCH INSTITUTE LTD	CONTRACTOR: T N CONSTRUCTIONS NO: 41,SANJEEWA BUILDING,LIYANAGEMULLA,SEEDUWA. TELEPHONE : 0114962324 FAX: 0112259012	PROJECT : CONSTURCTION OF PERMEABLE REACTIVE BARRIER AND ASSOCIATED FACILITIES AT SUNDARAPOLA DISPOSAL SITE IN KURUNEGALA MUNICIPAL COUNCIL	TITLE : PRB LOCATIONS	SCALE 1:1000 DRAWN BY: INDIKA APPROVED BY: PRANEETH DATE: 2018.08.10 DRAWING NO: PRB 011
CONSULTANT: WASTE TO ENERGY TECHNOLOGIES LIMITED	FUNDING AGENCY: JAPAN INTERNATIONAL COOPERATION AGENCY			

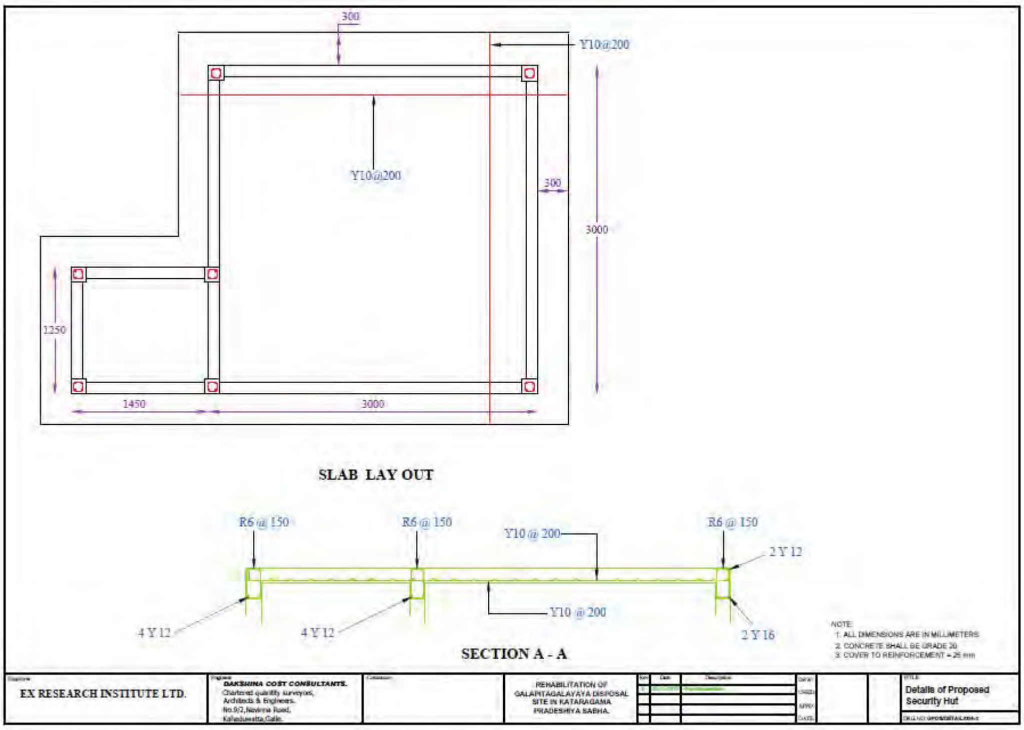




DOOR WINDOW SCHEDULE

ITEM	DESCRIPTION	SIZE	NO
D1	ALUMINUM PANNELED DOOR	950 mm X 1950 mm	1
D2	ALUMINUM PANELED DOOR	750 mm X 1950 mm	1
W1	ALUMINUM GLAZED WINDOW	900 mm X 1200 mm	3
F	ALUMINUM GLAZED FANLIGHT	650 mm X 475 mm	1

Appendix19



NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS
2. CONCRETE SHALL BE GRADE 20
3. COVER TO REINFORCEMENT = 25 mm

EX RESEARCH INSTITUTE LTD.

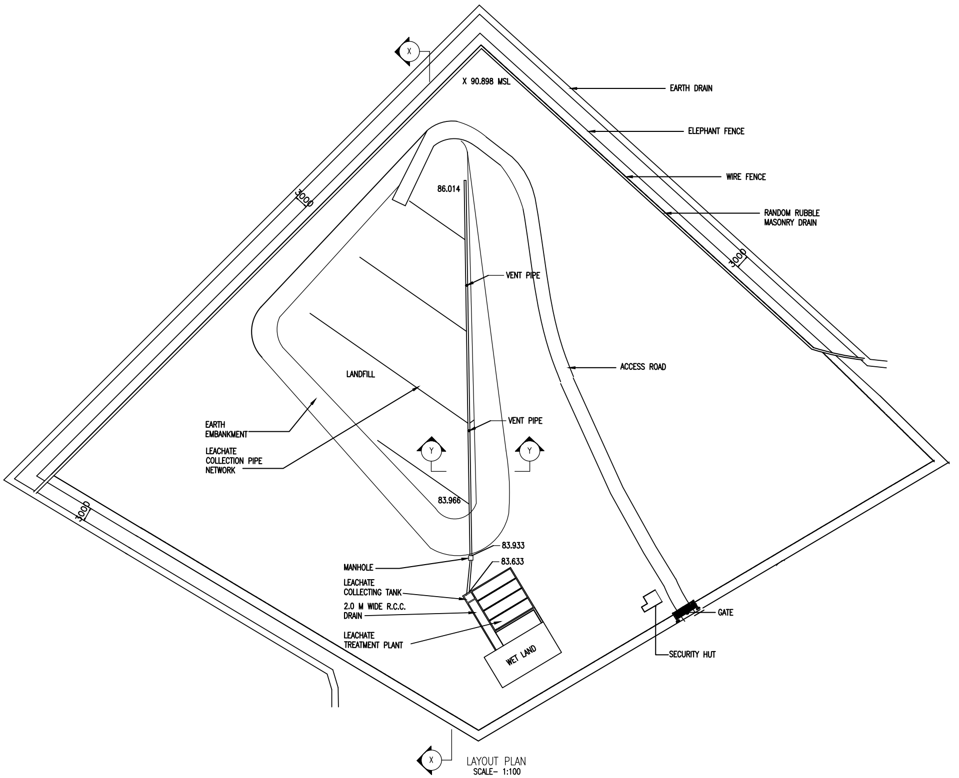
DAKSHINA COST CONSULTANTS.
Chartered quantity surveyors,
Architects & Engineers.
No.9/2,Navinna Road,
Kahaduwatta,Galle.

REHABILITATION OF
GALAPITAGALAYAYA DISPOSAL
SITE IN KATARAGAMA
PRADESHIYA SABHA.

TITLE
Details of Proposed
Security Hut

LIST OFDRAWINGS

NOS	Description	DRAWING NO
1	SITE LAYOUT	001
2	WIRE FEBCE	002
3	DRIVEWAY GATE	003
4	CAUSEWAY	004
5	ACCESS ROAD	005
6	RAMDOM RUBBLE MASONRY DRAINS AND EARTH DRAIN	006
7	LAND FILL - 1	007A
8	LAND FILL - 2	007B
9	LEACHATE COLLECTION PIPE	008
10	LEACHATE TREATMENT PLANT - 1	009A
11	LEACHATE YREATMENT PLANT - 2	009B
12	WET LAND	0010
13	NIGHT SOIL TREATMENT PLANT	0011
14	WEIGHT BRIDGE	0012



LAYOUT PLAN
SCALE- 1:100

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

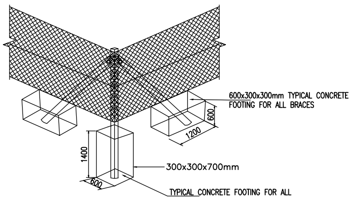
AS BUILT DRAWING
LAYOUT PLAN

Contractor
21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.
Building Construction,Management Designers &
Maintenance Contractors.

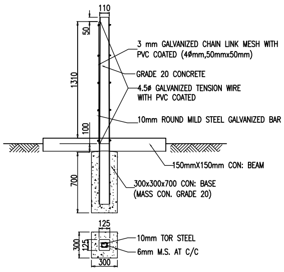
Office
519, 1st Floor,
Elvitigala Mawatha,
Narahenpita.

Tel: 0115927077
Fax: 0115927079
E.Mail: 21centurygroup.com

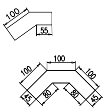
DRAWN BY Ranjan Fernando
CHECKED
SCALE AS INDICATED
DATE 20/09/2018
DRG. NO. 001



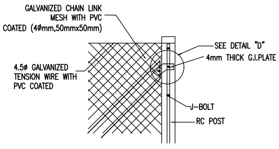
TYPICAL CORNER POST INSTALLATION
SCALE- 1:40



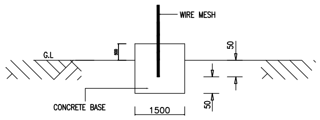
DETAIL OF CONCRETE FENCE POST
SCALE- 1:20



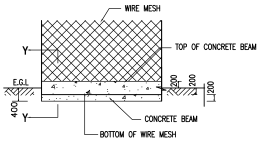
DETAIL "C" AND "D"
BRACE PLATE AT LINE BRACES
SCALE- 1:5



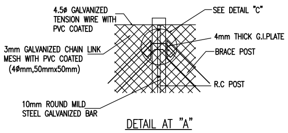
DETAIL AT "B"
SCALE- 1:20



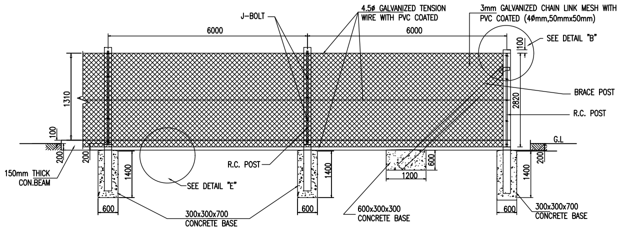
SECTION OF Y – Y
SCALE- 1:10



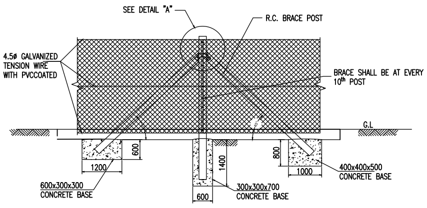
DETAIL AT "E"
SCALE- 1:20



DETAIL AT "A"
SCALE- 1:20



COMBINATION OF WIRE FENCE WITH CONCRETE POSTS
SCALE- 1:50



LINE BRACES
SCALE- 1:50

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Reach Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

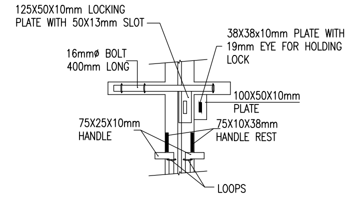
AS BUILT DRAWING
WIRE FENCE

Contractor
21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.
Building Construction,Management Designers &
Maintenance Contractors.

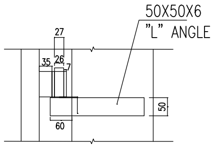
Office
519, 1st Floor,
Elvitigala Mawatha,
Narahenpita.

Tel: 0115927077
Fax: 0115927079
E.Mail: 21centurygroup.com

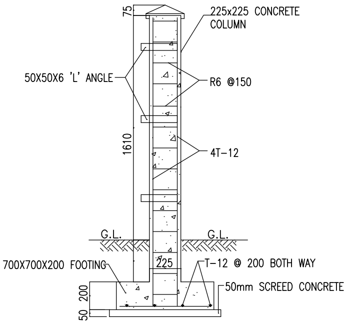
DRAWN BY Ranjan Fernando
CHECKED
SCALE AS INDICATED
DATE 20/09/2018
DRG. NO. 002



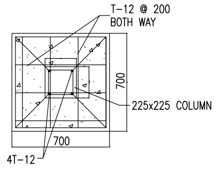
DETAIL 'B'
SCALE- 1:10



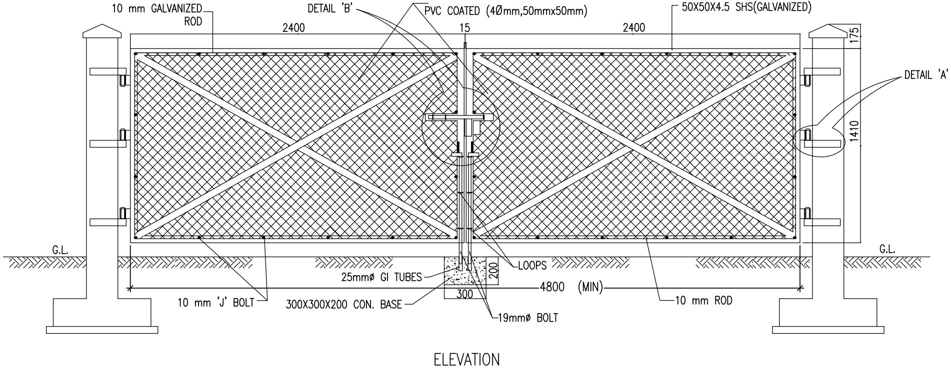
DETAIL 'A'
SCALE- 1:5



SECTION
SCALE- 1:25



PLAN
SCALE- 1:25



ELEVATION
SCALE- 1:25

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

AS BUILT DRAWING
DRIVEWAY GATE

Contractor
21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.
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Narahenpita.

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Fax: 0115927079
E.Mail: 21centurygroup.com

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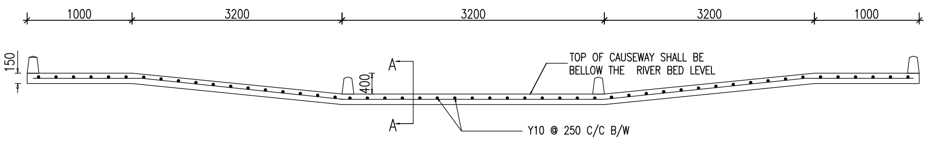
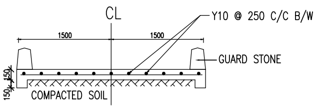
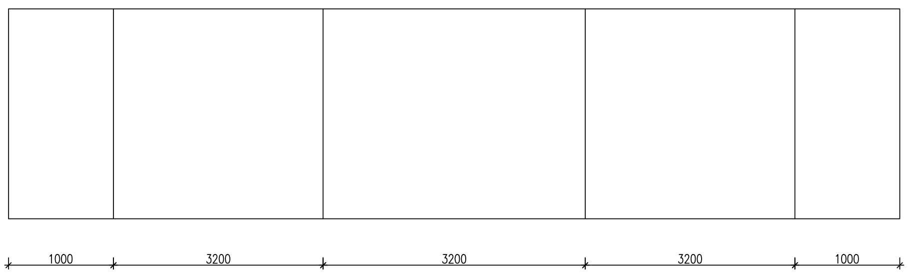
SCALE AS INDICATED
DATE 20/09/2018
DRG. NO. 003



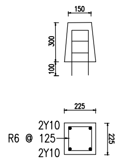
LONGITUDINAL SECTION OF CAUSEWAY
SCALE- 1:25



SECTION A-A
SCALE- 1:20



PLAN
SCALE- 1:25



DETAIL OF GUARD STONES
SCALE- 1:10

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

AS BUILT DRAWING
CAUSEWAY

Contractor
21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.
Building Construction,Management Designers &
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Office
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Narahenpita.

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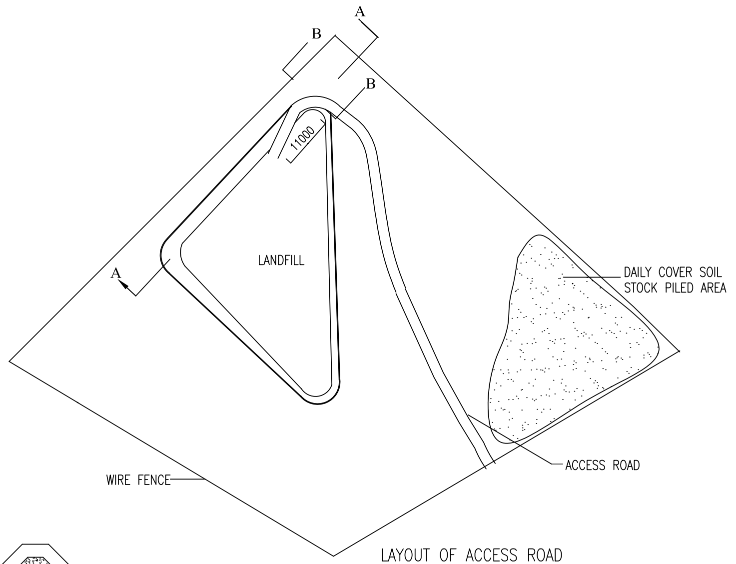
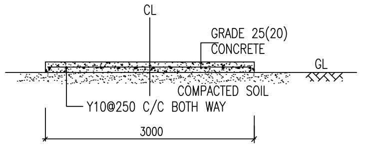
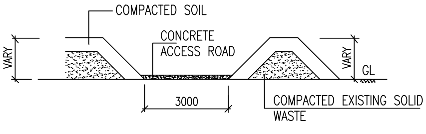


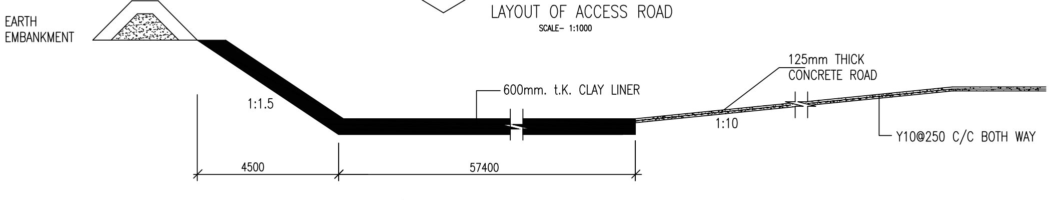
LAYOUT OF ACCESS ROAD
SCALE- 1:1000



CROSS SECTION OF ACCESS ROAD
SCALE- 1:50



SECTION B-B
SCALE- 1:20



SECTION A-A
SCALE- 1:20

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

AS BUILT DRAWING
ACCESS ROAD

Contractor
21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.
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Maintenance Contractors.

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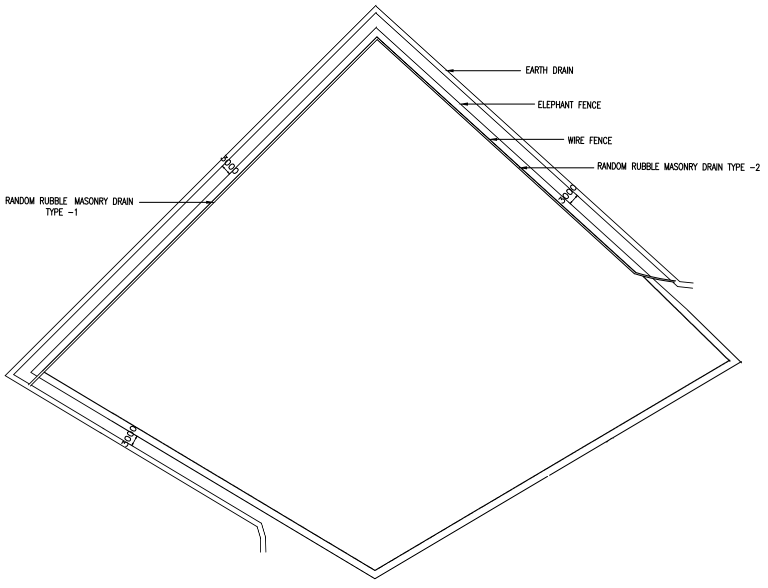
DATE 20/09/2018
DRG. NO. 005

Appendix 20



DRAIN LAYOUT
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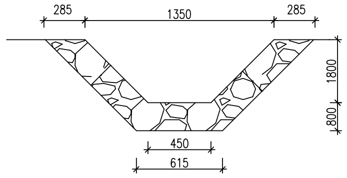
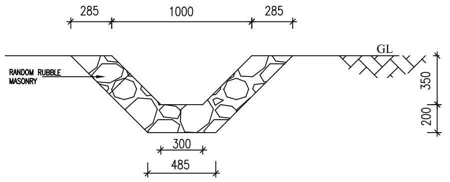
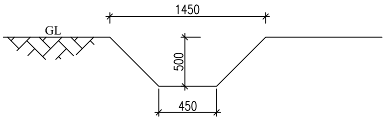


RUBBLE DRAIN
TYPE 2
SCALE- 1:20

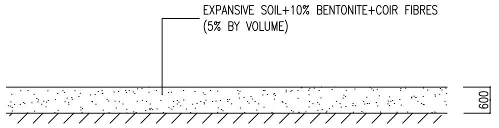


RUBBLE DRAIN
TYPE 1
SCALE- 1:20

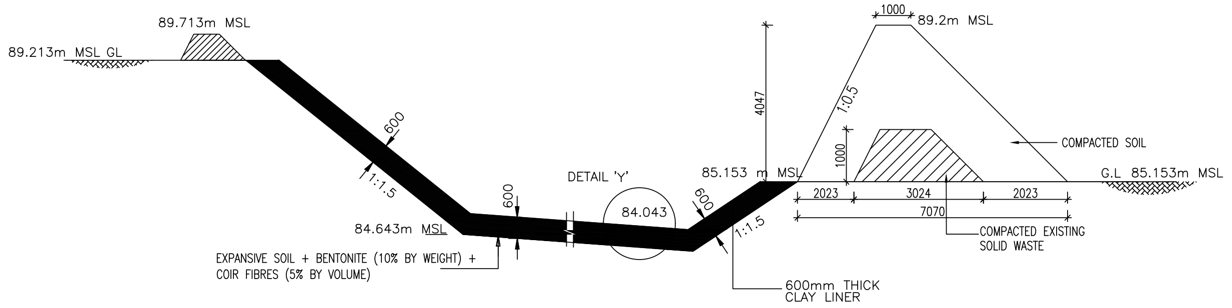


EARTH DRAIN
SCALE- 1:20

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE PRADESHIYA SABAHA AT KATARAGAMA.	Employer EX Research Institute Ltd. 104, Denzil Kobbakaduwa Mawatha. Battaramulla.	Engineer Dakshina Cost Consultant, No,9/2, Nawinna Road, Kahaduwatta, Galle.	AS BUILT DRAWING RUBBLE DRAIN & EARTH DRAIN	Contractor 21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD. Building Construction,Management Designers & Maintenance Contractors. Office 519, 1st Floor, Elvitigala Mawatha, Narahenpita. Tel: 0115927077 Fax: 0115927079 E.Mail: 21centurygroup.com	DRAWN BY Ranjan Fernando CHECKED SCALE AS INDICATED DATE 20/09/2018 DRG. NO. 006

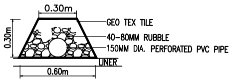


BED ROCK
SCALE- 1:10



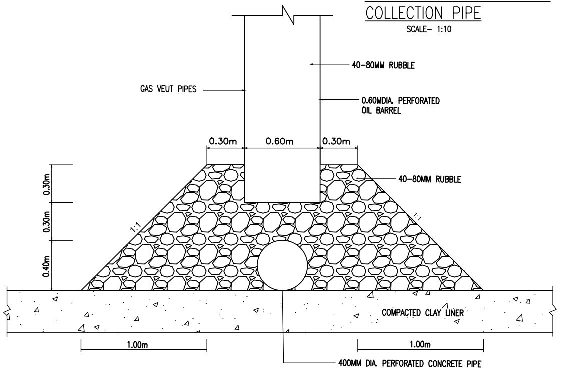
SECTION X-X
SCALE- 1:100

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE PRADESHIYA SABAHA AT KATARAGAMA.	Employer EX Research Institute Ltd. 104, Denzil Kobbakaduwa Mawatha. Battaramulla.	Engineer Dakshina Cost Consultant, No,9/2, Nawinna Road, Kahaduwatta, Galle.	AS BUILT DRAWING LAND FILL 2	21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD. Building Construction,Management Designers & Maintenance Contractors. Office 519, 1st Floor, Elvitigala Mawatha, Narahenpita. Tel: 0115927077 Fax: 0115927079 E.Mail: 21centurygroup.com	DRAWN BY Ranjan Fernando CHECKED SCALE AS INDICATED DATE 20/09/2018 DRG. NO. 007



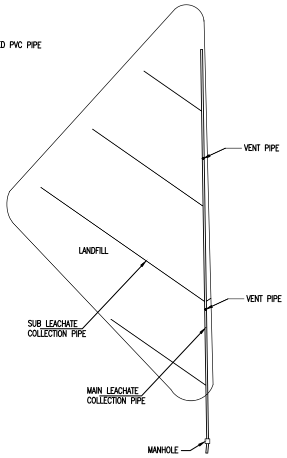
DETAILS OF SUB-LEACHATE COLLECTION PIPE

SCALE- 1:10



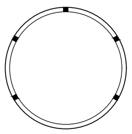
DETAIL OF VENT PIPE INSTALLATION

SCALE- 1:50



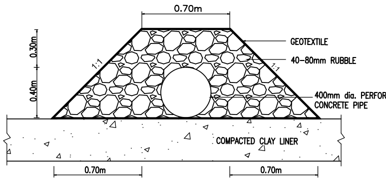
PLAN OF LEACHATE COLLECTION NETWORK

SCALE- 1:1000



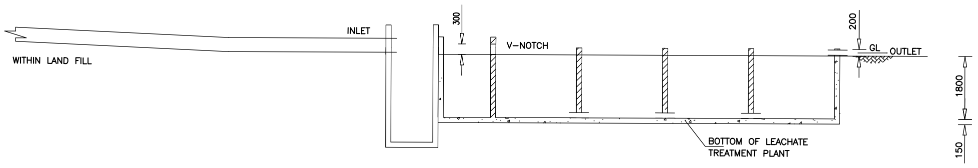
150MM DIA. PERFORATED PVC. PIPE

SCALE- 1:5



DETAIL OF MAIN LEACHAT PIPE INSTOLATION

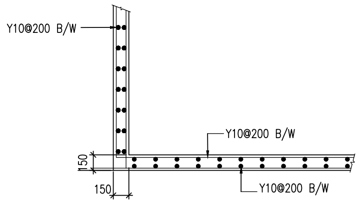
SCALE- 1:50



ELEVATION OF MAIN LEACHATE COLLECTION PIPE

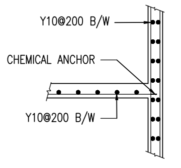
SCALE- 1:100

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE PRADESHIYA SABAHA AT KATARAGAMA.	**Employer** EX Research Institute Ltd. 104, Denzil Kobbakaduwa Mawatha. Battaramulla.	**Engineer** Dakshina Cost Consultant, No,9/2, Nawinna Road, Kahaduwatta, Galle.	AS BUILT DRAWING LEACHATE COLLECTION PIPES	**Contractor** 21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD. Building Construction,Management Designers & Maintenance Contractors. Office 519, 1st Floor, Elvitigala Mawatha, Narahenpita. Tel: 0115927077 Fax: 0115927079 E.Mail: 21centurygroup.com	DRAWN BY Ranjan Fernando CHECKED SCALE AS INDICATED DATE 20/09/2018 DRG. NO. 008



DETAIL @ 'A'

SCALE- 1:20



DETAIL @ 'B'

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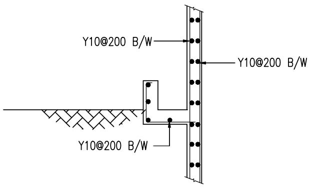
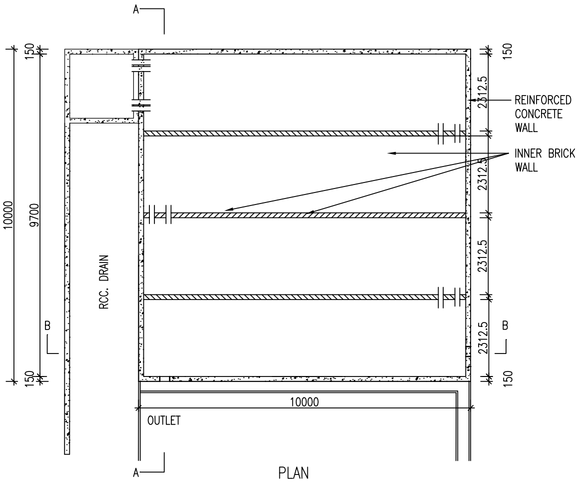


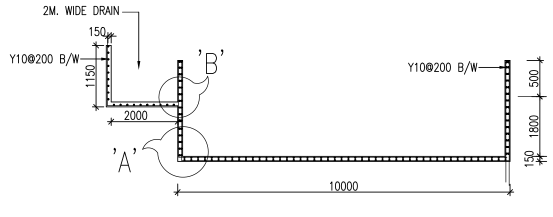
DETAIL @ 'C'

SCALE- 1:20



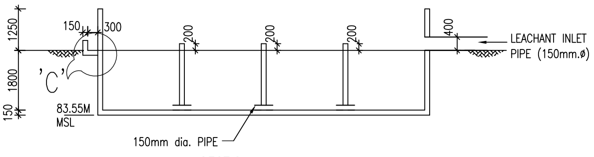
PLAN

SCALE- 1:100



SECTION B-B

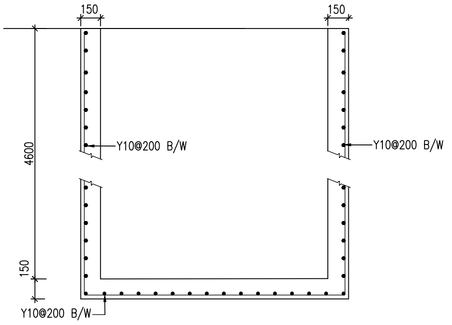
SCALE- 1:100



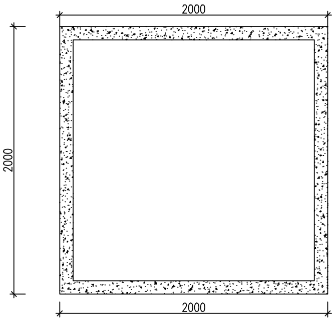
SECTION A-A

SCALE- 1:100

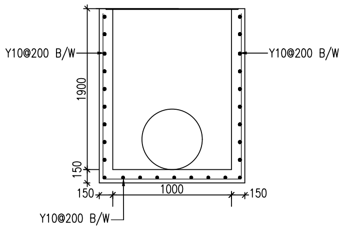
PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE PRADESHIYA SABAHA AT KATARAGAMA.	**Employer** EX Research Institute Ltd. 104, Denzil Kobbakaduwa Mawatha. Battaramulla.	**Engineer** Dakshina Cost Consultant, No,9/2, Nawinna Road, Kahaduwatta, Galle.	AS BUILT DRAWING LEACHANT TREATMENT PLANT	**21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.** Building Construction,Management Designers & Maintenance Contractors. Office 519, 1st Floor, Elvitigala Mawatha, Narahenpita. Tel: 0115927077 Fax: 0115927079 E.Mail: 21centurygroup.com	DRAWN BY Ranjan Fernando CHECKED SCALE AS INDICATED DATE 20/09/2018 DRG. NO. 009A



SECTION
SCALE- 1:100



PLAN OF LEACHATE COLLECTION TANK
SCALE- 1:100



SECTION
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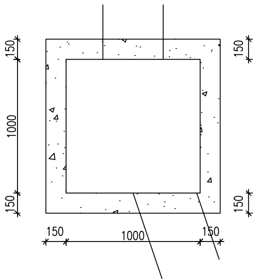

PLAN
MANHOLE
SCALE- 1:100

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

AS BUILT DRAWING
LEACHANT TREATMENT PLANT- 2

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Building Construction,Management Designers &
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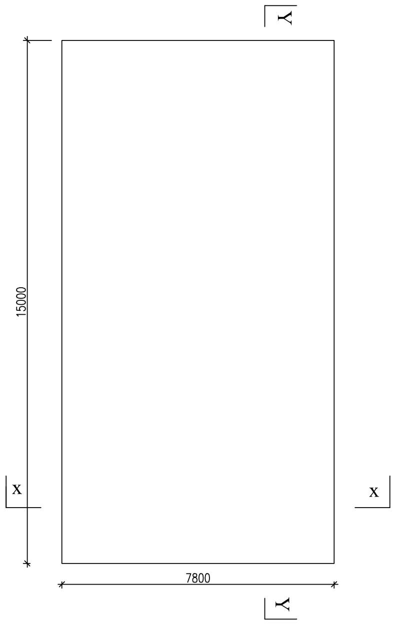
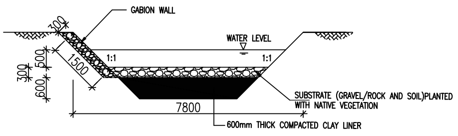
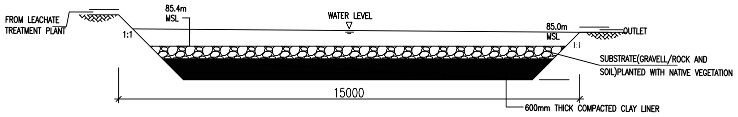


PLAN OF NATURAL WET LAND
SCALE- 1:100



SECTION X-X
SCALE- 1:50



SECTION Y-Y
SCALE- 1:50

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
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Kahaduwatta,
Galle.

AS BUILT DRAWING
WET LAND

Contractor
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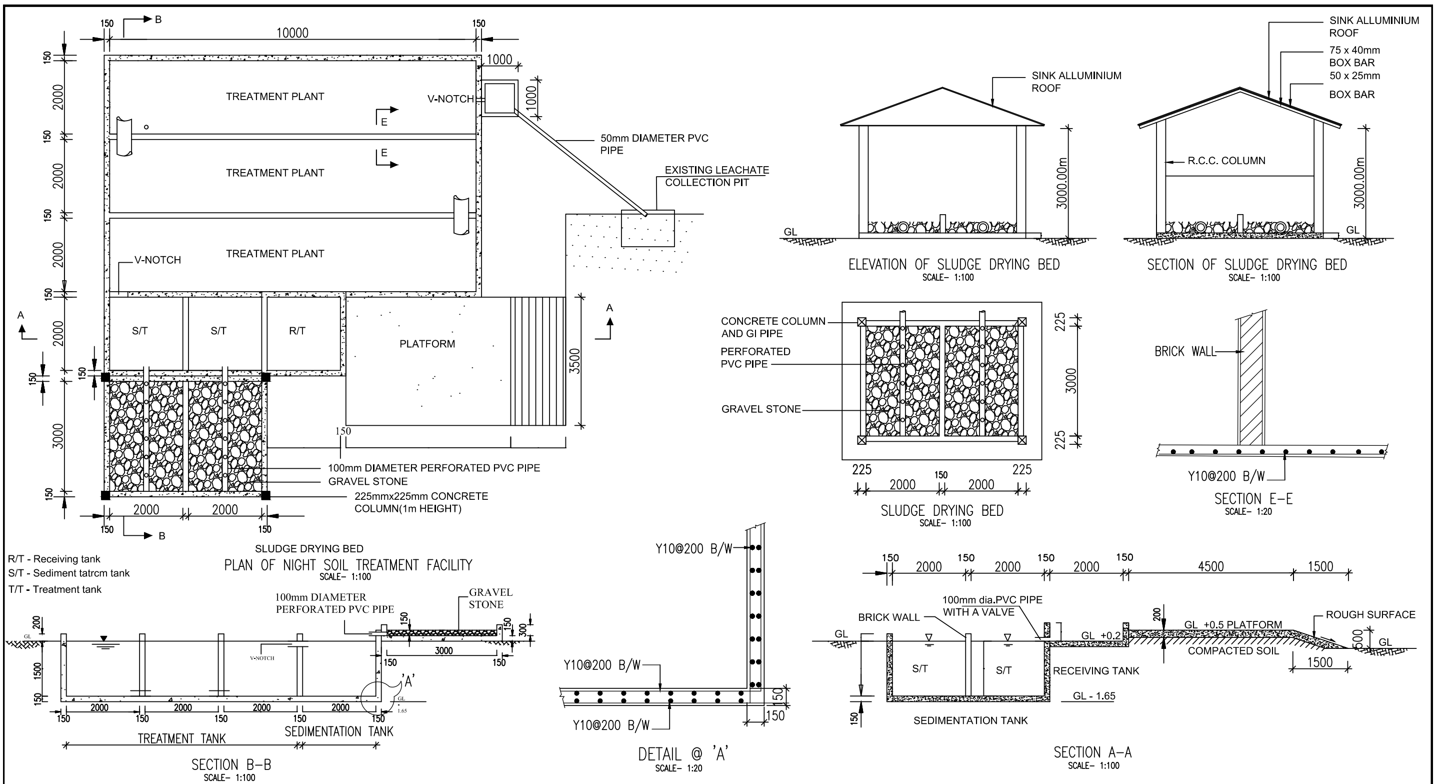

PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

AS BUILT DRAWING
NIGHT SOIL TREATMENT PLANT

21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.
Building Construction,Management Designers &
Maintenance Contractors.

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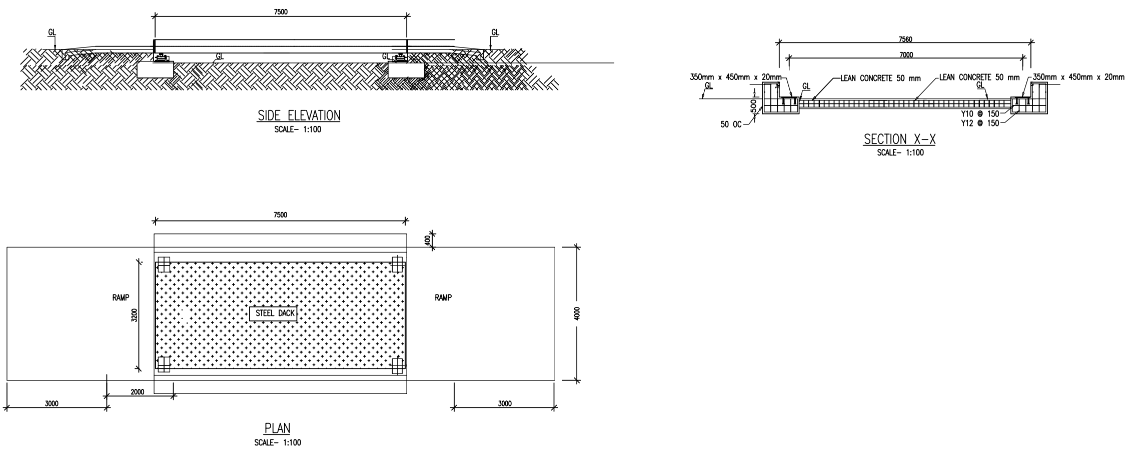
DATE 20/09/2018
DRG. NO. 0011



PROPOSED REHABILITATION GALPITAGALYAYA DISPOSAL SITE
PRADESHIYA SABAHA
AT KATARAGAMA.

Employer
EX Research Institute Ltd.
104, Denzil Kobbakaduwa Mawatha.
Battaramulla.

Engineer
Dakshina Cost Consultant,
No,9/2, Nawinna Road,
Kahaduwatta,
Galle.

AS BUILT DRAWING
WEIGH BRIDGE

21ST CENTARY PROPERTY DEVOLPMENT (PVT.) LTD.
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DATE 20/09/2018
DRG. NO. 0012

Monitoring Sheet for Compost Use

er Numl	Name and Surname	Address	Tel. Number	Installation Date
1				

Monitoring visit data

Date of visit Visited by :

1. Is it being used?	Details:
2. Has it ever been used?	
2.1 Why have they stopped using?	
2.2 What will they need to re-start using it?	
___ information leaflet ___ user group ___ instructor/advisor	
2.3 Are they willing to re-start using it?	
3. Any inappropoate waste in the bin	Details:
4. Are the wastes in proper size?	Details:
5.Have thay been mixed?	Details:

6. Any bad smell at an unexpected level?	Details:
7. Any unexpected insect or unexpected heat?	Details:
8. Is it unusually wet?	Details:

Any questions and comments given by the beneficiary

Any other observation

Operation and Maintenance of Permeable Reactive Barrier (PRB) and Leachate Treatment Facility in Kurunegala MC

Under the project of *Pollution Control and **Re**duction of Environmental **B**urden in Solid Waste Management (ReEB Waste)* by CEA with support of JICA

(Ver. 14th September2018)

Contents

1. Layout of PRB and Leachate Treatment Facility
2. Operation & Maintenance of PRB, Leachate Treatment Facility and Landfill Site
3. Required resource for Operation & Maintenance
4. Monitoring system

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1. Layout of PRB, Leachate Treatment Facility and Gentle Slope Landfill Site

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1. Layout of PRB and Leachate treatment system

Sundarapora municipal solid waste disposal site

---

2. Operation & Maintenance

---

2. 1 Operation & Maintenance of PRB

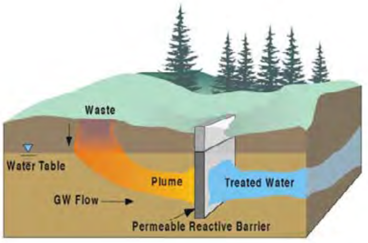
2. 1 Operation & Maintenance of PRB

- No regular operation and maintenance is required
- Regular underground water analysis at designated wells are required
- In case that heavy metals are detected at existing wells of households, PRB material should be replaced immediately.

2.Operation and Maintenance

2.1 Operation and Maintenance of PRB

(1) Structure of PRB

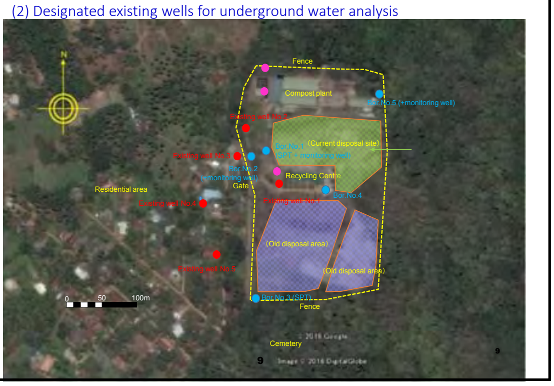


The PRB, one of in-situ methods for treating contaminated groundwater, is an emplacement of reactive media in the subsurface designed to intercept a contaminated plume, provide a flow path through the reactive media, and transform the contaminant(s) into environmentally acceptable forms to attain remediation concentration goals down-gradient of the barrier.

2.Operation and Maintenance

2.1 Operation and Maintenance of PRB

(2) Designated existing wells for underground water analysis

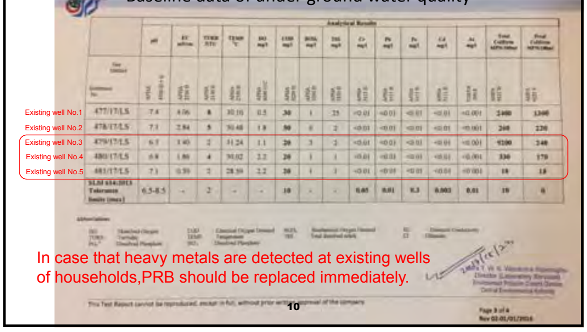


2.Operation and Maintenance

2.1 Operation and Maintenance of PRB

(3) Baseline data of underground water analysis at designated existing wells

Baseline data of under ground water quality



In case that heavy metals are detected at existing wells of households,PRB should be replaced immediately.

---

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

No.	Material	Description
1	Clay bricks	i. Made out of soil having > 90±5% of particles less than 2.00 mm through dry sieving ii. Common clay bricks hand or machine molded iii. Burnt in kiln at 600 °C to 900 °C for minimum of 3 hours iv. Dimensions L= 210±3 mm; D=72±3; W=140±3 v. Maximum allowable water content is 4% by weight vi. Allow to use broken/shattered clay bricks, if appropriate qualities are achieved and appropriate quantities are supplied in accordance with clauses 1-iv.
2	Coconut shell charcoal particles	i. Made out of coconut shell burnt at 400 °C to 600 °C for minimum of 0.5 hours ii. Free from unburnt coconut shell particles (maximum allowable unburnt particles = 5% by dry weight) iii. Free from soil, sand or any other inert particles (maximum allowable unburnt particles = 2% by dry weight) iv. Maximum allowable water content is 10% by weight
3	Bangadeniya soil	i. Soil having > 100% of particles less than 2.00 mm through sieving ii. Soil having at least 40% clay by dry weight iii. Maximum available field water content of 30% by weight iv. Maximum allowable organic matter content of 2% by weight v. Sourced from clay mines of Alluvial deposits (Entisol) in Bangadeniya

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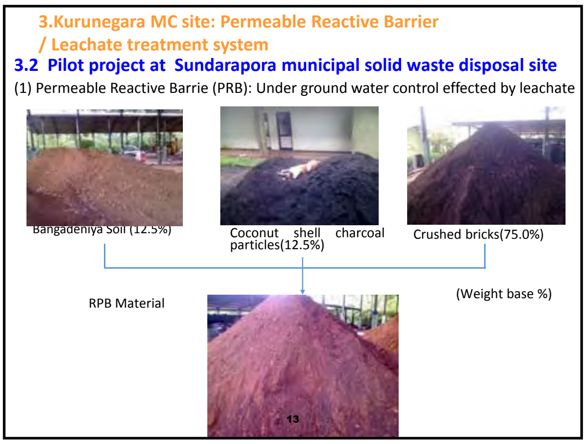
Table 0-1 Mixing ratio and longevity of PRB materials

Criteria	Units	Bangadeniya Soil (25%) + Charcoal powder (25%) + Brick particles (50%)			Bangadeniya Soil (12.5%) + Charcoal powder (12.5%) + Brick particles (75%)		
Degree of compaction	%	Dr= 75	Dr= 80	Dr= 90	Dr= 75	Dr= 80	Dr= 90
Hydraulic conductivity	cm/s	2.00E-03	7.00E-04	3.30E-05	2.50E-03	2.40E-03	9.80E-04
Heavy metal adsorption	mg/year	3.10E+05	1.10E+05	5.30E+03	3.90E+05	3.80E+05	1.50E+05
Dry bulk density	g/cm³	0.93	1.06	1.19	0.92	1.05	1.20
Heavy metal removal	mg/m³	2.10E+06	2.40E+06	2.70E+06	2.40E+06	2.80E+06	3.20E+06
Expected lifetime	Years/m³	6.90	22.00	523.00	6.20	7.30	20.50

after Saito et al., [2016] and Kawamoto et al., [2016]



3.Kurunegara MC site: Permeable Reactive Barrier / Leachate treatment system

3.2 Pilot project at Sundarapora municipal solid waste disposal site

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

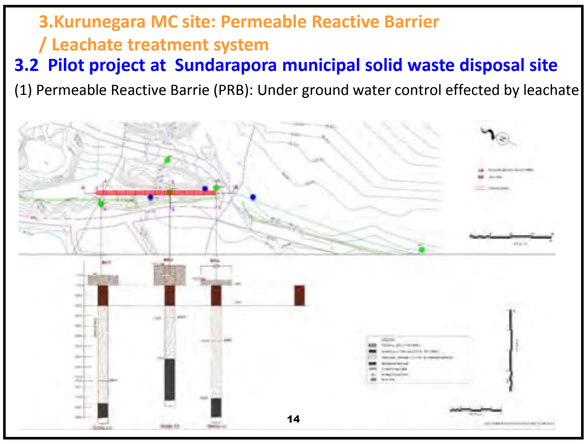
Bangadeniya Soil (12.5%)

Coconut shell charcoal particles(12.5%)

Crushed bricks(75.0%)

RPB Material

(Weight base %)



3.Kurunegara MC site: Permeable Reactive Barrier / Leachate treatment system

3.2 Pilot project at Sundarapora municipal solid waste disposal site

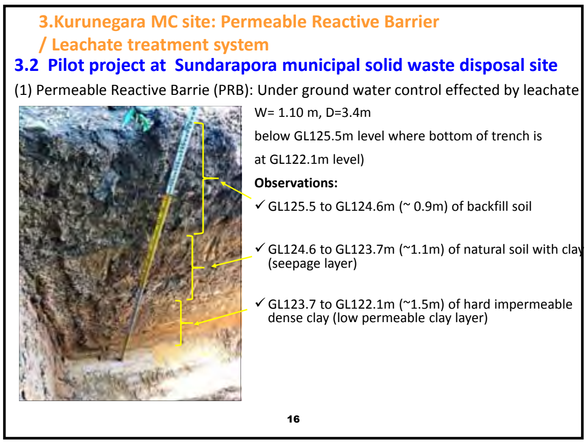
(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

3.Kurunegara MC site: Permeable Reactive Barrier / Leachate treatment system

3.2 Pilot project at Sundarapora municipal solid waste disposal site

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

Excavation of PRB trench



3.Kurunegara MC site: Permeable Reactive Barrier / Leachate treatment system

3.2 Pilot project at Sundarapora municipal solid waste disposal site

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

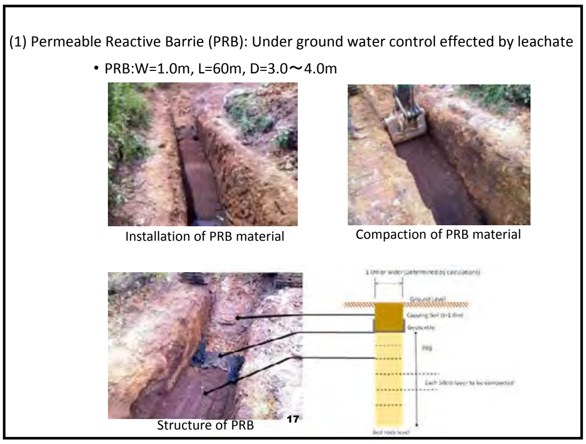
W= 1.10 m, D=3.4m

below GL125.5m level where bottom of trench is

at GL122.1m level)

Observations:

- ✓ GL125.5 to GL124.6m (~ 0.9m) of backfill soil
- ✓ GL124.6 to GL123.7m (~1.1m) of natural soil with clay (seepage layer)
- ✓ GL123.7 to GL122.1m (~1.5m) of hard impermeable dense clay (low permeable clay layer)



(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

- PRB:W=1.0m, L=60m, D=3.0〜4.0m

Installation of PRB material

Compaction of PRB material

Structure of PRB

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

Filling the excavated trench with PRB mixture (~ 3.5 m of length)

Taking core samples from first compacted layer (~0.5m from bottom). Core sample (S1) was taken from extended arm core sampling device. Observed small quantity of water seepage from either side of the trench.

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

Filling the second layer on top of first PRB layer (~0.5m and compaction by excavator bucket).

Core sample (S2) was taken from second compacted layer.

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

PRB filling on third layer (~0.5m)

Taking core sample from third compacted layer (S3).

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

Filling the forth layer (0.5m).

After filling up to final height (124.5m) that is 1.0m below the 125.5m surface level.

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

Tamping by steel tamper (~ 10kg) for compaction and smooth finishing.

Core sampling on the finished layer (S4, S5, S6). The finished section was having a width of 1.10m and length of 1.5m.

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

Laying the separation geotextile before backfilling with excavated clay soil.

After backfilling by clay soil. Filling is only halfway for demonstration purpose. The clay soil layer has not compacted to surface level (125.5m) yet to avoid collapsing.

(1) Permeable Reactive Barrie (PRB): Under ground water control effected by leachate

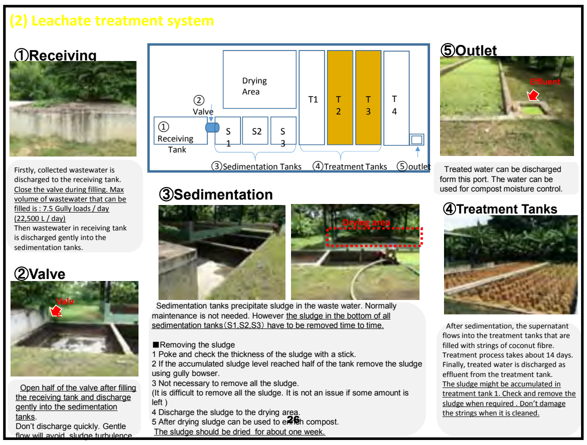
Laboratory testing of bulk density and water content

Sample	Wt of wet soil (g)	Dry weight of soil (g)	Water content (%) (Wb)	Water content (%) (Db)	Core volume (cm^3)	Wet Bulk density (kg/m^3)	Dry Bulk density (kg/m^3)
S1	166.0	123.0	25.9	35.0	98.8	1.680	**1.245**
S2	126.0	110.0	12.7	14.5	98.2	1.283	**1.120**
S3	125.0	110.0	12.0	13.6	98.2	1.273	**1.120**
S4	118.0	104.0	11.9	13.5	98.6	1.197	**1.055**
S5	126.0	110.0	12.7	14.5	98.2	1.283	**1.120**
S6	123.0	107.0	13.0	15.0	98.2	1.253	**1.090**

- The bottom layer (S1) has slightly over compacted. However all other layers has achieved required level of compaction 1.0-1.1 kg/m^3)
- Except the bottom layer (S1), water content is also within the acceptable limit below 27%.
- The higher compaction at the bottom layer might have caused by additional compaction effort. Thus care shall be taken when the deep layers are compacted by excavator.

2.2 Operation & Maintenance of

Leachate Treatment Facility



(2) Leachate treatment system

①Receiving

Firstly, collected wastewater is discharged to the receiving tank. <u>Close the valve during filling. Max volume of wastewater that can be filled is : 7.5 Gully loads / day (22,500 L / day)</u>
Then wastewater in receiving tank is discharged gently into the sedimentation tanks.

②Valve

<u>Open half of the valve after filling the receiving tank and discharge gently into the sedimentation tanks</u>.
Don't discharge quickly. Gentle flow will avoid sludge turbulence

③Sedimentation

Sedimentation tanks precipitate sludge in the waste water. Normally maintenance is not needed. However <u>the sludge in the bottom of all sedimentation tanks（S1,S2,S3）have to be removed time to time.</u>

■Removing the sludge
1 Poke and check the thickness of the sludge with a stick.
2 If the accumulated sludge level reached half of the tank remove the sludge using gully bowser.
3 Not necessary to remove all the sludge.
(It is difficult to remove all the sludge. It is not an issue if some amount is left)
4 Discharge the sludge to the drying area.
5 After drying sludge can be used to enrich compost.
<u>The sludge should be dried for about one week.</u>

⑤Outlet

Treated water can be discharged form this port. The water can be used for compost moisture control.

④Treatment Tanks

After sedimentation, the supernatant flows into the treatment tanks that are filled with strings of coconut fibre. Treatment process takes about 14 days. Finally, treated water is discharged as effluent from the treatment tank.
<u>The sludge might be accumulated in treatment tank 1. Check and remove the sludge when required . Don't damage the strings when it is cleaned.</u>

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2. 3 Operation & Maintenance

for

Making Gentle Slope

3. Rehabilitation Plan of existing waste disposal site

3.3 Making gentle slope and turfing
(Design is supported by ReEB Waste project team)

Image (1): making gentle slope and turfing
(Before rehabilitation)

Image(2): making gentle slope and turfing
(making gentle slope)


Image(3): making gentle slope and turfing
(making gentle slope and covering soil)


Image (4): making gentle slope and turfing
(making gentle slope, covering soil and turfing)


Image (5): making gentle slope and turfing
(turfing)


Image (6): making gentle slope and turfing
(completion)

3. Required resource for Operation & Maintenance

3. Required resource for Operation & Maintenance

3.1 Landfill site

- Engineer and/or Technical Officer
- Site manager:1
- Woker:1
- Security: daytime 1, night time 2
- JCB, Lorry

	Operation and Maintenance	Frequency	
0	General management of landfill site	Regularly	Engineer and/or Technical Officer
1	Instruction of discharge place for collection vehicle	Every day	Site manager
2	Regular covering soil	Once a week	JCB:1 Lorry or tractor:1
3	Cleaning the site	Every day	Worker: 1
4	Security	24hrs	Daytime:1, Night time:2
5	Maintain the electric fence	Every day	Worker:1
6	Maintain the drainage	Once a week	Woker:1
7	Maintain the slope (turfing)	Regularly	Worker
8	Maintain the access road	Regularly	Worker
9	Maintain the leachate treatment facility	Regularly	Worker

3. Required resource for Operation & Maintenance

3.2 Compost plant

- Site manager
- Workers:
- Drivers:
- Operator of weight bridge:1
- Security: daytime 1, night time 2
- JCB, Lorry

	Operation and Maintenance	Frequency	
0	General management of compost plant	Regularly	Technical Officer
1	Instruction of compost plant operation	Every day	Site manager
2	Regular composting work	Every day	Workers
3	Operation of weight bridge	Every day	Operator
4	Cleaning the site	Every day	Worker:
5	Security	24hrs	Daytime/ Night time
6	Maintain the facility inc. gully suck treatment facility	Regularly	Worker

4. Monitoring system

4.1 Establishment of Monitoring Committee

4.Monitoring system

4.1 Establishment of Monitoring Committee

The objectives of the monitoring

1. Empowerment
   To continuously ensure the good landfill and compost site operation.
2. Accountability
   To prove the good landfill and compost plant operation to other peoples.

4.Monitoring system

4.1 Establishment of Monitoring Committee

Monitoring Committee member

The monitoring committee consisting of:

- Chief Priest of the ####### Village Temple.
- Chairman: Chairman- KPS
- Health Committee Chairmen - KPS
- PS Secretory- KPS
- Medical Officer of Health- District office
- Chief Public Health Inspector/ Public Health Inspector- District office
- Health Supervisor - NEMC
- A officer from Wildlife Department
- District Forest Officer
- Environment Officer- CEA
- Grama Niladari (GS)- Moon plains

4.Monitoring system

4.2 Execution of Monitoring

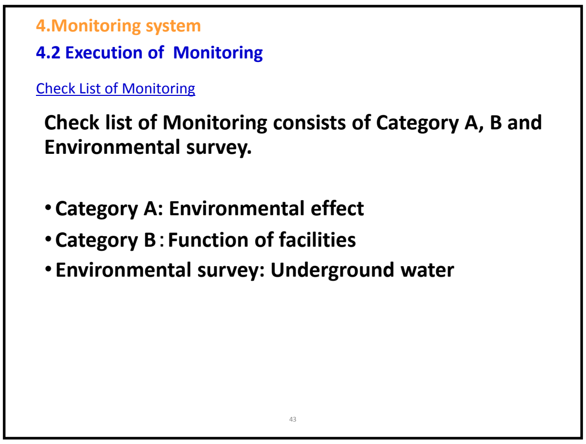
- ■The committee members shall jointly monitor and evaluate the landfill operation based on the check list.
- ■The monitoring report shall be publicized.

(1) Frequency of monitoring in accordance with the check list (Category A, B)

Period	Frequency
• First six month after start operation of landfill	every month
• Second six month after start operation of landfill	every two month

(2) Frequency of environmental survey (underground water quality)

Period	Frequency
• First year after start operation of landfill	every 6 months
• From second year after start operation of landfill	Once a yare



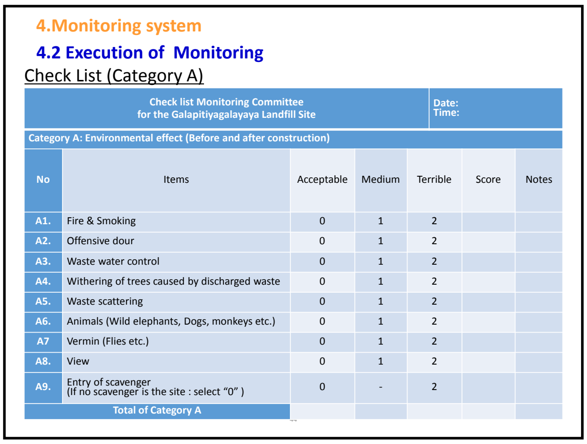
4.Monitoring system

4.2 Execution of Monitoring

Check List of Monitoring

Check list of Monitoring consists of Category A, B and Environmental survey.

- **Category A: Environmental effect**
- **Category B：Function of facilities**
- **Environmental survey: Underground water**

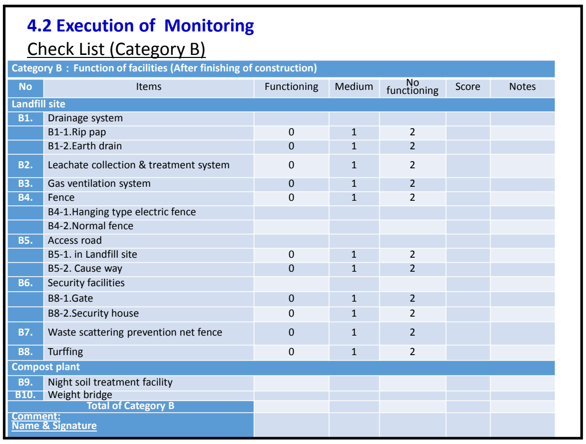


4.Monitoring system

4.2 Execution of Monitoring

Check List (Category A)

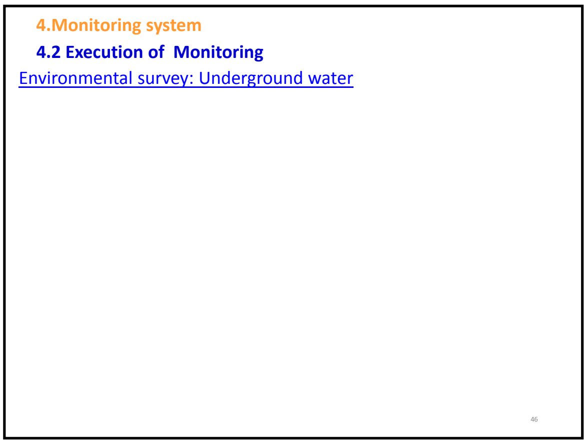
Check list Monitoring Committee for the Galapitiyagalayaya Landfill Site						Date: Time:
Category A: Environmental effect (Before and after construction)						
No	Items	Acceptable	Medium	Terrible	Score	Notes
A1.	Fire & Smoking	0	1	2		
A2.	Offensive dour	0	1	2		
A3.	Waste water control	0	1	2		
A4.	Withering of trees caused by discharged waste	0	1	2		
A5.	Waste scattering	0	1	2		
A6.	Animals (Wild elephants, Dogs, monkeys etc.)	0	1	2		
A7	Vermin (Flies etc.)	0	1	2		
A8.	View	0	1	2		
A9.	Entry of scavenger (If no scavenger is the site : select “0”)	0	-	2		
Total of Category A						



4.2 Execution of Monitoring

Check List (Category B)

Category B：Function of facilities (After finishing of construction)						
No	Items	Functioning	Medium	No functioning	Score	Notes
Landfill site						
B1.	Drainage system					
	B1-1.Rip pap	0	1	2		
	B1-2.Earth drain	0	1	2		
B2.	Leachate collection & treatment system	0	1	2		
B3.	Gas ventilation system	0	1	2		
B4.	Fence	0	1	2		
	B4-1.Hanging type electric fence					
	B4-2.Normal fence					
B5.	Access road					
	B5-1. in Landfill site	0	1	2		
	B5-2. Cause way	0	1	2		
B6.	Security facilities					
	B8-1.Gate	0	1	2		
	B8-2.Security house	0	1	2		
B7.	Waste scattering prevention net fence	0	1	2		
B8.	Turffing	0	1	2		
Compost plant						
B9.	Night soil treatment facility					
B10.	Weight bridge					
Total of Category B						
Comment: **Name & Signature**						



4.Monitoring system

4.2 Execution of Monitoring

Environmental survey: Underground water

Operation and Maintenance of Landfill site and Compost plant in Kataragama

Under the project of *Pollution Control and **Re**duction of **E**nvironmental **B**urden in Solid Waste Management (ReEB Waste)*
by CEA with support of JICA

(Ver. 11th September2018)

Contents

1. Layout of Landfill Site
2. Operation & Maintenance of landfill site and compost plant
3. Required resource for Operation & Maintenance
4. Monitoring system

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1. Layout of Landfill Site

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1. Layout of landfill site

1.1 Galapitagalayaya municipal solid waste disposal site

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2. Operation & Maintenance of landfill site and compost plant

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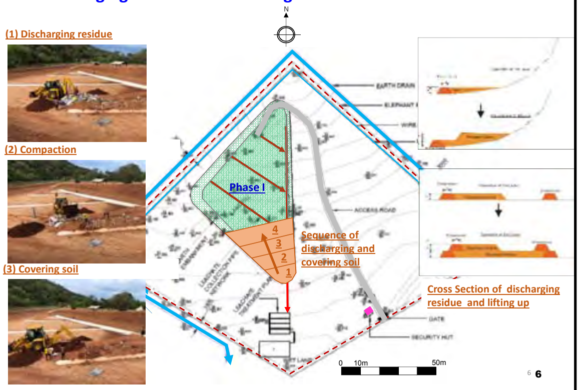
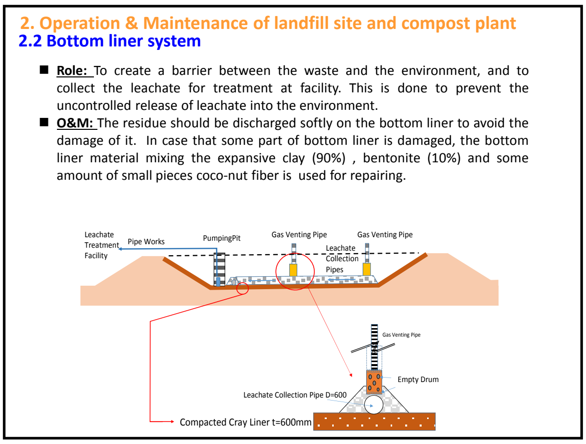
2. Operation & Maintenance of landfill site and compost plant

2.1 Discharging residue and covering soil

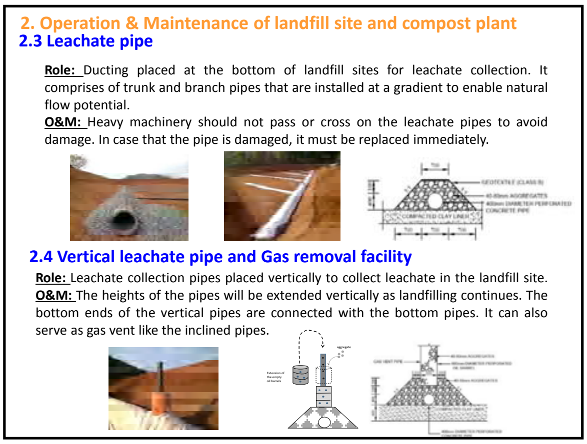




2. Operation & Maintenance of landfill site and compost plant

2.2 Bottom liner system

- **Role:** To create a barrier between the waste and the environment, and to collect the leachate for treatment at facility. This is done to prevent the uncontrolled release of leachate into the environment.
- **O&M:** The residue should be discharged softly on the bottom liner to avoid the damage of it. In case that some part of bottom liner is damaged, the bottom liner material mixing the expansive clay (90%) , bentonite (10%) and some amount of small pieces coco-nut fiber is used for repairing.



2. Operation & Maintenance of landfill site and compost plant

2.3 Leachate pipe

Role: Ducting placed at the bottom of landfill sites for leachate collection. It comprises of trunk and branch pipes that are installed at a gradient to enable natural flow potential.

O&M: Heavy machinery should not pass or cross on the leachate pipes to avoid damage. In case that the pipe is damaged, it must be replaced immediately.

2.4 Vertical leachate pipe and Gas removal facility

Role: Leachate collection pipes placed vertically to collect leachate in the landfill site.

O&M: The heights of the pipes will be extended vertically as landfilling continues. The bottom ends of the vertical pipes are connected with the bottom pipes. It can also serve as gas vent like the inclined pipes.

2. Operation & Maintenance of landfill site and compost plant

2.5 Leachate treatment facility

Role: To treat collected leachate with local available material.

O&M:

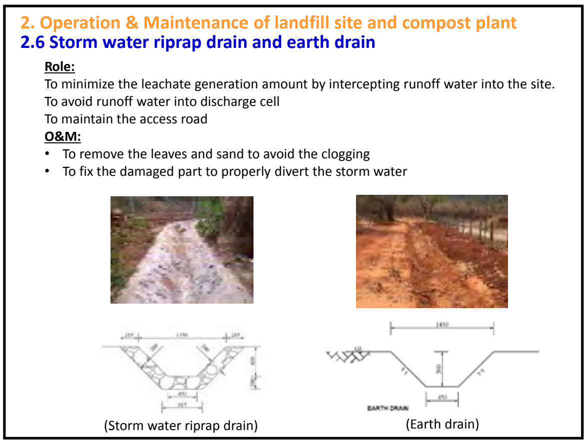
(Coco-nut fiber treatment system)

- To Cover mesh on the treatment tank to avoid leaves and scattered waste
- To remove sludge from manhole and treatment tank
- To replace the coco-nut fiver every 5-7 years

(Vegetation Purification Process-wetland)

- Maintain the plant and remove the scattered waste

(Coco-nut fiber treatment system and manhole) (Vegetation Purification Process-wetland)



2. Operation & Maintenance of landfill site and compost plant

2.6 Storm water riprap drain and earth drain

Role:

To minimize the leachate generation amount by intercepting runoff water into the site.

To avoid runoff water into discharge cell

To maintain the access road

O&M:

- To remove the leaves and sand to avoid the clogging
- To fix the damaged part to properly divert the storm water

(Storm water riprap drain) (Earth drain)

2. Operation & Maintenance of landfill site and compost plant

2.7 Main gate, security house and Access road

Role:

(Main gate and security house)

To control of illegal dumping and wild animals

To instruct the proper discharge place

(Access road)

To sustain the proper waste transportation to discharge place

O&M:

(Main gate and security house)

- To open the gate when the designated vehicles come to the site
- To record the number of designated vehicles

(Access road)

- To check and fix the damage part regularly.

(Main gate and security house) (Access road)

2. Operation & Maintenance of landfill site and compost plant

2.9 Turffing

2.10 Taking care of slope inside of the landfill site

2. Operation & Maintenance of landfill site and compost plant

2.8 Night soil treatment facility and weight bridge at compost plant

Role:

(Night soil treatment facility)

To treat night soil with local available material.

(Weight bridge)

Weigh bridge systems provide sufficient gate management and recording actual weight data of the waste to be loaded to the site.

O&M:

(Night soil treatment system)

- To Cover mesh on the treatment tank to avoid leaves and scattered waste
- To remove sludge from manhole and treatment tank
- To replace the coco-nut fiver every 5-7 years

(Weight bridge)

- To weight and record all in coming waste and residue for disposal site.

(Night soil treatment facility)

(Weight bridge)

3. Required resource for Operation & Maintenance

3. Required resource for Operation & Maintenance

3.1 Landfill site

- Engineer and/or Technical Officer
- Site manager:1
- Woker:1
- Security: daytime 1, night time 2
- JCB, Lorry

	Operation and Maintenance	Frequency	
0	General management of landfill site	Regularly	Engineer and/or Technical Officer
1	Instruction of discharge place for collection vehicle	Every day	Site manager
2	Regular covering soil	Once a week	JCB:1 Lorry or tractor:1
3	Cleaning the site	Every day	Worker: 1
4	Security	24hrs	Daytime:1, Night time:2
5	Maintain the electric fence	Every day	Worker:1
6	Maintain the drainage	Once a week	Woker:1
7	Maintain the slope (turffing)	Regularly	Worker
8	Maintain the access road	Regularly	Worker
9	Maintain the leachate treatment facility	Regularly	Worker

3. Required resource for Operation & Maintenance

3.2 Compost plant

- Site manager
- Workers:
- Drivers:
- Operator of weight bridge:1
- Security: daytime 1, night time 2
- JCB, Lorry

	Operation and Maintenance	Frequency	
0	General management of compost plant	Regularly	Technical Officer
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3	Operation of weight bridge	Every day	Operator
4	Cleaning the site	Every day	Worker:
5	Security	24hrs	Daytime/ Night time
6	Maintain the facility inc. gully suck treatment facility	Regularly	Worker

4. Monitoring system

4.1 Establishment of Monitoring Committee

4.Monitoring system

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The objectives of the monitoring

1. Empowerment
   To continuously ensure the good landfill and compost site operation.
2. Accountability
   To prove the good landfill and compost plant operation to other peoples.

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The monitoring committee consisting of:

- Chief Priest of the ####### Village Temple.
- Chairman: Chairman- KPS
- Health Committee Chairmen - KPS
- PS Secretory- KPS
- Medical Officer of Health- District office
- Chief Public Health Inspector/ Public Health Inspector- District office
- Health Supervisor - NEMC
- A officer from Wildlife Department
- District Forest Officer
- Environment Officer- CEA
- Grama Niladari (GS)- Moon plains

4.Monitoring system

4.2 Execution of Monitoring

■The committee members shall jointly monitor and evaluate the landfill operation based on the check list.

■The monitoring report shall be publicized.

(1) Frequency of monitoring in accordance with the check list (Category A, B)

Period	Frequency
• First six month after start operation of landfill	every month
• Second six month after start operation of landfill	every two month

(2) Frequency of environmental survey (underground water quality)

Period	Frequency
• First year after start operation of landfill	every 6 months
• From second year after start operation of landfill	Once a yare

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4.Monitoring system

4.2 Execution of Monitoring

Check List of Monitoring

Check list of Monitoring consists of Category A, B and Environmental survey.

- **Category A: Environmental effect**
- **Category B : Function of facilities**
- **Environmental survey: Underground water**

4.Monitoring system

4.2 Execution of Monitoring

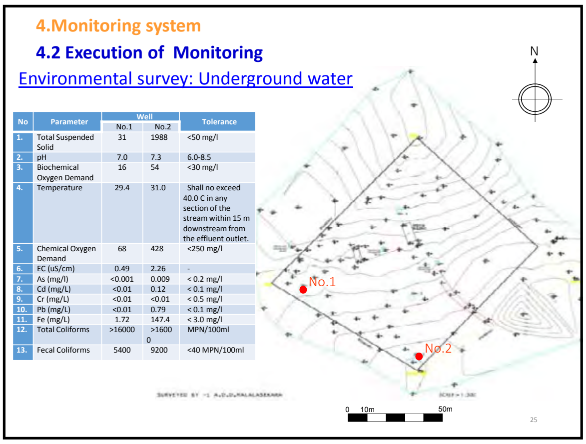
Check List (Category A)

Check list Monitoring Committee for the Galapitiyagalayaya Landfill Site						Date: Time:
Category A: Environmental effect (Before and after construction)						
No	Items	Acceptable	Medium	Terrible	Score	Notes
A1.	Fire & Smoking	0	1	2		
A2.	Offensive dour	0	1	2		
A3.	Waste water control	0	1	2		
A4.	Withering of trees caused by discharged waste	0	1	2		
A5.	Waste scattering	0	1	2		
A6.	Animals (Wild elephants, Dogs, monkeys etc.)	0	1	2		
A7	Vermin (Flies etc.)	0	1	2		
A8.	View	0	1	2		
A9.	Entry of scavenger (If no scavenger is the site : select "0")	0	-	2		
Total of Category A						

4.2 Execution of Monitoring

Check List (Category B)

Category B : Function of facilities (After finishing of construction)						
No	Items	Functioning	Medium	No functioning	Score	Notes
Landfill site						
B1.	Drainage system					
	B1-1.Rip pap	0	1	2		
	B1-2.Earth drain	0	1	2		
B2.	Leachate collection & treatment system	0	1	2		
B3.	Gas ventilation system	0	1	2		
B4.	Fence	0	1	2		
	B4-1.Hanging type electric fence					
	B4-2.Normal fence					
B5.	Access road					
	B5-1. in Landfill site	0	1	2		
	B5-2. Cause way	0	1	2		
B6.	Security facilities					
	B8-1.Gate	0	1	2		
	B8-2.Security house	0	1	2		
B7.	Waste scattering prevention net fence	0	1	2		
B8.	Turffing	0	1	2		
Compost plant						
B9.	Night soil treatment facility					
B10.	Weight bridge					
Total of Category B						
Comment: **Name & Signature**						



4.Monitoring system

4.2 Execution of Monitoring

Environmental survey: Underground water

No	Parameter	Well		Tolerance
		No.1	No.2	
1.	Total Suspended Solid	31	1988	<50 mg/l
2.	pH	7.0	7.3	6.0-8.5
3.	Biochemical Oxygen Demand	16	54	<30 mg/l
4.	Temperature	29.4	31.0	Shall no exceed 40.0 C in any section of the stream within 15 m downstream from the effluent outlet.
5.	Chemical Oxygen Demand	68	428	<250 mg/l
6.	EC (uS/cm)	0.49	2.26	-
7.	As (mg/l)	<0.001	0.009	< 0.2 mg/l
8.	Cd (mg/L)	<0.01	0.12	< 0.1 mg/l
9.	Cr (mg/L)	<0.01	<0.01	< 0.5 mg/l
10.	Pb (mg/L)	<0.01	0.79	< 0.1 mg/l
11.	Fe (mg/L)	1.72	147.4	< 3.0 mg/l
12.	Total Coliforms	>16000	>16000	MPN/100ml
13.	Fecal Coliforms	5400	9200	<40 MPN/100ml

The result of WACS at Katharagama PS

Zone 3

Type of material	Physical composition (g)											
	1at day (Bio)	2nd day (Non-bio)	3rd day (Bio)	4th. Day (Recyclable)	5th Day (Non-bio)	6th Day (Bio)	7th Day (Non-bio)	8th Day (Bio)	9th Day (Bio)	Total	Average	Rate
	12/11/2018	13/11/2018	14/11/2018	14/11/2018	15/11/2018	16/11/2018	17/11/2018	18/11/2018	19/11/2018	(g)	(g)	(%)
Kitchen Waste (Bio)	1567.0	20.3	1016.5	0	0.0	149.0	0.0	594.8	838.8	4186.4	523.30	46.6
Kitchen Waste (Non-Bio)	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
King coconut combs	4.5	0.0	8.5	3.8	0.0	28.8	0.0	0.0	44.9	86.7	10.84	1.0
Grass and Wood	160.2	0.0	744.3	0	0.0	1424.5	0.0	1328.2	609.0	4266.2	533.27	47.5
Paper	53.1	0.3	93.2	36.2	3.0	0.0	5.2	94.5	58.0	307.3	38.41	3.4
Textile	2.8	0.4	4.5	0	2.5	0.0	1.8	0.0	4.7	16.7	2.09	0.2
Soft Plastic	2.8	3.6	0.0	0	34.1	0.0	41.0	0.0	0.0	81.5	10.18	0.9
Hard Plastic	0.0	0.2	0.0	77.4	0.2	0.0	0.0	0.0	0.0	0.4	0.05	0.0
Metal	0.0	0.0	0.0	37.6	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Glass	0.0	0.0	0.0	89.6	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Leather and Rubber	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Ceramic and Stone	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Hiardly Biodegradable	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
Other	0.0	0.0	10.2	46	15.3	0.0	11.8	6.7	0.0	44.0	5.50	0.5
Total waste amount (kg)	1,790.4	24.8	1,877.3	296.2	55.1	1,602.3	59.8	2,024.3	1,555.4	8989.2	1123.64	100.0
				計算対象外								
Total loaded waste (ton)	1.79	0.12	1.88	0.305	0.055	1.575	0.06	2.025	1.555			

Zone 4

Type of material	Physical composition (g)										
	1at day (Bio)	2nd day (Bio)	3rd day (Bio)	4th. Day (Non-bio	5th Day (Bio)	6th Day (Non-bio)	7th Day (Bio)	8th Day (Bio)	Total	Average	Rate
	12/11/2018	13/11/2018	14/11/2018	15/11/2018	16/11/2018	17/11/2018	18/11/2018	19/11/2018	(g)	(g)	(%)
Kitchen Waste (Bio)	789.0	499.1	654.8	0.0	1302.1	0.0	170.5	372.5	3788.0	473.5	34.0
Kitchen Waste (Non-Bio)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
King coconut combs	123.6	417.7	151.5	0.0	0.0	0.0	209.2	0.0	902.0	112.8	8.1
Grass and Wood	113.5	2006.3	129.2	0.0	50.9	0.0	1185.1	1643.5	5128.5	641.1	46.0
Paper	207.6	9.9	64.4	49.9	35.1	28.7	135.2	179.3	710.1	88.8	6.4
Textile	0.0	0.0	0.0	34.8	1.8	9.1	0.0	14.7	60.5	7.6	0.5
Soft Plastic	0.0	0.0	0.0	283.1	6.1	62.7	0.0	0.0	352.0	44.0	3.2
Hard Plastic	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0	0.3	0.0
Metal	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.1	0.0
Glass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leather and Rubber	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0	8.5	1.1	0.1
Ceramic and Stone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hiardly Biodegradable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	6.4	12.0	2.6	95.2	29.0	49.4	0.0	0.0	194.6	24.3	1.7
Total waste amount (kg)	1240.0	2945.0	1002.6	474.2	1425.0	150.0	1700.0	2210.0	11146.8	1393.4	100.0
Total loaded weight (ton)	1.240	2.945	1.0	0.4	1.425	0.15	1.7	2.21			