Initial Environmental Examination

May 2018

CAM: Second Urban Environmental Management in the Tonle Sap Basin Project

Prepared by Ministry of Public Works and Transport for the Asian Development Bank.

CURRENCY EQUIVALENTS

(as of 8 May 2018)

Currency unit	–	riel (KR)
KR 1.00	=	$ 0.000245
$1.00	=	KR 4,086.62

ABBREVIATIONS

ADB	–	Asian Development Bank
BOD	–	Biochemical Oxygen Demand
CDIA	–	Cities Development Initiative for Asia
CEMP	–	Construction Environmental Management Plan
C-EHS	–	Contractor Environmental Health and Safety Officer
COD	–	Chemical Oxygen Demand
CRVA	–	Climate Risk Vulnerability Assessment
DDPP	–	Detailed Design and Project Preparation
EA	–	Executing Agency
EIA	–	Environmental Impact Assessment
EMP	–	Environmental Management Plan
FGD	–	Focus Group Discussion
GHG	–	Greenhouse Gas
GRM	–	Grievance Redress Mechanism
IA	–	Implementing Agency
IEE	–	Initial Environmental Examination
IEIA	–	Initial Environmental Impact Assessment
MoE	–	Ministry of Environment
MOWRAM	–	Ministry of Water Resources and Meteorology
MPWT	–	Ministry of Public Works and Transport
PDoE	–	Provincial Department of Environment
PMC	–	Project Management Consultants
PMC-I/NES	–	PIM-International and National Environment Specialists
PIU	–	Project Implementation Unit
PIU-SFP	–	PIU Safeguards Focal Point
PMU	–	Project Management Unit
PMU-ESO	–	PMU Environmental Safeguards Officer
PSC	–	Project Steering Committee
RCP	–	Representative Concentration Pathway
SHC	–	Sewer Household Connection
STP	–	Sewage Treatment Plant
SPS	–	Safeguards Policy Statement
TS-1	–	Tonle Sap Urban Environmental Improvement Project
TSBR	–	Tonle Sap Biosphere Reserve
TSS	–	Total Suspended Solid
WHO	–	World Health Organisation

WEIGHTS AND MEASURES

dBA	–	A-weighted Decibel
km	–	Kilometer
km2	–	Square kilometer
LAeq	–	Equivalent Continuous Level 'A weighting' - 'A'-weighting = correction by factors that weight sound to correlate with the sensitivity of the human ear to sounds at different frequencies
m	–	Meter
^{oC}	–	Degree Celsius
PM10	–	Particulate Matter 10 micrometers or less
PM2.5	–	Particulate Matter 2.5 micrometers or less
µg/m3	–	Microgram per cubic meter

GLOSSARY

District	–	Sub-divisions of the 24 provinces in Cambodia
Commune	–	Sub-divisions of districts, referred to as Sangkats in urban areas

NOTE

(i) In this report, "$" refers to United States dollars.

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1. EXECUTIVE SUMMARY

1.1. The Project

1. Second Urban Environmental Management in the Tonle Sap Basin Project (the project) will support the Government of Cambodia in improving urban services and enhancing climate resilience in the Tonle Sap Basin. The project is part of ADB's programmatic approach in the Tonle Sap Basin, and will build on an ongoing project, under which similar interventions are financed in two of the basin's towns.

2. The project focuses on improvement of solid waste management through the development of controlled landfills, and improvement of wastewater treatment, through the development of sewage treatment plants (STP) and storm water drainage. A summary of the project interventions and their locations is shown in Table 1.

Table 1. Summary of Project Interventions

Sub-Project City	Sewage Treatment Plant	Drainage	Landfill
Serei Saophoan	✓	✓	✓
Battambang	✓	×	✓
Stueng Saen	✓	✓	✓

3. The Project is classified as category B for environment and confirmed during the project preparation. This consolidated IEE addressing all subprojects has been undertaken in accordance with ADB Safeguards Policy Statement (SPS) 2009. Each sub-project under this IEE has a separate Environmental Management Plan (EMP). The IEE and EMP will be updated as needed to meet the final detailed designs and will inform the domestic Initial Environmental Impact Assessments (IEIAs) that will be approved by Ministry of Environment (MOE) at detailed engineering design stage.

1.2. Key Findings

4. The environmental baseline study confirms that the local communities are the most sensitive receptors in the project area. The project locations are dominated by rice fields and other agricultural land. No protected areas or habitats and species of conservation value were identified in the project area of influence.

5. The project sites are located in an environment which contains many surface water bodies including ponds, rivers discharging to the Tonle Sap lake and river, and a network of irrigation canals used for paddy field cultivation. The surface water bodies in the area are known to be used for household uses, such as washing as well as fishing. Management of run-off and potential pollution impacts are a key focus of the EMP measures.

6. Impacts during construction will be localized and short-term and limited to the common impacts associated with any construction project and its associated groundworks. This includes the generation of noise, dust, pollutants and greenhouse gas emissions, traffic and waste. These impacts will particularly be felt in the urban core where excavation for pipe networks will be required in higher density areas.

7. The most significant environment risks associated with the sub-projects are during the operation phase. Both STPs and landfill sites can cause environmental pollution if they are not managed and maintained effectively. Such pollution can include long term risks to groundwater and soils from poor leachate management and medium term risks to water quality from STP effluent discharges, potentially affecting aquatic flora and fauna and human health.

8. If effectively managed, the project facilities will bring about environmental improvements to the local project areas and urban core. Field visits show that the current environment is being contaminated with both sewage and leachate and the growing pressures on the urban areas means that this is likely to continue. The development of well engineered waste management and wastewater treatment facilities will mean that the pollution of the environment should be reduced and therefore the risks to human health and water quality, will be less. In addition, the municipalities will have improved disaster and climate change resilient infrastructure.

9. In Stueng Saen and Serei Saophoan, the new wastewater infrastructure will form the foundation for developing citywide wastewater systems in the years ahead. In Battambang the intervention will be a catalyst to expansion of the city on the eastern side of the river, which is currently hampered by inadequate municipal infrastructure including drainage and wastewater management services. The new landfill sites will be adequate for the next 20 years and so will solve the emerging problem of near-full capacity of the existing solid waste management site. This in turn will contribute to the aesthetics and hygiene of the urban environment and improve the quality of life or "liveability" of the cities. In addition, the Serei Saophoan landfill site will be used as a demonstration site which will provide opportunities for operator training on all aspects of landfill operations and facility maintenance including compliance with the operational environmental monitoring and management plans.

10. The community consultations undertaken for this IEE show widespread support for the sub-projects as the residents recognize the need for improved waste management and sewage treatment. The communities are also subject to impacts from flooding and therefore are keen to see drainage improvements in their cities which will contribute to increased climate resilience.

1.3. Environmental Management Plan

11. The EMPs aim to avoid impacts where possible and mitigate those impacts which cannot be eliminated to an acceptable and minimum level. The EMP includes detailed requirements for:

- Mitigation and monitoring measures;
- Institutional arrangements and project responsibilities;
- EMP budget for implementation
- Caapacity building and training requirements
- Public consultation and information disclosure
- GRM including clearly defined timescale and responsibilities

12. The project includes a Capacity Building Program to address technical and institutional issues and ensure the sustainable provision of quality services.

13. Project Management Consultant (PMC) will be responsible for ensuring adequate training during project implementation and will include training as follows:

- EMP adjustment and implementation - Development and adjustment of the EMP, roles and responsibilities, monitoring, supervision and reporting

- Grievance Redress Mechanism – roles and responsibilities
- Environmental protection - Pollution control on construction sites (air, noise, wastewater, solid waste)
- Environmental monitoring - Monitoring methods, data collection and processing, reporting systems.

14. The key mitigation measures during construction will include:

- Good construction practices will be adopted to ensure minimal disturbance to affected persons from construction related nuisance, such as noise, dust and pollutant emissions.
- Access to properties and agricultural land will be maintained and encroachment avoided to allow people to continue their activities unimpeded.
- The contractor will submit site specific Construction Environmental Management Plans (CEMP) for the key activities which will also require the contractor to develop appropriate maps to ensure all stakeholders are clear on where activities will take place.
- A community and occupational health and safety plan is required as part of the CEMP, emphasizing the need to address risks in particular to site operatives.

15. Mitigation and monitoring measures are also required for the operation phase. The importance of training in landfill operations and STP management should be emphasized if the investments are to be sustainable, and operations are to be effectively maintained as per the landfill and STP design. Recognizing that operator performance is critical to environmental performance, a detailed long-term operator training plan and associated budget is provided in the capacity development component of this project.

16. A Grievance Redress Mechanism (GRM) will be established to receive and facilitate resolution of affected peoples' concerns and grievances about project social and environmental safeguards performance. It should address affected people's concerns and complaints promptly, using a transparent process that is readily accessible to all affected persons. It will contain multiple entry points to allow affected people to approach the Contractor, PIU, their local leaders, the Ministry of Public Works and Transport or ADB.

1.4. Conclusion

17. This IEE was undertaken to determine the environmental issues and concerns associated with all subprojects. The assessment confirms that the project is classified as Category B for environment. There are no significant adverse impacts that cannot be readily mitigated If implemented effectively, the EMP will mitigate impacts on the natural environment and affected people to an acceptable level. The key parties for mitigation measure implementation are the construction contractors and the operators. They will be supported by qualified national and international environmental consultants within the Project Management Consultant teams. The implementation of this EMP will be closely monitored and reported on by the relevant stakeholders in the project.

18. The most significant impacts from the project will arise from facility operation, for both the STP and the landfills. As a result, there is a comprehensive training and capacity building component to the project which is essential for ensuring the investment is both financially and environmentally sustainable and achieves anticipated outcomes.

19. Overall, the expected project outcome is improved urban environmental services in participating cities. The project is anticipated to bring environmental benefits to the populations of the project cities. It will serve to improve sewage and waste management, reduce pollution impacts andprovide long term urban environmental improvements, health benefits and promote sustainable city development.

2. INTRODUCTION

2.1. Background and introduction

2.1.1. Project Outputs and Location

20. This IEE was developed during the Detailed Design and Project Preparation (DDPP) phase of the Second urban environmental management in the Tonle Sap basin project (the project).

21. Output 1: Improved public services. The project will finance three wastewater sub-projects: (i) a new 4,800 m3/day capacity WWTP at Battambang and 86.8 km of new sewers, (ii) a new 2,500 m3/day capacity WWTP in Stung Saen and 39.2km of new sewers, and (iii) a new 2,500 m3/day capacity WWTP in Serei Saophoan and 78.2km of new sewers.[1] The project will finance two drainage sub-projects: (i) a 17.1 km drainage network in Stung Saen; and (ii) a 8.5km drainage network in Serei Saophoan. The project will finance three controlled landfills: (i) 48,000 m3 landfill in Stung Saen; (ii) 130,000m3 landfill in Serei Saophoan and (iii) 350,000m3 landfill in Battambang. The project will also finance the provision of about 100 public toilets in markets and schools as well as provision of free latrines for 760 poor households.

22. Output 2: Improved institutional effectiveness. The project will strengthen institutional effectiveness through improving staff capacity in critical areas (including improved urban service delivery, O&M of urban facilities, public private partnerships and other institutional arrangements), supporting the establishment of urban service units, and dedicated consultant support for project management. As a long-term contribution to the sector, the project will promote gender inclusivity and finance scholarships in civil engineering for 15 women.

23. Output 3: Improved policy and planning environment. The project will develop urban development strategies and master plans for all three cities. It will develop a road map for financial sustainability for wastewater and solid waste (including a proposed road map and arrangement for tariffs, and mechanism for ensuring household connections). It will build community awareness on the benefits of proper sanitation and separate sewage systems and safe disposal of solid waste.

24. The location of the project is in the three secondary cities of Serei Saophoan, Banteay Meanchay Province, Battambang, Battambang Province and Stueng Saen, Kampong Thom Province. These provinces are three of the five provinces that surround the Tonle Sap lake basin.

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[1] The project will also finance free household connections to the sewer system (i.e. the line from the sewer to the boundary of the property). The project also includes a financing allocation for on-site plumbing (i.e. the plumbing needed within the boundary of the property). This will be provided as a subsidy to ID poor households, however, the government may choose to recover all or part of this cost for non-ID poor households.

2.1.2. ADB and Domestic Environmental Due Diligence

25. The project classification of environment category B has been confirmed during project preparation. This consolidated IEE covering all subprojects has been prepared based on the preliminary designs. Each sub-project under this IEE has a separate Environmental Management Plan (EMP). The IEE and EMPs have been undertaken in accordance with ADB Safeguards Policy Statement (SPS) 2009 and Royal Government of Cambodia (RGC) environmental requirements and guidelines and will be updated where necessary to meet the final detailed designs.

26. The requirements for Ministry of Environment (MoE) approvals under Cambodian law are set out in detail in Section 3.1.2. An approved company, registered with the Ministry of Environment (MoE) will prepare separate IEIAs for each landfill and combined IEIAs for drainage and sewerage components for each town.

2.1.3. Structure of This Report

27. This IEE report follows the format prescribed in ADB SPS 2009. For the purposes of this project, this is a consolidated IEE containing information for all sub-projects including:

- The policy legal and administrative framework;
- A description of the project and all sub-projects;
- The environmental baseline for the project locations;
- Alternatives analysis for all sub-project interventions; and
- Information on disclosure and consultation for this IEE.

28. Appendices to this report contain the Environmental Management Plans (EMPs) for each sub-project, arranged by city, which reflects the intended construction contract packages. The EMPs are specifically designed to aid the construction contractors and operators in management of environmental impacts and therefore contain:

- Brief sub-project descriptions
- Institutional arrangements and responsibilities for EMP implementation;
- Summary of environmental impacts on key receptors;
- Mitigation measures for implementation at all phases of construction and operation;
- Monitoring requirements;
- Consultation requirements during construction;
- Grievance Redress Mechanism; and
- Estimated costs of environmental safeguard measures.

29. In addition, the EMPs also include detailed receptor maps and site location maps to support contractors with preparation of site-specific Construction EMPs (CEMPs) that include specific protection and monitoring measures in respect of sensitive receptors.

3. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.1. Environmental Assessment Requirements

3.1.1. Environmental Assessment Requirements of ADB

30. Safeguard requirements for all projects funded by ADB are defined in SPS 2009 which establishes an environmental review process to ensure that projects undertaken as part of programs funded through ADB loans are environmentally sound; are designed to operate in compliance with applicable regulatory requirements; and are not likely to cause significant environmental, health, or safety hazards. SPS 2009 is underpinned by the ADB Operations Manual, Bank Policy (OM Section F1/BP, October 2013). The policy also promotes adoption of international good practice as reflected the World Bank Group's Environmental, Health and Safety (EHS) Guidelines. This IEE is intended to meet SPS 2009 requirements.

31. SPS 2009 environmental assessment requirements specify that:

- At an early stage of project preparation, the borrower/client will identify potential direct, indirect, cumulative, and induced environmental impacts on and risks to physical, biological, socioeconomic, and cultural resources and determine their significance and scope, in consultation with stakeholders, including affected people and concerned nongovernment organizations. If potentially adverse environmental impacts and risks are identified, the borrower/client will undertake an environmental assessment as early as possible in the project cycle.
- The assessment process will be based on current information, including an accurate project description, and appropriate environmental and social baseline data;
- Impacts and risks will be analyzed in the context of the project's area of influence;
- Environmental impacts and risks will be analyzed for all relevant stages of the project cycle, including preconstruction, construction, operations, decommissioning, and post-closure activities such as rehabilitation or restoration; and
- The assessment will identify potential transboundary effects as well as global impacts;

32. Other requirements of SPS 2009 include:

- Alternatives analysis. There is a requirement to examine alternatives to the project's location, design, technology, and components and their potential environmental and social impacts and consider the no project alternative. SPS 2009 states that this is only for projects which have ''significant adverse environmental impacts that are irreversible, diverse, or unprecedented'' i.e., category A projects. This does not apply to this category B IEE but is included for completion.
- Environmental management plan. The borrower/client will prepare an EMP that addresses the potential impacts and risks identified by the environmental assessment.
- Consultation and participation. The borrower/client will carry out meaningful consultation with affected people and other concerned stakeholders, including civil society, and facilitate their informed participation.
- Information disclosure. Environmental information on the project, including the IEE and other safeguards information will be disclosed in accordance with ADB's Public Communications Policy (2011) and SPS (2009). This includes: (i) The EMP will be translated into Khmer language and be made available at each provincial department of public works and transport (PDPWT); (ii) The IEE will be disclosed on ADB's project website (www.adb.org);
- Grievance redress mechanism. The borrower/client will establish a mechanism to receive and facilitate resolution of affected people's concerns, complaints, and grievances about the project's environmental performance.

- Monitoring. The borrower/client will monitor and measure the progress of implementation of the EMP.

33. As stated in the "Guidelines for Climate Proofing Investments in the Water Sector: Water Supply and Sanitation, Climate Impacts", ADB (2016) there may be impacts from climate change on wastewater treatment and solid waste disposal. Warmer temperatures can mean (i) Increased operating challenges to biological and chemical processes of treatment facilities (ii) Increased temperatures and increased evaporation in receiving water bodies, changing chemical balances and increased eutrophication (iii) Reduced capacity to meet wastewater treatment requirements and standards. More frequent and/or intense extreme weather events can lead to •(i) increased risk of direct flood damage to treatment plant, pumping and conveyance, and outfall and (ii) Increased risk of untreated sewage overflows contaminating water supply sources.

34. These climate change risks are assessed in the project Climate Change Assessment and are reflected where appropriate in the project designs.

3.1.2. Environmental Assessments Requirements of Cambodia

35. Environmental assessment in Cambodia is governed by the following law and guideline document:

- Sub-decree on EIA Process No. 72 (1999). This law provides the detailed guidelines for implementation of the EIA Process. Its Annex requires the conduct of IEIA or EIA on the following activities under the Project: (i) waste processing, burning activities, all sizes; (ii) wastewater treatment plants, all sizes; (iii) drainage systems, >5,000 ha.
- Declaration on Guideline for Conducting IEIA and EIA Reports No. 376 (2009). This declaration specifies the basic contents of IEIA/EIA Reports, which should include: (i) introduction; (ii) legal framework; (iii) project description; (iv) description of the existing environment; (v) public participation; (vi) assessment of, and mitigation measures for, significant environmental impacts; (vii) environmental management plan; (viii) cost-benefit analysis; and (ix) conclusion and recommendations.

36. The Ministry of Environment (MoE) through its EIA Department regulates and monitors the EIA Process. The MoE is responsible for: (i) review and approval of IEIA/EIA reports in collaboration with other relevant ministries and (ii) monitoring the EMP implementation of Project Proponents/Owners throughout the different project phases. MoE operates at the municipal and provincial levels through its Provincial Department of Environment (PDoE).

37. The project owner (public or private) is required to submit the necessary project document (IEIA/EIA report) to MoE for review and approval. After submission of IEIA/EIA report, it should take a maximum of 30 working days for a decision.

38. A meeting[2] held between the MoE, Ministry of Public Works and Transport (MPWT) and consultant teams for ADB projects on 6th December 2017 confirmed that for the projects and their sub-projects discussed, the following is required:

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[2] **Participants from MPWT and MoE**: 1. H.E Vong Pisith (PD), 2. Mr. Danh Serey (Head of EIA department), meeting held and MoE, Phonm Penh**. Participants from consulting teams**: 3. Mr. Taing Sophanara (Deputy Team Leader of 2nd GMS-CTDP2), 4 Mr. Srei Socheat (Deputy Team Leader Tonle Sap 1 Project), 5. Mr. Morm

- EIA department agrees that this project needs to prepare IEIA report which can be informed by the IEE report and incorporate the additional baseline environmental survey (air and water quality) results.
- The IEIA report for landfills should be prepared in separate report from other subprojects.
- The IEIA report for the drainage and sewerage can be prepared together in one IEIA report.
- EIA department agrees with and supports the project and will facilitate MoE to give a general approval letter to MPWT after receiving IEIA report and request letter from MPWT.

39. A registered company, authorized to complete IEIA reports in Cambodia, is required to submit the IEIA report on behalf of the project owner, MPWT.

3.2. National Environmental Policy and Legislation

3.2.1. Legal Framework for Environmental Management

40. In 1993 the new Constitution of Cambodia included environmental considerations for the first time. Specifically, Article 59 states: ''The State shall protect the environment and balance of abundant natural resources and establish a precise plan of management of land, water, air, wind, geology, ecological system, mines, energy, petrol and gas, rock and sand, gems, forests and forestry products, wildlife, fish and aquatic resources''. This led to the establishment of the Ministry of Environment.

41. The hierarchy of legislation in Cambodia is:

- Royal Decree signed by the King;
- Sub-decree signed by the Prime Minister;
- Ministerial Decision signed by a Minister; and
- Regulation issued by a Ministry.

42. A Royal Decree ratifies laws passed by parliament. These can be supplemented by "PRAKAS" or ministerial decisions. These laws allow sub-decrees and regulations to be passed which can stipulate procedures and standards to be met in order to ensure compliance with the law. Many of these sub-decrees and standards have been drafted but have not yet been ratified by parliament.

3.2.2. Policies and legal instruments

43. Cambodia's main legal framework for addressing environmental protection, management of natural resources and public consultation is the Law on Environmental Protection and Natural Resource Management ('the Environment Law'), which was adopted in 1996.

44. The Environment Law has the following objectives:

- Protect and upgrade environmental quality and reduce pollution;

Deth, (Deputy Team Leader Tonle Sap 2 Project), 6. Mr. Chea Mong (Environmental Specialist of Tonle Sap 1 Project).

- Assess the impacts of proposed projects before approval;
- Ensure rational and sustainable use of the Kingdom's resources;
- Encourage public participation in environmental protection and natural resource management; and
- Reduce activities which impact negatively on the environment.

45. Specific regulations and standards for environmental quality are contained in three sub-decrees:

- Sub-decree on Solid Waste Management (1999);
- Sub-decree on Water Pollution Control (2009); and
- Sub-decree on Air Pollution Control and Noise Disturbance (2000)

46. A summary of other legislative and policy instruments relevant to the project is presented in Table 2. A summary of national and international guidance for landfill site criteria are presented in Table *3*. The key environmental quality standards applied to the EMP for this IEE are listed in Table *4* and presented in detail in Annex 1. The most stringent limit (national or international) shall apply.

Table 2. Relevant Laws, Regulations and Guidelines

Law/Regulation/Guideline	Year	Summary
Royal Decree on the Protection of Natural Areas	1993	Classified 23 protected areas in Cambodia into four categories: (i) natural parks; (ii) wildlife sanctuaries; (iii) protected landscapes; and (iv) multiple-use areas. Designated the Tonle Sap (316,250 ha) as a multiple-use area or area necessary for the stability of the water, forestry, wildlife and fishery resources, for tourism, and for conservation of long-term existing natural resources with a view to assure sustainable economic development.
Law on the Protection of Cultural Heritage (NS/RKM/0196/26)	1996	Regulates the protection of national cultural heritage and cultural property in general against illegal destruction, modification, alteration, excavation, alienation, exportation or importation. Its Article 37 stipulates that in case of chance find of a cultural property during construction, work should be stopped and the person who found the property should immediately make a declaration to the local police, who shall, in turn, transmit the property to the Provincial Governor without delay.
Sub-decree on Water Pollution Control (Sub-decree No. 27 ANRK/BK)	2009	Regulates activities that cause pollution in public water areas in order to sustain good water quality so that the protection of human health and the conservation of biodiversity are ensured. Its Annexes 2, 4 and 5 provide the industrial effluent standards, including effluent from wastewater stabilization ponds, water quality standards for public waters for the purpose of biodiversity conservation, and water quality standards for public waters and health, respectively.
Sub-decree on Solid Waste Management (Sub-decree No. 36 ANK/BK),	1999	Article 1: Regulates solid waste management to ensure the protection of human health and the conservation of biodiversity through using appropriate technical approaches. Article 2: This sub-decree applies to all activities related to

Law/Regulation/Guideline	Year	Summary
		disposal, storage, collection, transport, recycling, dumping of garbage and hazardous waste. Article 4: The Ministry of Environment shall establish guidelines on disposal, collection, transport, storage, recycling, minimizing, and dumping of household waste in provinces and cities in order to ensure the safe management of household waste. The authorities of the provinces and cities shall establish the waste management plan in their province and city for short, medium and long-term.
Sub-decree on Control of Air Pollution and Noise Disturbance (Sub-decree No. 42 ANK/BK	2000	Regulates air and noise pollution from mobile and fixed sources through monitoring, curb and mitigation activities to protect the environmental quality and public health. It contains the following relevant standards: (i)) ambient air quality standard (Annex 1); and (ii) maximum allowable noise level in public and residential areas (Annex 6). Article 3 A. “Source of pollution” is defined and separates mobile sources (including transport) and fixed sources such as factories and construction sites. Article 3 B. “Pollutant” is defined as smoke, dust, ash particle substance, gas, vapour, fog, odour, radio-active substance
Law on Land (NS/RKM/0801/14)	2001	Provides that: (i) unless it is in the public interest, no person may be deprived of ownership of his immovable property; and (ii) ownership deprivation shall be carried out according to legal forms and procedures and after an advanced payment of fair and just compensation. (Article 5)
Royal Decree on the Establishment and Management of Tonle Sap Biosphere Reserve (Royal Decree No. NS/RKT/0401/070)	2001	Establishes the Tonle Sap Biosphere Reserve (TSBR) in accordance with the statutory framework of the World Network of Biosphere Reserves. Divides the TSBR into 3 zones: (i) core areas; (ii) buffer zone and (iii) flexible transition zone. Core area: set aside for long term protection, human activity is limited to monitoring and research. Buffer zone: is area surrounding the core areas helping to protect the environment. It may accommodate education and training activities. Transition area: may contain a variety of agricultural activities and human settlements. Here all stakeholders have to cooperate to achieve sustainable development

Law/Regulation/Guideline	Year	Summary
Environmental Guidelines on Solid Waste Management[3]	2006	Contains a Landfill Ordinance that regulates landfill requirements to: (i) reduce as far as possible the adverse effects of waste disposal on the environment; (ii) preserve groundwater, surface water & air quality & to reduce emissions of greenhouse gases (iii) ensure waste is not harmful to human, natural & animal health during operation & decommissioning; and (iv) provide information and technical recommendation on the construction, operation and closing/follow-up management of landfills to ensure public health and safety and environmental protection.
Labour Law (1997) Decree No. CS/RKM/0397/01	1997	This law governs relations between employers and workers resulting from employment contracts to be performed within Cambodia. The key sections relevant to this project include: Chapter VIII Health and Safety of Worker. The key provisions relate to the quality of the premises; cleaning and hygiene; lodging of personnel, if applicable (such as workers camp); ventilation and sanitation; individual protective instruments and work clothes; lighting and noise levels in the workplace. Article 230: Work places must guarantee the safety of workers. However the only specific occupational health and safety Prakas relates to the garment industry and brick manufacture. Chapter IX Work-Related Accidents Article 248: All occupational illness, as defined by law, shall be considered a work-related accident. The law sets out how accidents should be managed in terms of compensation.
Law on Water Resources Management (NS/RKM/0607/016)	2007	Requires license/permit/written authorization for the: (i) abstraction & use of water resources other than for domestic purposes, watering for animal husbandry, fishing & irrigation of domestic gardens and orchards; (ii) extraction of sand, soil & gravel from the beds & banks of water courses, lakes, canals & reservoirs; (iii) filling of river, tributary, stream, natural lakes, canal & reservoir; and (iv) discharge, disposal or deposit of polluting substances that are likely to deteriorate water quality and to endanger human, animal and plant health. (Articles 12 & 22) Its Article 24 stipulates that Ministry of Water Resources and Meteorology (MOWRAM), in collaboration with other concerned agencies, may designate a floodplain area as flood retention area.
Royal Decree on Protected	2008	Defines the framework of management, conservation &

[3] http://comped-cam.org/Documents/developmentguideline/06_03_25_Environmental%20gl%20on%20swm_END.pdf.

Law/Regulation/Guideline	Year	Summary
Areas (Royal Decree No. NS/RKM/0208/007)		development of protected areas to ensure the conservation of biodiversity, & sustainable use of natural resources in protected areas. Article 11 divides the protected area into 4 zones namely, core zone, conservation zone, sustainable use zone & community zone. Article 36 strictly prohibits all types of public infrastructure in the Core Zone & Conservation Zone; & allows development of public infrastructures in the Sustainable Use Zone & Community Zone with approval from the Royal Government at MoE's request. Article 41 provides for the protection of each protected area against destructive/harmful practices, such as destroying water quality in all forms, poisoning, using of chemical substances, disposing of solid and liquid wastes into water or on land. Article 44 requires all proposals & investments within or adjacent to protected area boundary an Environmental and Social Impact Assessment. Annex. (Paragraph 2) sets out the objectives for the TSBR Each protected area shall be divided into four (4) management zoning systems: 1. Core zone: management area(s) of high conservation values containing threatened and critically endangered species, and fragile ecosystems. Access to the zone is prohibited except the Nature Conservation and Protection Administration's officials and researchers who, with prior permission from the Ministry of Environment, conduct nature and scientific studies for the purpose of preservation and protection of biological resources and natural environment with the exception of national security and defence sectors. 2. Conservation zone: management area(s) of high conservation values containing natural resources, ecosystems, watershed areas, and Natural landscape located adjacent to the core zone. Access to the zone is allowed only with prior consent of the Nature Conservation and Protection Administration at the area with the exception of national security and defense sectors. Small-scale community uses of Non-Timber Forest Products to support local ethnic minorities' livelihood may be allowed under strict control, provided that they do not present serious adverse impacts on biodiversity within the zone. 3. Sustainable use zone: management area(s) of high economic values for national economic development and management, and conservation of the protected area(s) itself thus contributing to the local community, and indigenous ethnic minorities' livelihood improvement.

<table>
<tr><th>Law/Regulation/Guideline</th><th>Year</th><th>Summary</th></tr>
<tr><td></td><td></td><td>After consulting with relevant ministries and institutions, local authorities, and local communities in accordance with relevant laws and procedures, the Royal Government of Cambodia may permit development and investment activities in this zone in accordance with the request from the Ministry of Environment.

4. Community zone: management area(s) for socio-economic development of the local communities and indigenous ethnic minorities and may contain existing residential lands, paddy field and field garden or swidden (Chamkar).</td></tr>
<tr><td>Expropriation Law</td><td>2010</td><td>Defines the principles, mechanisms, and procedures of expropriation, and defining fair and just compensation for any construction, rehabilitation, and public physical infrastructure expansion project for the public and national interests and development of Cambodia.</td></tr>
<tr><td>Sub-Decree on Demarcation of 647,406 Hectare Flooded Forest Domain in Six Provinces adjacent to Tonle Sap Lake (Kampong Chhnang, Pursat, Battambang, Banteay Meanchey, Siem Reap and Kampong Thom) (Sub-decree No. 197 ANKr/BK)</td><td>2011</td><td>Stipulates a zoning system for the area between the national highways and the Tonle Sap Lake system and the nature of agriculture activities that are permitted and banned in each zone.</td></tr>
<tr><td>Guidance on Selection of Landfill Sites (2016)</td><td>2016</td><td>The Guidance sets out the requirements for site selection in terms of:

<table>
<tr><th></th><th>MoE (2016) Requirements</th></tr>
<tr><td rowspan="6">Distance to Receptors</td><td>1 km from any residential property</td></tr>
<tr><td>3 km from any school/health centre/natural resources/ water source</td></tr>
<tr><td>5 km from any place of worship and resort</td></tr>
<tr><td>8 km from an airport</td></tr>
<tr><td>10 km from town center</td></tr>
<tr><td>15 km from any heritage site</td></tr>
<tr><td rowspan="2">Hydrology</td><td>Not in a flooded area</td></tr>
<tr><td>Depth to Groundwater – More than 3m</td></tr>
<tr><td rowspan="6">Cell Design</td><td>Gas collection (flaring)</td></tr>
<tr><td>Leachate collection system</td></tr>
<tr><td>Leachate treatment (lagoon)</td></tr>
<tr><td>Clay liner ≥ 1m (first liner)</td></tr>
<tr><td>HDPE liner (second liner)</td></tr>
<tr><td>Permeable liner (third liner)</td></tr>
</table>
</td></tr>
</table>

Law/Regulation/Guideline	Year	Summary
		Drainage system: Depth 1m, width 0,6 m

47. Landfill Site Guidance. A meeting was held at MoE4 Phnom Penh on 31-10-17 in order to discuss the application of the guidance for ADB projects. MoE advised the project team to follow the guidance where possible, but recognized it was not always possible given the very stringent requirements. MoE emphasized that groundwater protection was the main concern however the requirements could be applied pragmatically with MoE review of the landfill design before it is finalised.

48. A comparison of national and international landfill siting guidance is in Table 3. The table shows that the mimimum distance to houses in any of the international guidance is 250m (ADB and World Bank/IFC) however ADB guidance also refers to daily cover indicating that 250m is appropriate for a site which has daily cover. The highest depth to groundwater in any of the international guidance is 1.5 m (World Bank/IFC). The Cambodian guidance is most stringent for distance to housing and depth to groundwater.

Table 3. Comparison of Landfill Selection Criteria

Source of Guidance	Residential Receptors	Water Receptors
International Solid Waste Association (ISWA) - Guidelines for Design and Operation of Municipal Solid Waste Landfills in Tropical Climates (2013).	Not located in the immediate proximity of occupied dwellings Minimum 500m	No distance given
ADB – Integrated SWM for Local Governments., A Practical Guide (2017)	No residential development within 250 m	The site must be located in an area where the landfill's operation will not detrimentally affect environmentally sensitive resources such as aquifer/ groundwater
World Bank / IFC EHS Guidelines: Sanitary Landfill (2007)	Typically further than 250 meters (for gas only, no mention of dust /odour)	Perennial stream should not be located within 300 down gradient Groundwater's seasonally high table level (i.e., 10 year high) should be at least 1.5 meters below
Cambodian Landfill Site Selection Guidance	1km from residences	Out of flooded area Depth to ground water over 3m

[4] Participants: HE Heng Nareth, Director General, General Directorate of Environmental Protection, MOE; HE Vong Pisith, Deputy Director General, MPWT; Mr Dy Kiden, Director, Department of Solid Waste Management, MOE; Ms Genevieve O'Farrell, Environmental Specialist, ADB; Ms Rachel Wildblood, Environmental Specialist, TS-1; Mr Teemu Jantunen, Resettlement and Social Development Specialist, TS-1; Mr Chea Mong, National Environmental Specialist, TS-1; Mr Mongtoeun Yim, National Solid Waste Management Specialist, TS-1.

Table 4. Key National Environmental Standards

Environmental Issue	National Standard	International Standard
Ambient air quality	Annex 1, Ambient Air Quality Standard, of Sub-decree on Control of Air Pollution and Noise Disturbance, 2000	WHO Air Quality Guidelines, global update 2005
Noise	Annex 6, Max. Standard of Noise Level Allowable in the Public and Residential Areas, of Sub-decree on Control of Air Pollution and Noise Disturbance, 2000	WHO Guidelines for Community Noise, 1999
Groundwater quality	Drinking water Quality Standards, 2004	WHO Guidelines for Drinking-water Quality, Fourth Edition, 2011
Surface water quality	Annex 4, Water Quality Standards for Public Waters for the Purpose of Biodiversity Conservation, and Annex 5, Water Quality Standards for Public Waters and Health, of Sub-decree on Water Pollution Control, 1999	US EPA National Recommended Water Quality Criteria Mekong River Commission (MRC)_ Technical Guidelines for the Protection of Aquatic Life MRC Technical Guidelines for the Protection of Human Health
Effluent quality (including leachate)	Annex 2, Effluent standard (Discharged wastewater to public water areas or sewers), of Sub-decree on Water Pollution Control, 1999	EHS General Guidelines and Guidelines for Water and Sanitation

49. In terms of SPS 2009 requirements, during the design, construction, and operation of the project the borrower/client will apply pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environment, Health and Safety Guidelines. These standards contain performance levels and measures that are normally acceptable and applicable to projects. When host country regulations differ from these levels and measures, the borrower/client will achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, the borrower/client will provide full and detailed justification for any proposed alternatives that are consistent with the requirements presented in this document. These Environment, Health and Safety Guidelines are considered throughout the Environmental Management Plans for the sub-projects.

3.3. International Agreements

50. Cambodia is party to the following international environmental agreements relevant to the Project: (i) UNESCO World Heritage Convention, 1991; (ii) Convention on Biodiversity, 1995; (iii) UN Framework Convention on Climate Change, 1995; (iv) Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1997; (v) Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat, 1999; (vi) Basel Convention on the Control of Transboundary Movements of the Hazardous Wastes and Their Disposal, 2001; (vii) Vienna Convention for the Protection of the Ozone Layer and its

Montreal Protocol on Substances that Deplete the Ozone Layer, 2001, and all Amendments, 2007; (viii) Climate Change Kyoto Protocol, 2002; and (ix) International Tropical Timber Agreement, 2006.

51. Cambodia joined the UNESCO Network of Biosphere Reserves in 1997. It is committed to the Millennium Development Goals, the seventh goal of which is to "ensure environmental sustainability". It is among the 168 Governments that adopted the Hyogo Framework for Action 2005-2015, a 10-year global footprint for disaster risk reduction efforts, in January 2005. At the regional level, it ratified the following ASEAN Agreements: (i) on Transboundary Haze Pollution in 2006; and (ii) on Disaster Management and Emergency Response, which entered into force in 2009. At the sub-regional level, Cambodia, along with Lao PDR, Thailand and Viet Nam, signed the "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" (or the Mekong Agreement) in April 1995.

4. DESCRIPTION OF THE PROJECT

4.1. Rationale

52. Cambodia's population was estimated at 15.2 million in 2016, spread across 24 provinces, 26 cities and numerous district cities. While Cambodia remains almost 80% rural, urbanization is accelerating and is expected to reach 30% of the national total by 2030. In recent years, Cambodia's robust 7% economic growth has been driven by garments, construction and tourism. With an increasingly urban economy, urban services contribute to environmentally sustainable and inclusive growth through laying basic infrastructure for businesses and households, creating jobs, safeguarding the surrounding environment and ecosystem, and reducing exposure to flooding and other extreme events. They also contribute to the health, welfare and protection of Cambodia's people. Strong urban-rural linkages mean that developments in Cambodia's growing provincial cities, including Battambang (Battambang Province), Serei Saophoan (Banteay Meanchey Province) and Stueng Saen (Kampong Thom Province), have significant spillover effects to rural areas, where poverty is more acute.

53. Tonle Sap Basin. The Tonle Sap basin is home to about a third of Cambodia's population, and nearly half of the population depends on the lake's resources, particularly its fish, for their livelihoods. Rural-urban migration is occurring at unprecedented rates. Cambodia's urban population growth rate of about 4%, one of the highest in Southeast Asia, translates into significant growth in the basin's cities. In a largely rural region, the three projects cities (whose populations range from 40,000 to 86,000), together with the cities of Siem Reap, Kampong Chhnang and Pursat, are key for economic growth and their development is linked to the surrounding environment. While flooding is important for maintaining the ecosystem services of the basin, severe flooding, including in the basin's urban areas located along rivers, can cause damage to life and property. The basin's urban areas are also sensitive to climate change, as they are located next to rivers and most experience flooding during the wet season.[5]

54. Access to services. At present, wastewater and solid waste services in urban area (excluding Phnom Penh) is inadequate. While about 80% of the population has access to

[5] The Tonle Sap river, which connects the Tonle Sap lake to the Mekong river, reverses its flow seasonally. During the wet season, when the basin is flooded, the lake's surface area increases by four to six times compared to the dry season. See: Mekong River Commission. 2010. Technical Note 10: Impacts on the Tonle Sap Ecosystem.

improved sanitation, a large proportion (69.3%) have individual systems (septic tanks) while access to sewerage and wastewater treatment is very limited (10.7%).6 More than 75% of households in Cambodia's urban areas (excluding Phnom Penh) do not have access to solid waste services. The main reasons for these service delivery gaps are (i) inadequate coverage and delivery of urban environmental infrastructure and services; (ii) inadequate management of public investments, and (iii) poor urban planning that doesn't consider environmental management and climate change events.

55. Institutional arrangements. The Ministry of Public Works and Transport (MPWT) is responsible for asset creation for urban sanitation, with the PDPWT responsible for operations and maintenance. Solid waste management is the responsibility of the city, although in practice the role of the city versus the Ministry of Environment is not always clear. Due to limited technical capacities at the provincial and municipal level, MPWT continues to be involved with the construction of large-scale infrastructure including wastewater treatment plants, sewerage networks and controlled landfills.

56. The Project. General observations indicate that the expansion in infrastructure and service provision has not been matched by equitable distribution, with disproportionate access in the capital region and certain municipalities. In order to contribute to the provision of a quality urban environment to this fast-growing urban population, including in secondary urban centers, the Second Urban Environmental Management in the Tonle Sap Basin Project will support the government of Cambodia in improving urban services and enhancing climate and disaster risk resilience in participating towns in the Tonle Sap Basin. The project will directly build on a preparatory study conducted by the Cities Development Initiative for Asia (CDIA) program (hereinafter referred to as "CDIA study") which was completed in Q3 2017. The project is part of ADB's programmatic approach to resilient and environmentally sensitive urban development in the Tonle Sap Basin, and will build on an ongoing project, under which similar interventions are financed in two of the basin's towns, in Kampong Chhnang and Pursat (Tonle Sap Urban Environmental Improvement Project, TS-1).

4.2. Project Impact, Outcome and Outputs

57. The expected project impact is sustainable, inclusive, equitable and resilient growth achieved. The outcome will be improved urban environmental services in participating cities. The project outcome includes:

58. Output 1: Improved urban services. The project will finance three wastewater sub-projects: (i) a new 4,800 m3/day capacity WWTP at Battambang and 87 km of new sewers, (ii) a new 2,300 m3/day capacity WWTP in Stueng Saen and 39km of new sewers, and (iii) a new 2,500 m3/day capacity WWTP in Serei Saophoan and 78km of new sewers. The project will finance two drainage sub-projects: (i) a 17 km drainage network in Stueng Saen; and (ii) a 8.5km drainage network in Serei Saophoan. The project will finance three controlled landfills: (i) 48,000 m3 landfill in Stueng Saen; (ii) 130,000m3 landfill in Serei Saophoan and (iii) 350,000m3 landfill in Battambang. The project will also finance the provision of about 100 public toilets in

[6] Improved sanitation includes flush and/or pour flush to piped sewers, septic tanks, and pit latrines with slab. Government of Cambodia, Ministry of Planning. 2014. Cambodia Socio-Economic Survey. Phnom Penh.

markets and schools as well as provision of free household latrines for 760 poor households and free sewerage connections for all households.

59. Output 2: Improved institutional effectiveness. The project will strengthen institutional effectiveness by: (i) improving staff capacity in critical areas (including improved urban service delivery, O&M of urban facilities, public private partnerships (PPPs) and other institutional arrangements); (ii) supporting the establishment of urban service units; and (iii) providing dedicated consultant support for project management. As a long-term contribution to the sector, the project will promote gender inclusivity and finance scholarships in civil engineering for 15 women.

60. Output 3: Improved policy and planning environment. The project will develop urban development strategies and master plans for all three cities. It will develop a road map for financial sustainability for wastewater and solid waste (including a proposed road map and arrangement for tariffs, and mechanism for ensuring household connections). It will build community awareness on the benefits of proper sanitation, separate sewerage systems and safe disposal of solid waste

61. The location of the urban centers in which the project is based, is shown in Figure 1.

Figure 1. Location of Project Urban Centers

Source: DDPP Team.

62. Detailed site descriptions are given in Annex 2.

4.3. Climate Change

63. Climate adaptation. The project is classified as being at medium risk from future climate change impacts. The project design includes climate adaptation and disaster risk reduction measures for the sewage treatment plants in Battambang and Serei Saophoan, these include raising the heights of platform formation, increased heights of bunds around waste water treatment plant lagoons, raising the height of access roads and increased drainage. Drainage network pipes have been designed for 10-year flood return periods and a further safety factor for climate change is included, as the nearest (ie. next largest standard pipe size adopted) which allows for extra drainage capacity.

64. Climate adaptation and incremental disaster risk reduction structural measures are estimated to cost $3,200,000, to be funded through the ADF grant ($1,270,000) and the loan ($1,830,000).

4.4. Detailed Description of the Sub-Project Landfill Designs

65. A detailed analysis of the landfill designs is provided in Feasibility Study Report Volume 2 – Engineering Designs. A summary of the designs relevant to this IEE is provided here. The designs for each project city are broadly the same therefore the technology is discussed here for all project locations.

66. Waste Generation Rates. Existing data on waste generation was used, in conjunction with meetings with local authorities, to quantify waste arisings. Waste arisings are predicted on the basis of a number of factors including waste per capita and population and are critical to determining the size of landfill required and therefore its overall lifespan. A rate of 0.7 kg/ capita, rising to 1.35 kg is assumed for modelling purposes, with a model horizon of 2018-2040.

4.4.1. Landfill Design and Technology

67. Solid waste management. The project will construct controlled landfills in all three cities with sufficient volume capacity to accommodate waste from the existing dump sites as well as new waste for the next 10 years. The landfill sites (to be purchased after loan approval) will be sized to serve the needs of the cities until at least 2040, to allow for development of additional landfill cells in the future. An alternatives analysis concluded that a controlled landfill was the lowest life-cycle cost solution, which, in the local context, has most of the environmental and operational benefits without the technical complexities of a fully engineered sanitary landfill. For treatment of leachate, alternatives (including lagoons, constructed wetlands, and reinjection and recirculation) were considered, and the selected option (reinjection and recirculation) is considered for local conditions and capacity[7]. The project will provide training to ensure

[7] *Technical Overview – ADB Solid Waste Management Projects in Cambodia and Laos* (April, 2018). The Solid Waste Management Specialist for this project undertook a strategic review of the design approaches adopted for landfills proposed in Cambodia and Lao PDR through various ADB projects. The aim of the review was to recommend sustainable design options for leachate and methane gas management that are appropriate for DMCs with poor O&M capacity and a climate with high rainfall. Appendix A of the report includes a detailed account of leachate management and has been extracted and included in Annex 8 of this IEE and requirements to refer to the specified EHS requirements included in the EMPs.

sustainable O&M of project facilities. The project will also prepare a landfill closure plan and finance the closure and rehabilitation of the two dump sites located on public land in Stueng Saen and Serei Saophoan.

68. A controlled landfill standard facility is to be provided. This is considered to provide the best balance between capital cost and operating difficulty compared with environmental controls and sustainability. The landfill design incorporates the following common features:

- A gravel or laterite access road from the appropriate main road to the landfill site;
- Full perimeter fence;
- Buildings for the gatehouse, generator where required and office buildings and ablution facilities;
- An artificially lined cell with sufficient life for five years operation;
- A leachate collection system;
- Internal access roads;
- Appurtenant works such as lighting, weighbridge, sump pumps;
- Equipment including a 20-ton bulldozer, a 20-ton tracked excavator and a 6 x 4 tipping truck.

4.4.1.1. Leachate Management

69. Leachate management is a key factor in any landfill design. The degradation of the organic component of the waste mass produces a small quantity of liquid leachate and gaseous by-products. The leachate produced is partially absorbed into the dry waste mass and partially lost as vapour due to the heat of the biodegradation process. However, rainfall onto operational areas will increase the liquid in the landfill cell.

70. The system proposed consists of a series of slotted pipes in the landfill base leading to a leachate pumping station. Leachate is pumped either to be reinjected at the top of the mound in wet weather or to irrigate landscaping in dry periods. The external final batters will become naturally vegetated. The proposal to irrigate external batters will further encourage vegetation growth, particularly in the drier periods. Active grass growth on the external batters can reduce odour transmission as well as increase evapotranspiration.

71. Given the limited industrial activity in the project areas, the leachate is not anticipated to contain high levels of pollutants to the extent which would mean it is inappropriate to use for irrigation within the site. The soil irrigated in the early stages of landfill development will be within the landfill footprint and then used for cover as the site develops.

4.4.1.2. Landfill Gas

72. Landfill gas will be managed through passive release via vertical gas collection wells approximately 35m apart, connecting into a central chamber for venting.. In the future, should sufficient quantities of gas be produced as to be commercially viable, technology to collect and utilise the gas could be retrofitted to the gas wells, or flares fitted to combust the gas emissions.

4.4.1.3. Site Weighbridge and Equipment

73. Weighbridge. Each site will include a 60 tonne weighbridge at the site entrance. It will allow determination of the exact mass of waste coming to site from public, institutional and commercial operators, and the issuance of any subsequent gate fees.

74. Vehicles. A Caterpillar D6 or equivalent 20-tonne bulldozer is essential on site to provide waste compaction and profiling activities, as well as pushing and compacting soil cover material. A Caterpillar 200 series or equivalent 20 tonne tracked excavator is required onsite.

Traditionally excavators are used on landfills to load cover material into trucks for placement as daily cover, intermediate or final cover. They also are required for digging drainage systems on the site as well as cleaning litter out of drains prior to it exiting the site, and other minor site development works. Finally, they can be used for short periods if the bulldozer becomes unserviceable.

75. In addition to these two items, a 10-wheeler body tip truck is required to be able to move soil around the site and assist with any drain clean-ups (litter removal) and other site haulage activities.

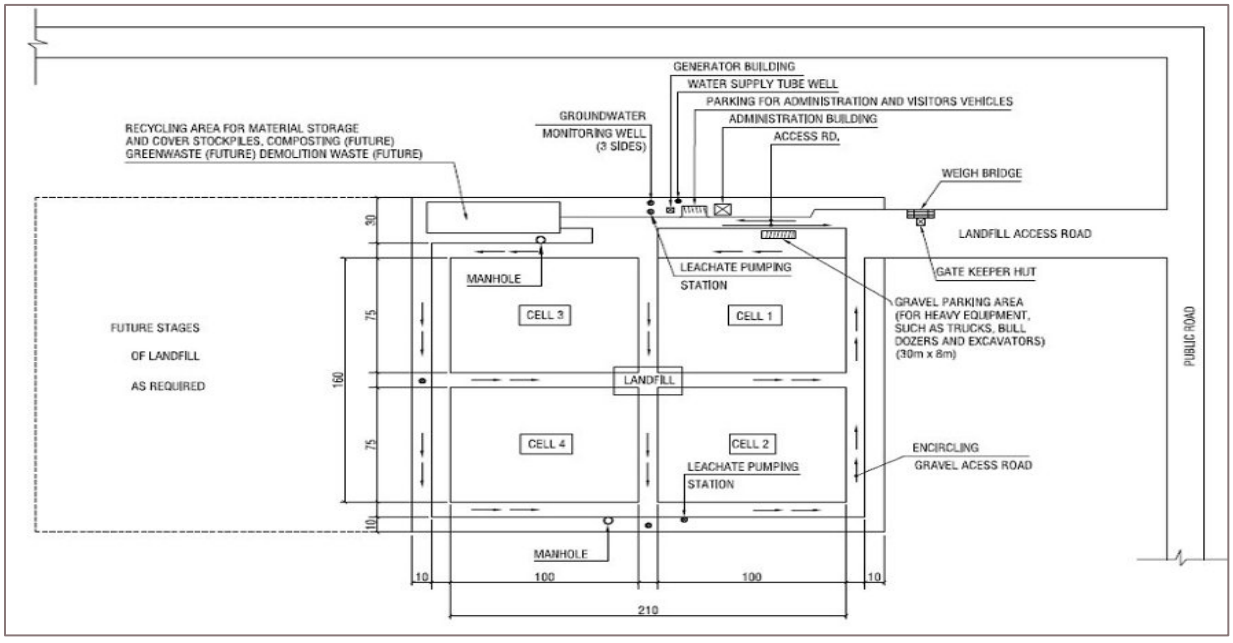
76. Water Tank. An 8,000 to 10,000-litre water tank equipped with a small pump and spray bar is also needed for dust control and fighting small fires. The tank will be placed in the tip truck body when required.

4.4.1.4. Recyclables Stockpile Areas

77. Given the low density of some materials such as plastic bags and particularly Polyethylene Terephthalate (PET) drink bottles, an extensive area is required to allow this material to be stockpiled by scavengers prior to being densified either through presses or chippers, or simply accumulated awaiting sale. Otherwise this material will effectively remain commercially unattractive to the scavengers. The layout of these stockpile areas needs to be determined during detail design. The landfill budget allows for the purchase of personal protective equipment (PPE) for waste pickers and health and safety training as well as provision of hygiene and sanitation facilities, potable water and a registration system to avoid children working on the site.

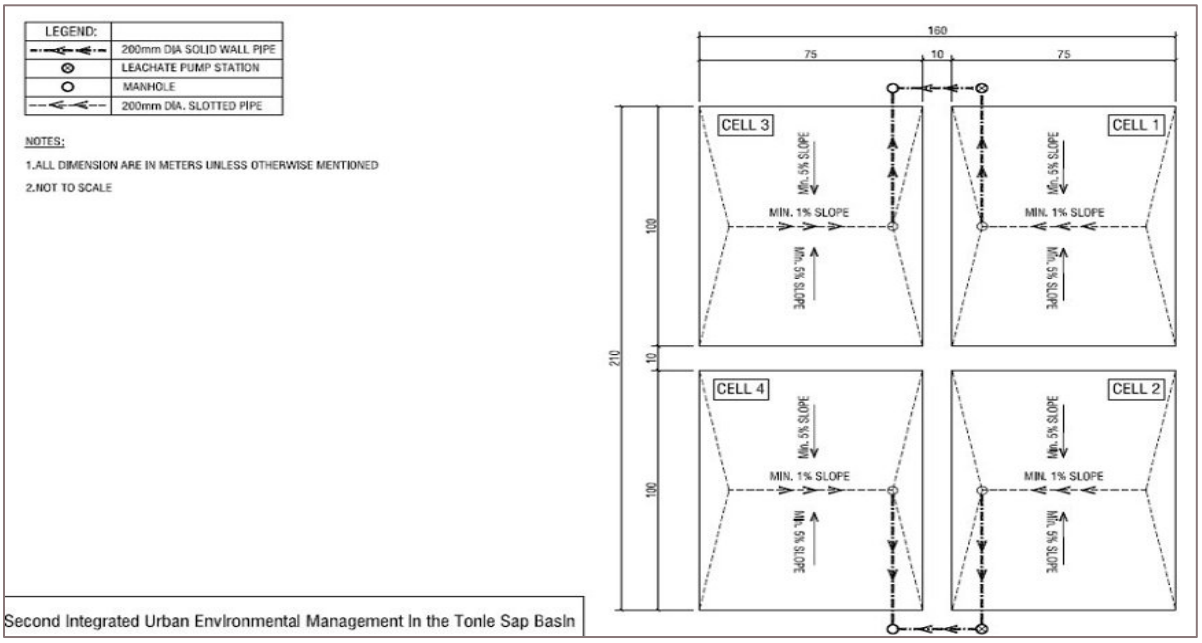
78. A typical site layout, leachate collection system and cross section are provided in Figure 2 to Figure 4. Note these are typical and demonstrate common characteristics for all sub-project landfill sites.

Figure 2. Typical landfill layout



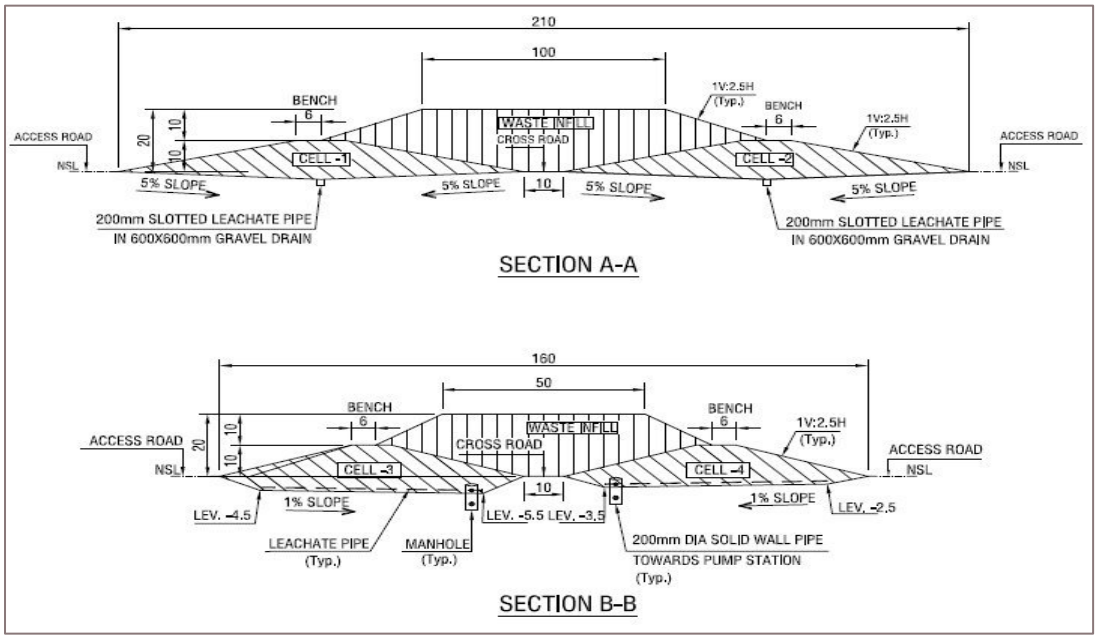
Source: DDPP Team - Note: Not to scale. Dimensions in meters unless otherwise mentioned

Figure 3. Typical landfill leachate pipe layout



Source: DDPP Team

Figure 4. Typical landfill cross section



Source: DDPP Team - Note: Not to scale. Dimensions in meters unless otherwise mentioned

4.4.1.5. Dumpsite Closure.

79. The existing dumpsites in Serei Saophoan and Stueng Saen are on publicly owned land and as such are planned to be closed by the project. The key components of a landfill closure plan will be to encapsulate the waste on site and put in place an environmental management

plan and monitoring plan. The encapsulation will entail profiling, compacting and covering the dump pile with soil. Grass or other vegetation should be planted to minimize the erosion.

80. An ongoing maintenance program should include regular cleaning and repairs as required to the leachate collection and disposal systems, reinstatement of eroded batters, replacement of soils that are eroded, replanting any vegetation that dies back, filling any depressions that occur on site due to differential settlement, reparation of access roads to allow accessibility at all times, and repairs to the perimeter and internal fences as needed.

81. An ongoing monitoring program should include sampling and reporting on water quality in the aquifers and surface runoff.

82. Waste pickers are present on all current dumpsites and under the design of the project, a safe potable water supply, washing facilities and personal protective equipment will be provided. Under the capacity building component there is an allocation for training to formalize their role in the new controlled landfill sites and to increase awareness of health issues. A registration process will be established so only licensed adult pickers will be allowed on site. For further information on the role of waste pickers see the sub-project specific Resettlement Plan.

4.5. Detailed Description of the Sub-Project Sewage Treatment Plant Designs

83. A detailed analysis of the Sewage Treatment Plant (STP) designs is provided in Feasibility Study Report Volume 2 – Engineering Designs. A summary of the designs relevant to this IEE is provided here. The designs for each project city are broadly the same, therefore the technology is discussed here for all project locations.

84. Water Demand Projections. Water demand and use determines the STP capacity required. The Commercial and Institutional Water Demand Projections are based on the application of 15% of the total domestic population for each Sangkat and adding to the total population in the calculation of sewage flows. This is in accordance with international norms and is a conservative projection of the future flows from these sources, taking consideration of the current and future growth in the commercial sector including hotels, guesthouses, restaurants, schools and institutions appropriate to each sub-project city.

4.5.1. Sewage Treatment Plant Design and Technology

85. Wastewater and Drainage Systems. The sub-projects adopt a technically viable solution that conforms with general engineering guidelines, projected storm water runoff and wastewater generation, and the required treated effluent quality. An alternatives analysis for the wastewater and drainage pipeline system (separate verses combined systems) and wastewater treatment (including the potential for constructed wetlands) was conducted. Lagoon-based systems are proposed for the wastewater treatment, as these represent the lowest life-cycle cost solution and are easy to maintain. In one city, Serei Saophoan, the option to integrate a constructed wetland in the final stage of treatment will be further explored during detailed engineering design, as a pilot demonstration of a new, nature-based approach to wastewater treatment in Cambodia

86. The technology is based on a pond system. Each step of treatment represents a progressively more advanced technology which leads to an enhanced pollutant removal efficiency and includes:

- Inlet screening – An automatic fine screen.

- Anaerobic ponds, 5m deep - A first stage for treatment of high strength wastewaters, including mixtures of industrial/domestic wastewaters and septage with high organic loading
- Facultative ponds 3 m deep - Designed to be naturally aerated to maintain the biological activity of the bacteria
- Maturation ponds 2 m deep - aerobic lagoons used as UV disinfection for bacteriological pollutant removal and tertiary or "effluent polishing" treatment
- Sludge stabilisation/drying ponds- sludge will need to be removed after 3-5 years

87. Screening. The screenings from the pre-treatment processes are generally disposed of to landfill. To allow for periodic maintenance, repair and cleaning without disruption of the treatment process, a bypass channel with a manually cleaned screen shall be provided. Should the automatic screen stop working e.g. due to power outage, the flow will overflow into the bypass channel and be manually screened. A 6 mm screen will remove 25-45% of the Biochemical Oxygen Demand (BOD) and 25-40% of Total Suspended Solids (TSS).

88. Sewerage Secondary Treatment – Biological. A combination of anaerobic and facultative lagoons with maturation ponds for disinfection. The lagoons technology is a stable system that allows a high-quality effluent to be produced. Floating baffles shall be applied for the Facultative and Maturation Ponds to provide hydraulic mixing and to reduce the sizes of the ponds.

89. Treated effluent quality. Based on the treatment processes to be employed at the new facilities the expected rate of pollutant removal of the various pollutant for a well-operated facility will be in excess of 80% of carbon (biochemical and carbon oxygen demands), 30% for nitrogen and 10% of phosphorus. Therefore, treated effluent quality anticipated to be approximately:

- 50-70 mg/L BOD5 which is within the national standard of 80 mg/L (refer Annex 1). As there are negligible factories in the services areas, total chemical; oxygen demand will be almost the same as biochemical demand.
- The modest nutrient removal rates would likely mean exceedance of the limits in the national standards of 20 mg/L nitrate, 7 mg/L ammonia and 6 mg/L phosphate. However, as the discharges will be to irrigation canals, the additional nutrients would of beneficial use for farmers.
- The bacteriological removal rate in the treatment plant is expected to be of the order of 99.97% which would mean an *E.coli* count of the order of 1,000 -10,000 MPN/100 mg/L. If the receiving water provides a dilution factor of at least 4 to 1 then assimilative capacity of the receiving water should stay within the 5,000 MPN/100 mL national guideline limit tabulated in Annex 1. It is noted that the national standards do not provide a limit on E.coli concentrations in the discharged effluent.

90. Sludge management. The water content of the sludge is very high, therefore, before final disposal further treatment of anaerobic sludge from the ponds is required to reduce water content and oxygen demand of the sludge. Two sludge lagoons are proposed to be implemented, to provide STP operations flexibility and to ensure availability of a sludge lagoon when treatment or trying is being performed in the other sludge lagoon. The excess supernatant wastewater in the sludge treatment/drying lagoon will flow by gravity back to the STP inlet for further treatment. During the sludge treatment/stabilization phase, a supernatant layer will be maintained to prevent odours, except for the stabilized sludge drying phase.

91. A typical STP layout is provided in Figure 5.

Figure 5. Typical STP Layout

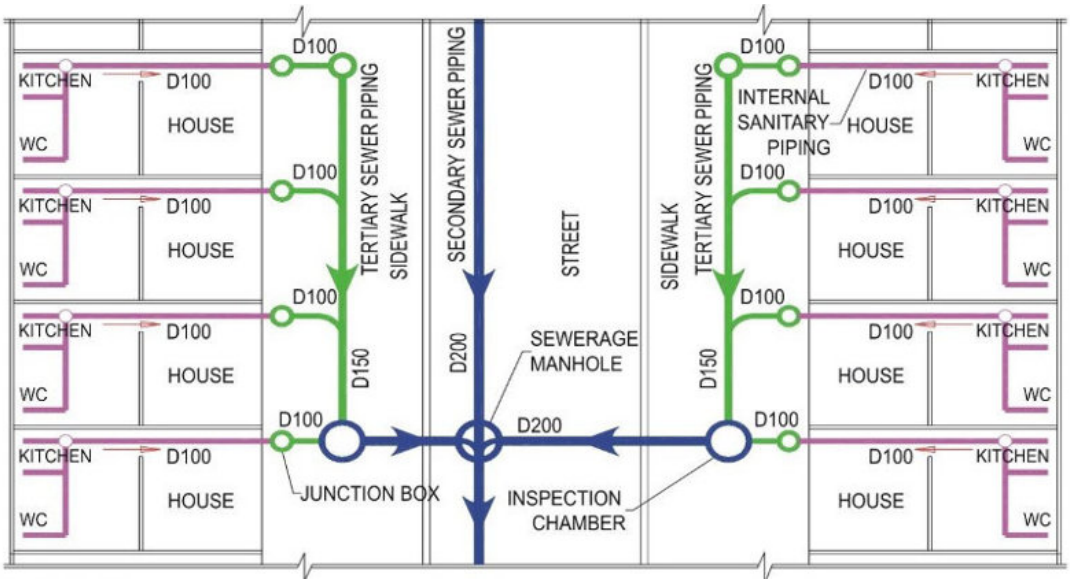
Source: DDPP Team - Note: Not to scale.

92. Included in the project design is a required tertiary sewer network and sewer household connections (SHC) all to be funded under the project, as shown in Figure 6. SHC are service pipelines from the street sewer extended to an inspection opening or point just inside the property boundary line. The tertiary sewers and SHC were not included in the pre-feasibility study for this project but are included here as a crucial part of the sewage treatment system and a pro-poor and social inclusion design feature.

93. Effluent Management. The approach to effluent management ensures that the absorptive capacity of the receiving waterway is not exceeded and health risks to users of the waterways are minimized. In general, during the detailed design stage the receiving water should be sampled (preferably minimum three consecutive non-rainfall days) to at least get an indication of the ambient water quality (in particular coliforms, biochemical oxygen demand, nutrients – nitrogen and phosphorus). Based on that, an indicative estimate should be made of the absorptive capacity of the waterway that is commensurate with its primary use (e.g. rice paddies, vegetable farming, ablutions, etc.) and to stay within the safe limits recommended in

the WHO guidelines for water quality[8]. The details of the specific effluent management method in each city are provided in the subsequernt sections.

Figure 6. Design Relationship & Interface between the Sewerage Piping Systems



Primary Sewer Main (in road) Project Funded

Tertiary Sewer Main (in sidewalk) Project Funded

Internal Sanitary Piping (house & property) Funded to be decided

Source: DDPP Team

94. The project also includes drainage improvements in Serei Saophoan and Stueng Saen This involves working within the natural drainage catchments to improve stormwater flow with the installation of a pipe network of varying diameters (Ø400mm- Ø1800mm). The outfall for the drainage networks is into a natural drainage area including rivers (directly or via canals), streams and ponds, depending on the location. Where possible the drainage is gravity fed, reducing the energy and maintenance requirements.

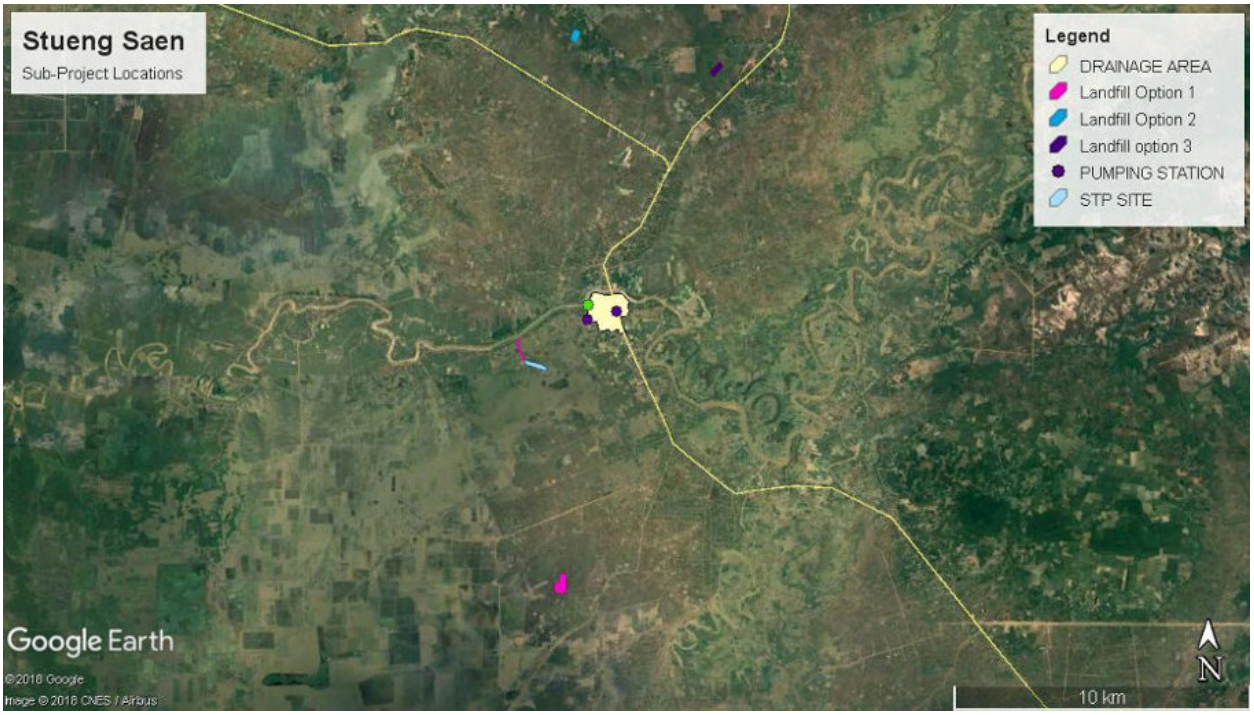
[8] The Cambodian national standard on water quality of waterways is rather limited, it is recommended that the World Health Organization guidelines on water quality standards for agricultural use be adopted

4.6. Detailed Description of the Sub-Projects in Stueng Saen

4.6.1. Introduction

95. The locations of the projects in Stueng Saen are shown in Figure 7. This shows the projects in relation to the urban center. For detailed site maps with key receptors identified, see the relevant EMP for the town.

Figure 7. Stueng Saen Project Locations

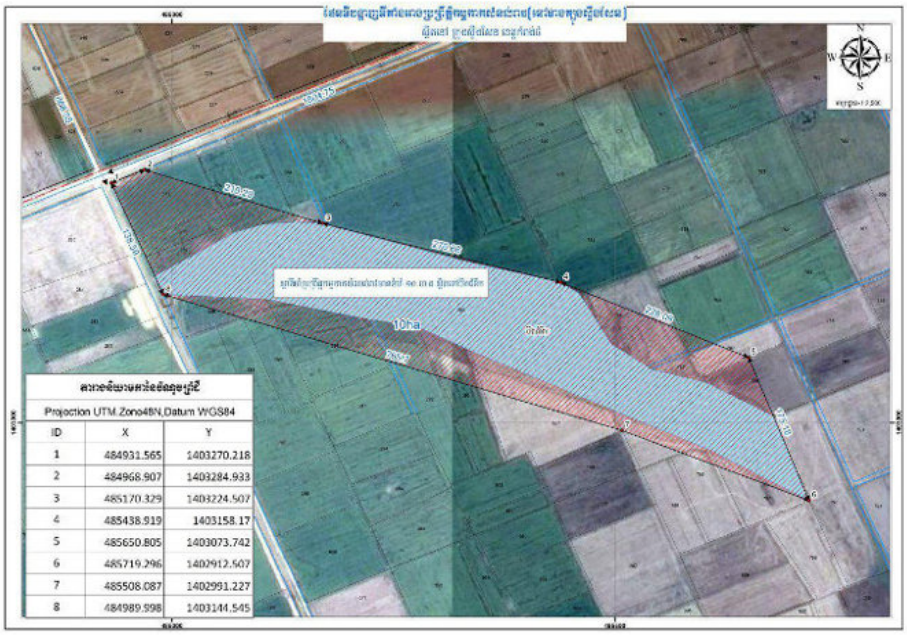


Source: DDPP Team

4.6.2. Sub-Project: Wastewater collection and treatment and drainage system in Stueng Saen

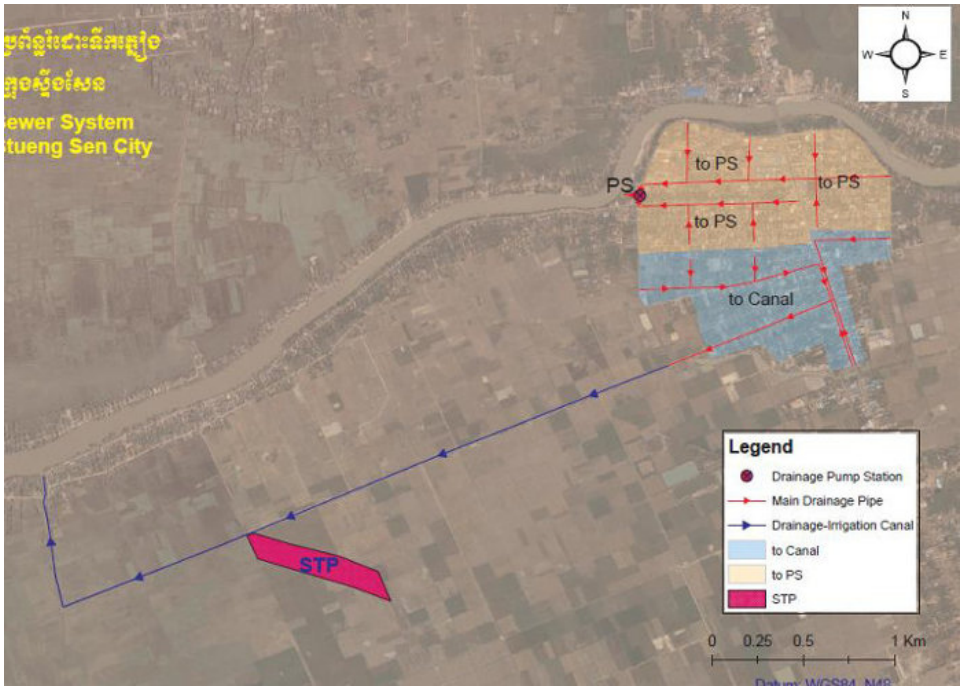
96. The project locations are provided in the detailed maps in Figure 7 to Figure 10.

Figure 8. Stueng Saen STP Location



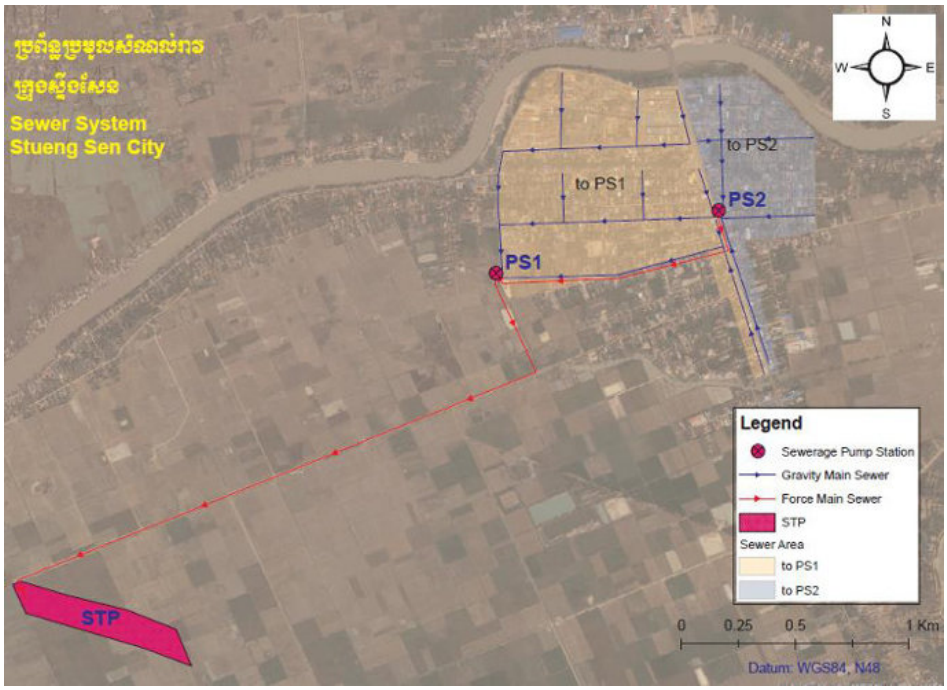
Source: DDPP Team

Figure 9. Stueng Saen Drainage System



Source: DDPP Team

Figure 10. Stueng Saen Sewer System



Source: DDPP Team

97. The sewage system shall include a collection network, household/building service connections, a STP, two pump stations and associated pumping mains.

98. Other infrastructure upgrading shall include raising 1.1 km of existing access road (4m wide) to the STP to be 0.5 m above maximum flood levels. The elevations vary between 1-1.5 m, as determined by the Climate Change Assessment for the project. The treatment plant site will need to be protected by a dike about 3 m high and the site will be raised using imported soil.

99. A separate storm drainage system for the city centre south of the Stueng Saen River is included where several drainage issues need to be resolved.

100. The project will include the following investments:

- Construction of separate primary, secondary and tertiary sewers, including SHC:
  - 8.8km gravity sewer pipes
  - 4.2 km pressurised sewer pipes
  - 26 km Ø160mm tertiary sewers for household connections within project timescales;
- Construction of two sewer pump stations and pumping mains;
- Construction of 3,500 m3/d STP, including associated buildings;
- Septage receiving station;
- Upgrade STP Access Road (1 km)
- Widen 100m site access road and raise by 1m;
- Construction of storm-water drainage system
- Construction of one storm-water drainage pumping station; and
- Provision of Operations & Maintenance Equipment.

101. STP Site. The site is 10 hectares (ha) in size and has the advantage that 60% is already public land, the land to be acquired is low cost, the site is reasonably close to the city centre, is 1km from any residential area. The treated effluent from the plant will be discharged to the nearest canal. This irrigation canal is of sufficient size to provide adequate dilution of the treated effluent and so an effluent pipe with submerged discharge would suffice.

102. As the site will be largely left undeveloped after Stage 1, it provides an opportunity for further polishing of the treated effluent through grass filtration during the dry season which will provide the added benefits of enabling the grass to be harvested for animal fodder and some reduction in effluent discharged as some of the water will be taken up through evapotranspiration and ground infiltration. As an alternative to grass harvesting, animals such as cattle could be used to "keep the grass down". During the wet season rainfall runoff from the land and increased flow in the canal will dilute the effluent further, and. people are less reliant on open canals as a source of water for in-house use. Therefore water quality will be less of a concern. The additional site preparation would involve grading of the land for flow control and the construction of an interceptor channel at the down-gradient end for ultimate discharge of the polished effluent.

103. The primary disadvantage is that the STP site experiences 2-3 m flooding for three months each year during the rainy season; however, this can be mitigated by constructing a 3 m high dike around the STP site. The soil used for constructing the dike will need to be clay soil imported from another location, since there is insufficient soil onsite, due to the existing 6 Ha pond at the site.

104. Drainage. The majority of the city of Stueng Sen drains naturally to either rice paddies and/or the Stueng Sen River. It has been agreed with MPWT that only the central area of the city shall receive a storm drainage system under the project.

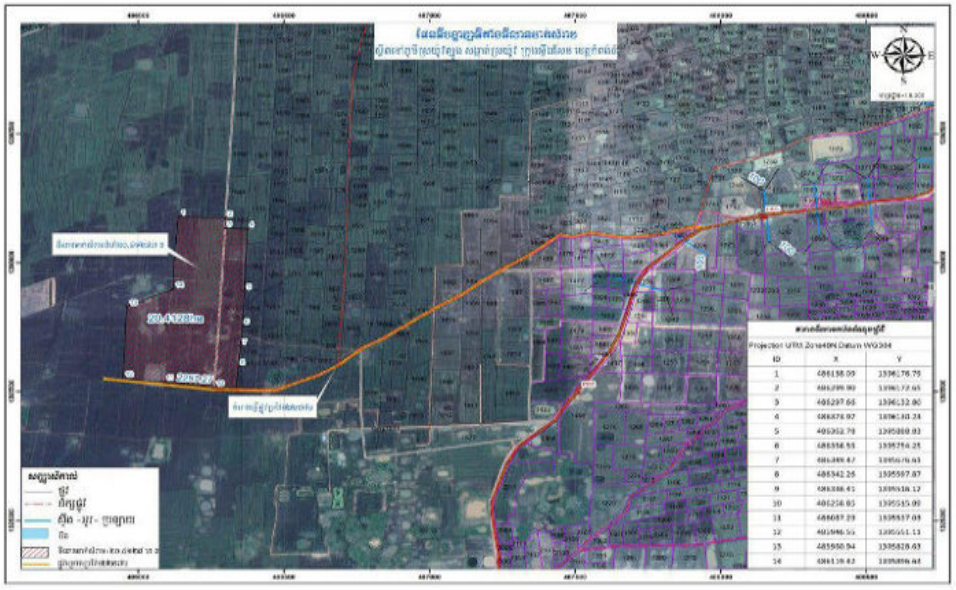
105. The drainage investment comprises:

- Reinforced concrete pipes for the drainage network, since they are least cost, the preferred material for drainage construction and the pipes can be constructed locally;
- Drainage outlet points to Stueng Saen river;
- Pumping station to pump water over the dyke during the rainy season. It has a gravity flow pipe with sluice gate bypass though the dike for storm drainage for periods when river flow is low, and the river height is low; and
- Installation of 17 km of pipe in the urban core.

4.6.3. Sub-Project: Landfill construction in Stueng Saen

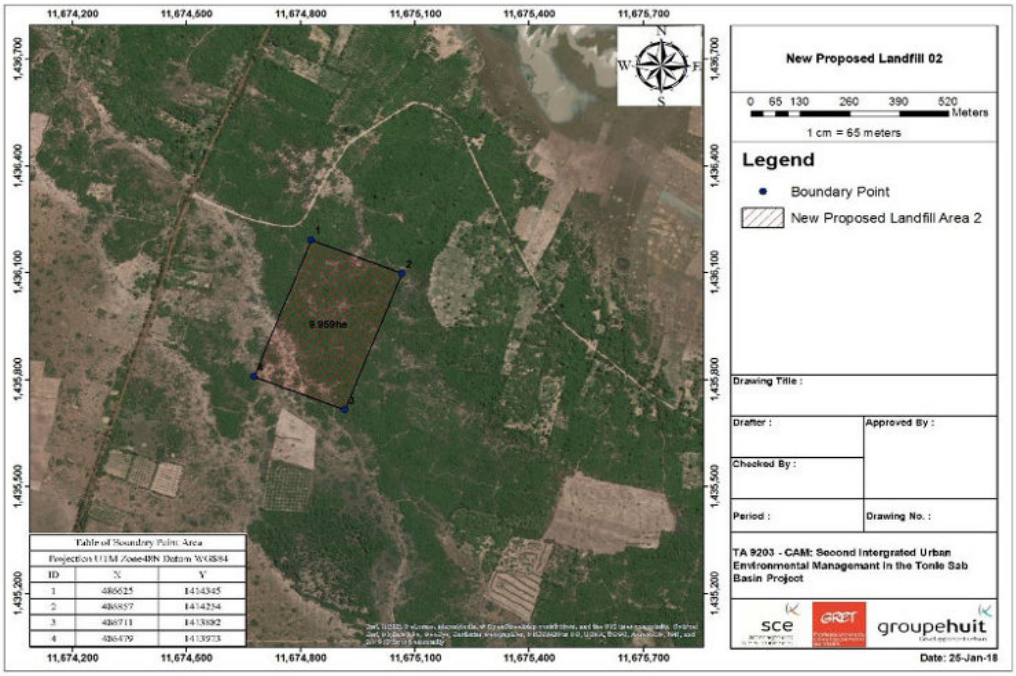
106. The specific landfill areas are shown in Figure 11 to Figure 13.

Figure 11. Stueng Saen Landfill Option 1 Location and Area



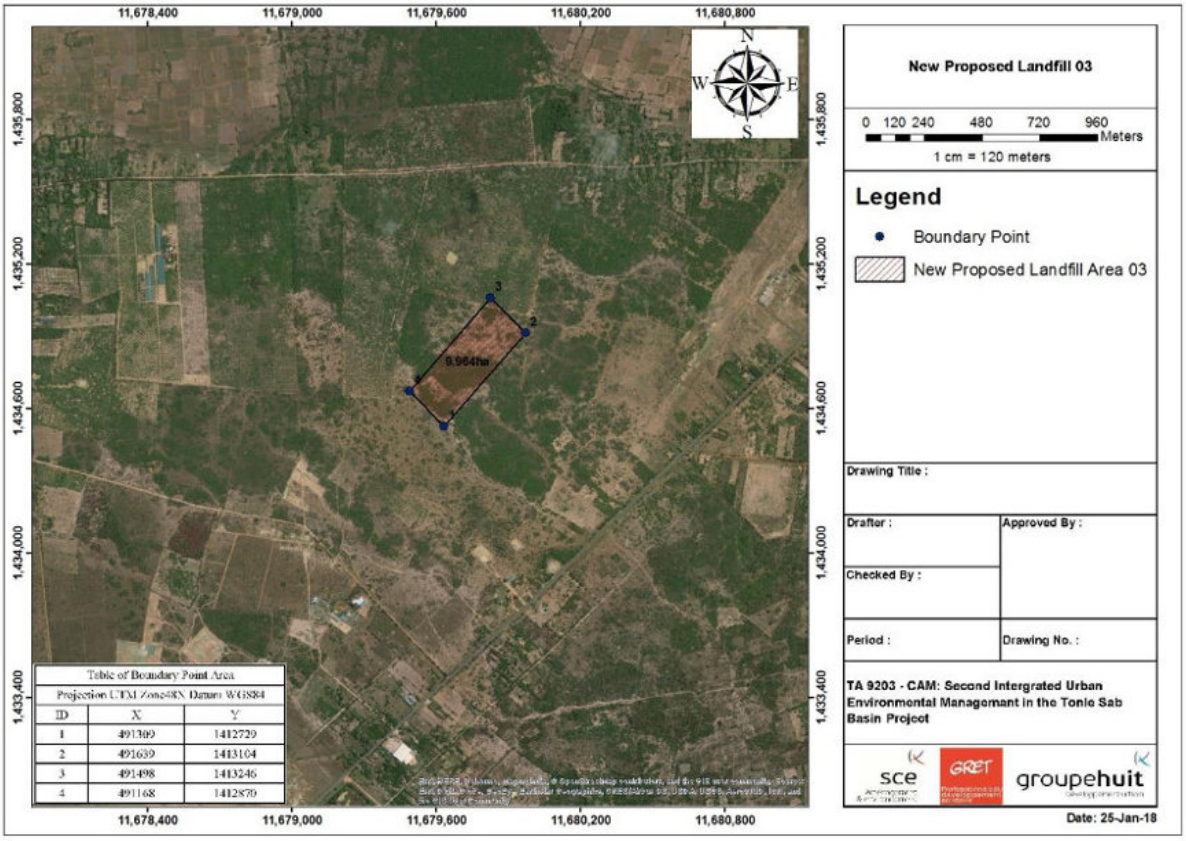
Source: DDPP Team

Figure 12. Stueng Saen Landfill Option 2 Location and Area



Source: DDPP Team

Figure 13. Stueng Saen Landfill Option 3 Location and Area



Source: DDPP Team

107. Three siting options are considered for the city.

- Option 1 located near Srayov Village and requires a new 2 km long access road leading to the landfill site from the main road. Both the new access road and the landfill site are flood prone and therefore the cost of the site and site development is inflated by the need for a 1.5 m high encircling dike as well as raising the road level also by the same amount. This makes the site 25% more expensive than the other two sites which are flood free. The soil types on site appear to be highly variable. There are significant quantities of sand present, as well as a loam/silt. There is little cracking in the drier surficial areas indicating low clay content.
- Option 2 located at Wat O Rumdeng, Snoa Village. The site is flood free and is sufficiently remote from housing and other sensitive receptors such as local watercourses. The soil is a highly leached silt with some clay content and is suitable for landfill development and cover material.
- Option 3 located at Voyav Village and is flood free. However, it is within a kilometre of an airport reserve which presents constraints to landfill siting due to potential bird strikes. It is reasonably remote from housing but does have a cemetery adjacent to the access road which would potentially cause an issue with local residents. It is not further analyzed at this time from an engineering perspective.

108. The options are compared in terms of costs and pros and cons in Table 5.

Table 5. Stueng Saen Landfill Comparison

Option	Capital Costs USD (million)	Comments and Issues
Option 1 – Srayov Village	$2.74M	• Large cost associated with providing a raised access road and encircling bund as site floods to a depth of 1 metre • Stormwater Pump not being operated within the encircling dike so site floods and wets waste forming excess leachate. • Leachate pump may not be operated as generator may not be started when required • Sufficiently remote from main road and housing and other sensitive aspects such as watercourses
Option 2 – Wat O Rumdeng, Snoa village	$2.2M	• Stormwater pumpout less critical as not a fully-enclosed bunded site and will partially self-drain • Assumes leachate system will be better operated as on mains power, not a generator. • Sufficiently remote from main road and housing and other sensitive aspects such as watercourses

Source: DDPP Team

109. Based on these assessments, it is considered that site two is the preferred site, subject to further assessment at the detailed design stage. In conclusion, it is considered that a sustainable landfill could be developed on the preferred site in Stung Saen.

110. The detailed requirements for the landfill are set out in Table 6 and Table 7. These tables are adapted for relevance to the IEE; a full version is available in the Feasibility Study Report Volume 2 – Engineering designs.

Table 6. Stueng Saen Landfill Requirements Option 1

A	EARTHWORKS	UNIT	QUANTITY
	Bulk earthworks for landfill Cell base area of 100m by 75m on average - Stage 1	m^3	11,250
	Trimming of landfill cell base - Stage 1	m^2	7,500
	Compaction of landfill cell base - Stage 1	m^3	3,750
	Bulk earthworks for leachate pump station, monitoring wells and leachate exit pipes	m^3	75
	Levelling and trimming of recycling area, building footprints, etc.	m^2	1,200
	Earthworks works for building platform	m^3	750
	Compaction for perimeter dike	m^3	10,920
	Earthworks works for internal dike around stage 1 to keep out impounded rainwater inside external dike	m^3	380
	Earthworks works for perimeter dike	m^3	10,920
	Installation of clay core for perimeter dike	m	780
	Compaction for perimeter dike	m^3	10,920
	Earthworks for external access road	m^3	36,000
	Compaction for external access road	m^3	36,000
B	**BUILDINGS**		
	Administration, ablution, laboratory and storeroom	m^2	60
	Generator building	m^2	12
	Gatehouse (elevated to allow load inspection where possible)	m^2	8
C	**ROADS, DIKE and HARDSTAND**		
	Access road surface - gravel surface for 2 lanes	m	2,000
	Access road culverts every 250m	Item	8
	Erosion protection on external dike	m^2	3,120
	Erosion protection on external access road	m^2	16,000
	Perimeter and internal access road within the landfill around Stage 1	m	350
	Gravel surface for parking areas	m^2	300
D	**SITE INFRASTRUCTURE**		
	HDPE liner and geotech protective layer	m^2	9,350
	Selected soil to protect liner on top (between leachate gravel drains)	m^3	4,500
	Leachate collector pipe - 200 dia HDPE slotted	m	600
	Leachate exit pipe - 200m dia HDPE solid wall to pump station	m	65
	Gravel backfill around leachate pipe	m^3	216
	Leachate pump station	Item	1
	Irrigation and reinjection relocatable pipe (75mm HDPE)	m	300
	Construction of Groundwater Monitoring wells	Item	3
	Enclosure fence surrounding all 4 stages on top of dike and buildings, parking areas, etc.	m	830
	Movable litter fence	m	50
	Lighting column and LED lamps - solar powered	Item	15
	Water supply (well with pump and header tank)	Item	1
	Sanitation (Septic tank and leach field)	Item	1
	Weighbridge 60T	Item	1

Source: DDPP Team

Table 7. Stueng Saen Landfill Requirements Option 2

A	EARTHWORKS	UNIT	QUANTITY
	Bulk earthworks for landfill Cell base area of 100m by 75m on average - Stage 1	m^3	11,250
	Trimming of landfill cell base - Stage 1	m^2	7,500
	Compaction of landfill cell base - Stage 1	m^3	3,750
	Bulk earthworks for leachate pump station, monitoring wells and leachate exit pipes	m^3	75
	Levelling and trimming of recycling area, building footprints, etc.	m^2	1,200
B	**BUILDINGS**		
	Administration, ablution, laboratory and storeroom	m^2	60
	Gatehouse (elevated to allow load inspection where possible)	m^2	8
C	**ROADS and HARDSTAND**		
	Access road surface - widened road plus gravel surface for 2 lanes over 500m	m	750
	Perimeter and internal access road within the landfill around Stage 1	m	366
	Gravel surface for parking areas	m^2	300
D	**SITE INFRASTRUCTURE**		
	HDPE liner and geotech protective layer	m^2	9,350
	Selected soil to protect liner on top (between leachate gravel drains)	m^3	4,500
	Leachate collector pipe - 200 dia HDPE slotted	m	600
	Leachate exit pipe - 200m dia HDPE solid wall to pump station	m	65
	Gravel backfill around leachate pipe	m^3	216
	Leachate pump station	Item	1
	Irrigation and reinjection relocatable pipe (75mm HDPE)	m	300
	Construction of Groundwater Monitoring wells	Item	3
	Enclosure fence surrounding all 4 stages and buildings, parking areas, etc.	m	830
	Movable litter fence	m	50
	Electric elevated power cable from laterite road to site along landfill access road	item	800
	Water supply (well with pump and header tank)	Item	1
	Sanitation (Septic tank and leach field)	Item	1
	Weighbridge 60T	Item	1

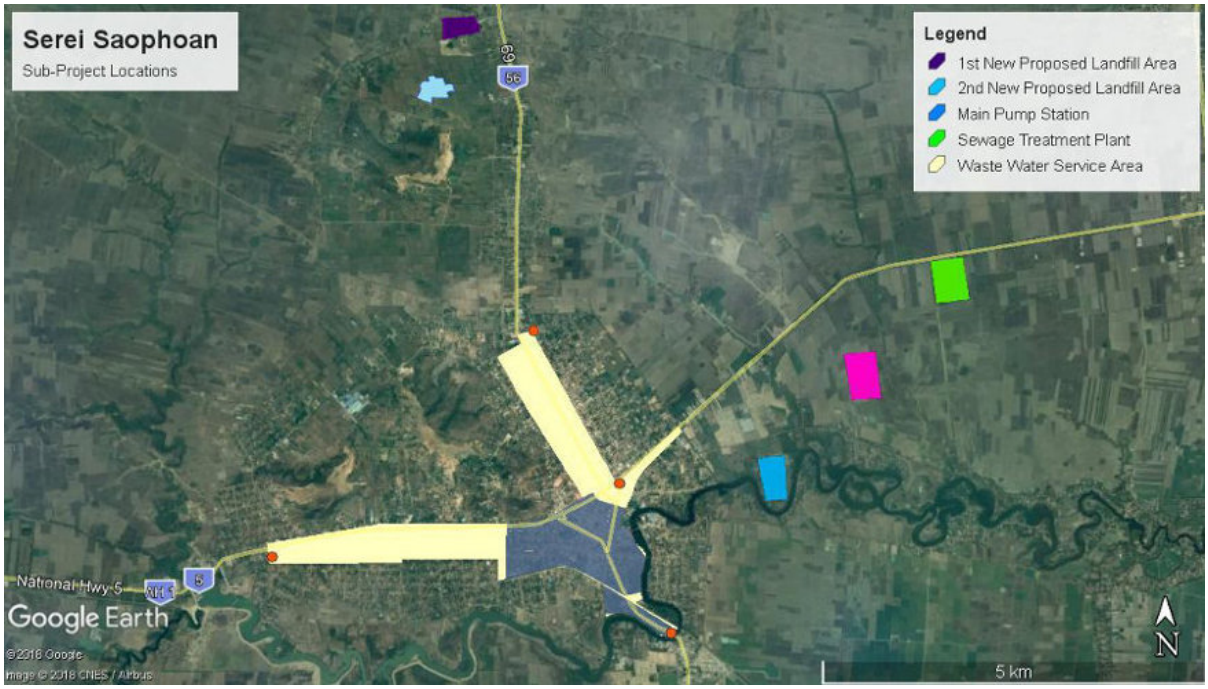
Source: DDPP Team

4.7. Detailed Description of the Sub-Projects in Serei Saophoan

4.7.1. Introduction

111. The locations of the projects in Serei Saophoan are shown in Figure 14. This shows the projects in relation to the urban center; it identifies the existing and site options for the new landfill and STP. For detailed site maps with key receptors identified, see the relevant EMP for the town.

Figure 14. Serei Saophoan Project Locations



Source: DDPP Team

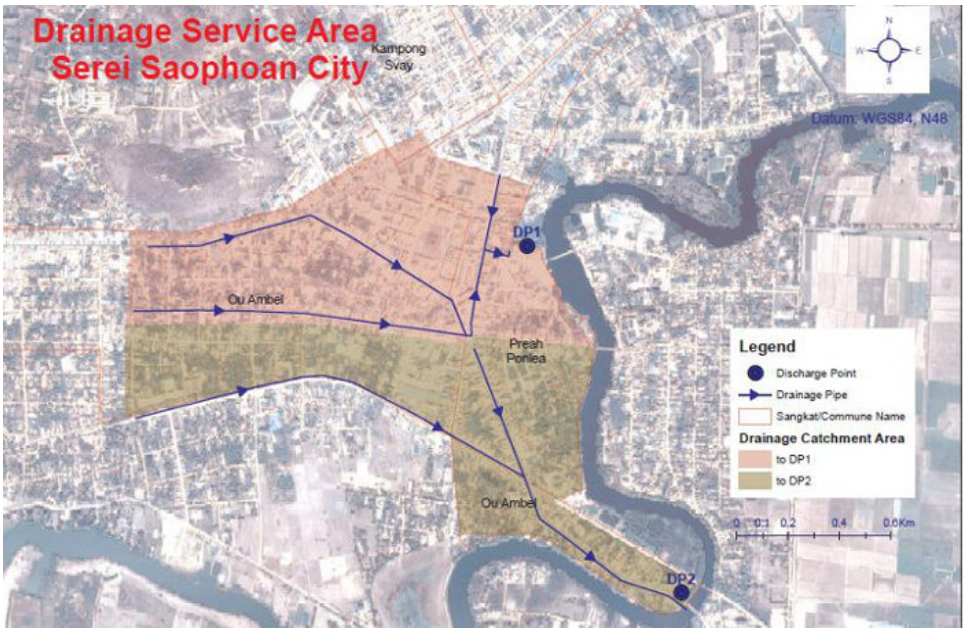
4.7.2. Sub-Project: Wastewater collection and treatment system (first phase) Serei Saophoan

112. The options for the STP sites are given in Figure 15. The drainage and sewer system locations are given in Figure 16 and Figure 17, respectively.

Figure 15. Serei Saophoan STP Site Options

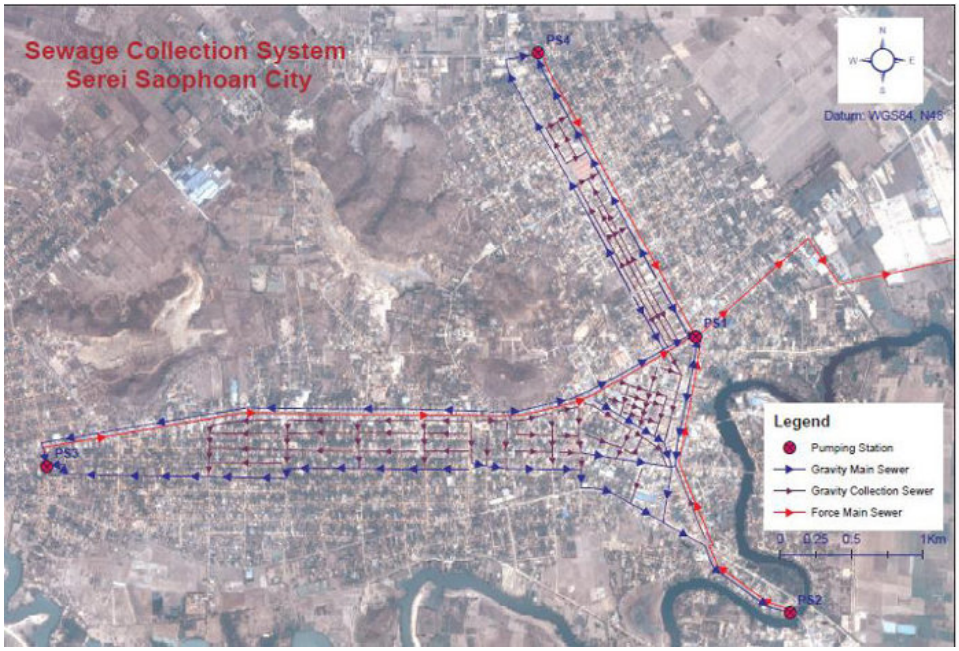
Source: DDPP Team

Figure 16. Serei Saophoan Drainage System Location



Source: DDPP Team

Figure 17. Serei Saophoan Sewer System Location



Source: DDPP Team

113. The sewage system shall include a separate sewer collection network, household/building service connections, a STP, four pump stations and associated pumping

mains. Other infrastructure upgrading associated with the STP are dredging the existing canal receiving treated effluent discharge from the STP and raising existing access road to the STP above the maximum flood levels (Option 2 and 3).

114. Drainage works shall cover the central core area of the city where several drainage issues need to be resolved; however, the remainder of the city drains naturally to either the river or rice paddies.

115. The project will include the following investments:

- Construction of separate sewer network including primary, secondary and tertiary sewers and SHC;
  - 27 km gravity sewer pipeline
  - 14 km pressurized sewer pipeline
  - 98 km of Ø160mm tertiary sewers for household connections within project timescales
- Construction of sewer pump stations and pumping mains;
- Construction of STP, including associated buildings
- Upgrade STP access road and raise road elevation above the maximum flood level;
  - Option 1; 460m of 4m wide road raised by 3m;
  - Option 2; 1.1km of 4m wide road raised b 1.3m, and 400m of 4m wide site access road raised by 3m;
- Construction of storm-water drainage system in central area of the city; and
- Provision of operations & maintenance equipment.

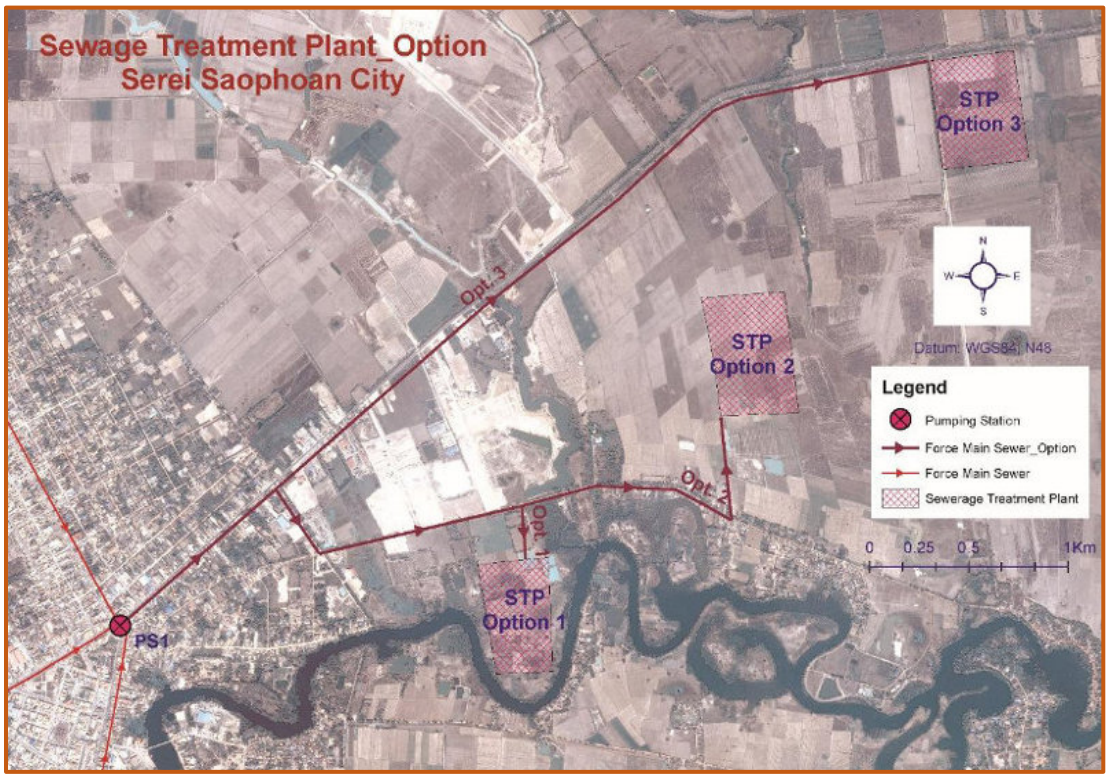
116. STP Sites. Three options considered have been identified by Provincial Department of Public Works and Transport (PDPWT) for the location of the STP. For all threeoptions the locations of catchment areas, the sewer collection mains, pump stations and pumping mains shall remain the same.

- Option 1 site is close to the city centre (2.5 km) and adjacent to the Serei Saophoan River for ease of effluent disposal; however, the site is adjacent to an ongoing land development project and the land is rather costly. Option 1 would require 0.5 km of access road, elevated 3 m above flood level and 3 km of sewage pumping main.
- Option 2 site is 4 km away from the city centre and further away from residential areas, the land cost is substantially lower than Option 1. Option 2 would require 1.5 km of access road elevated by 3 m and a 4 km long sewage pumping main. Effluent would be piped into drainage/irrigation canal which requires some dredging.
- Option 3 site is 5.5 km from the city centre, although it has good access directly off the National Highway. The location adjacent to a National Highway may result in a higher land cost than Option 2. Option 3 would require a 5.5 km long sewage pumping. Effluent piped into drainage/irrigation canal which requires some dredging.

117. All STP site options are 10 ha in size and experience 2-3 m flooding for three months each year during September-November; however, this can be mitigated by constructing a 3 m high dike around the STP site. The soil used for constructing the dike can be clay soil either imported from another location or existing clay soil on the selected 10 Ha STP site.

118. The sewage pumping pipe routes for each STP option are shown in Figure 18.

Figure 18. Sewage Pumping Pipe Route for STP Options



119. Effluent discharge. The effluent will be discharged to the nearby irrigation canal used primarily for rice paddies. As such the potential health risks to the public are the primary sensitive parameter. Should the dilution of the effluent meet WHO water quality guidelines for waters used for agriculture in terms of biological parameters (coliform concentrations), then a direct discharge to the canal will be acceptable. However, if the direct discharge would result in exceedance of the safe limits then a part of the existing canal should be partitioned to separate the effluent from the general canal water. Sign boards should be erected and placed at regular intervals warning people that the water is unfit for consumption and which side of the canal should water be taken for agricultural use.

120. The barrier could be in the form of removable stop logs between piles driven into the canal bed. This would provide flexibility to adjust and mix the two waters thus promoting dilution (to safe limits and also providing valuable nutrients to the farmers. Seepage from through the gaps between the logs would also result in some dilution and assimilation of the effluent with the general irrigation water.

121. Drainage. The majority of the city drains naturally to either rice paddies or the Saphoan River. Consequently, only the central area of the city requires a storm drainage system.

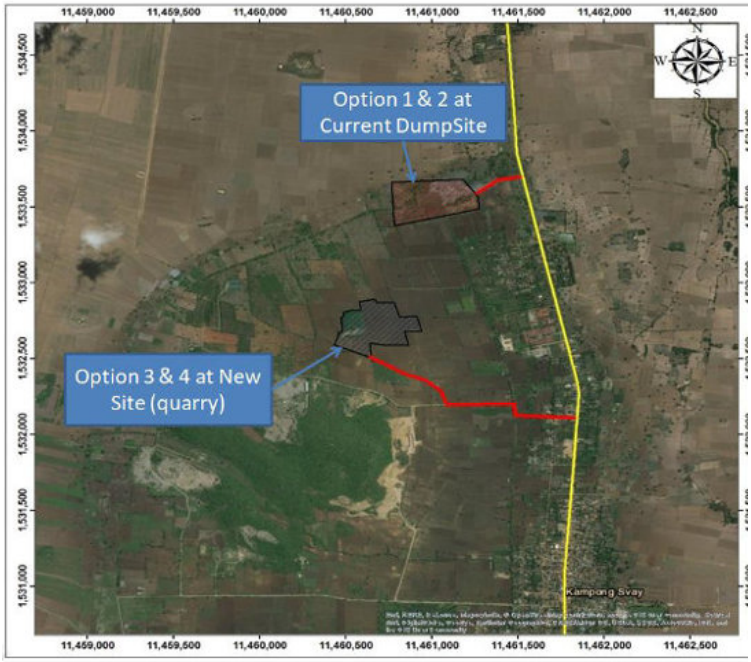
122. The drainage investment comprises:

- Reinforced concrete pipes for the drainage network;
- Drainage outlet points to Serei Saophoan river;
- Installation of 8.5 km of pipe in the urban core.

4.7.3. Sub-Project: Landfill construction Serei Saophoan

123. The landfill site options are shown in Figure 19.

Figure 19. Serei Saophoan Landfill Site Location



Source: DDPP Team

124. Four options are considered for remediating the current dumpsite and providing a suitable location for waste disposal, as described below

- Option 1 is to use the existing abandoned pits at the current dump site and engineer the pits to include liner.
- Option 2 is to construct a new disposal area at the western end of the overall current dump site, away from the pits, and on reasonably level ground only for old waste and pre-2022 waste;
- Option 3 is to haul all old waste and pre-2022 waste to the new landfill site at a current quarry in 2022 and mix with the fresh incoming waste post 2022; and
- Option 4 is to haul all old waste and pre-2022 waste to a new landfill on the existing site in 2022 and mix with the fresh incoming waste post 2022.

125. The options are compared in terms of costs and pros and cons in Table 8.

Table 8. Serei Saophaon Landfill Comparison

Option	CAPEX (USD)	Comments and Issues
Option 1 – Waste into Pit at Old Site	$2,900,000	• Stormwater Pump not being operated and maintained so site floods and wets waste forming leachate. • Leachate pump not operated and maintained once site closes • Difficult liner development as fitting around old waste relocation activities

		• Progressive liner development can lead to poor liner jointing between new and old liner • Close to main road and will be visible as partially above grade
Option 2 – Waste into New Flat Area at Old Site	$2,880,000	• Requires good scheduling of drying waste in pits before placement into liner to avoid excess leachate generation • Assumes leachate system will be maintained. • Still close to main road and will be visible as completely above grade
Option 3 – Waste into Landfill at New Site (quarry)	$2,540,000	• Leachate and stormwater systems will be maintained once remediated waste received as part of ongoing landfill operation • Mixing old partially stabilised and drier remediation waste with fresh waste will improve net moisture content, workability and compaction • Rapid initial waste placement from both remediation and fresh waste will quickly cover the leachate pipe network, reducing potential stormwater infiltration. • Rapid mound development with a large proportion of drier remediated waste means reinjection systems will be more effective during early operational periods • Cost efficiencies associated with partial backfilling an old pit • Site is more remote from the main road than the old site
Option 4 – Waste into Landfill at Old Site	$3,630,000	• Leachate and stormwater systems will be maintained once remediated waste received as part of ongoing landfill operation • Mixing old partially stabilised and drier remediation waste with fresh waste will improve net moisture content, workability and compaction • Rapid initial waste placement from both remediation and fresh waste will quickly cover the leachate pipe network, reducing potential stormwater infiltration. • Rapid mound development with a large proportion of drier remediated waste means reinjection systems will be more effective during early operational periods • Cost inefficiencies associated with no backfilling of an old pit • Site is closer to the main road than the new site

Source: DDPP Team

126. Option 3 Waste into Landfill at New Site (quarry) is the least cost by approximately 10 percent and has generally positive issues compared with Options 1, 2 and 4, all of which have a number of operational and especially sustainability concerns once the mound is sealed or significant cost penalties in the case of option 4.

127. Overall, Option 3 is the preferred option, namely enlarging the size of the first stage of the new landfill at the new location (quarry site) and removing all waste and contaminated soil from the old site and haul to the new site to co-dispose with the incoming fresh daily waste.

128. The proposed site is a gravel quarry with one pit currently being worked and a number of abandoned pits. The pit depth varied from less than 6 m to over 12 m based on inspection only. The soil types on site appear to be highly variable. There are significant quantities of

decomposed granite present which is the main material being won for sale, and this material is generally in the upper levels.

Table 9. Serei Saophaon Landfill Requirements Option 3

A	**EARTHWORKS**		
	Bulk earthworks for landfill Cell base area of 125m by 100m on average - Stage 1	m^3	18,750
	Bulk earthworks for profiling and stabilising landfill perimeter batters	m^3	11,880
	Trimming of landfill cell base - Stage 1	m^2	12,500
	Compaction of landfill cell base - Stage 1	m^2	12,500
	Bulk earthworks for leachate pump station, monitoring wells and leachate exit pipes	m^3	75
	Levelling and trimming of recycling area, building footprints, etc.	m^2	2,500
B	**BUILDINGS**		
	Administration, ablution, laboratory and storeroom	m^2	60
	Generator building	m^2	12
	Gatehouse (elevated to allow load inspection where possible)	m^2	8
C	**ROADS, DIKE and HARDSTAND**		
	Perimeter and internal access road within the landfill around Stage 1	m	590
	Gravel surface for parking areas	m^2	500
D	**SITE INFRASTRUCTURE**		
	HDPE liner and geotech protective layer	m^2	20,150
	Selected soil to protect liner on top (between leachate gravel drains)	m^3	7,500
	Leachate collector pipe - 200 dia HDPE slotted	m	575
	Leachate exit pipe - 200m dia HDPE solid wall to pump station	m	100
	Gravel backfill around leachate pipe	m^3	207
	Leachate pump station	Item	1
	Leachate pump/s and controls	Item	1
	Irrigation and reinjection relocatable pipe (75mm HDPE)	m	200
	Construction of Groundwater Monitoring wells	Item	3
	Enclosure fence surrounding all 4 stages on top of dike and buildings, parking areas, etc.	m	550
	Movable litter fence	m	50
	Water supply (well with pump and header tank)	Item	1
	Sanitation (Septic tank and leach field)	Item	1
	Weighbridge 60T	Item	1

Source: DDPP Team

129. In conclusion, it is considered that a sustainable landfill could be developed on the preferred site, which is the quarry site as per Option 3.

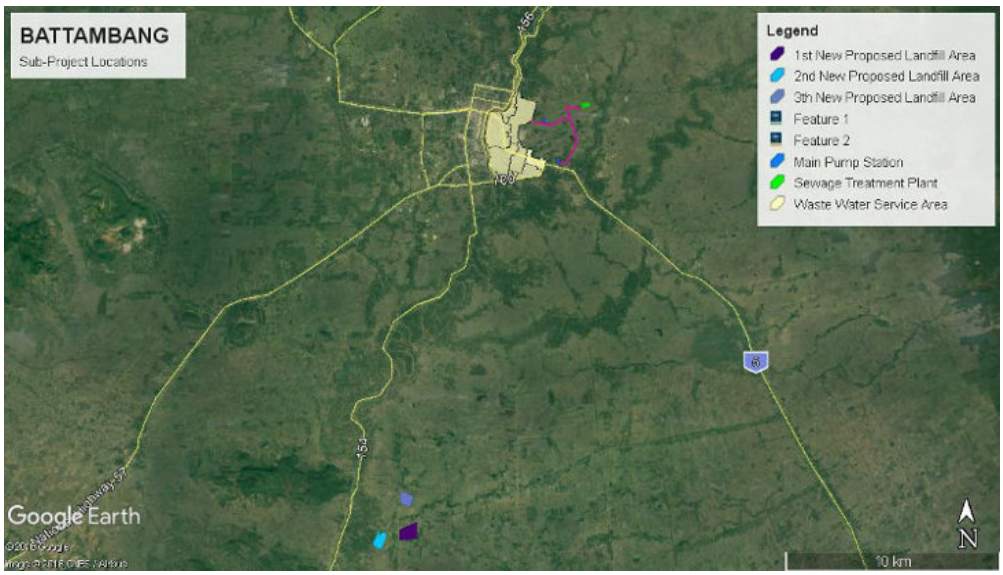
130. The new facility has been sized and costed to accept all old waste currently on the existing dumpsite, waste to be delivered to the existing dumpsite up until the commissioning of a new landfill cell in 2022, and finally fresh waste to be delivered to the new site up until 2027 thereby providing a five-year life for stage one which is in accordance with typical design requirements. A staging plan will be defined by the detailed design team to show what is required in future stages. Following project implementation, the municipalities will have the technical designs and skills necessary to build and operate subsequent stages. The requirement for the development of a staging plan is set out in Feasibility Study Report, Volume 2 – Engineering Design.

4.8. Detailed Description of the Sub-Projects in Battambang

4.8.1. Introduction

131. The locations of the projects in Battambang are shown in Figure 20. This shows the projects in relation to the urban center. For detailed site maps with key receptors identified, see the relevant EMP for the city.

Figure 20. Battambang Project Locations



Source: DDPP Team

4.8.2. Sub-Project: Wastewater treatment, Battambang

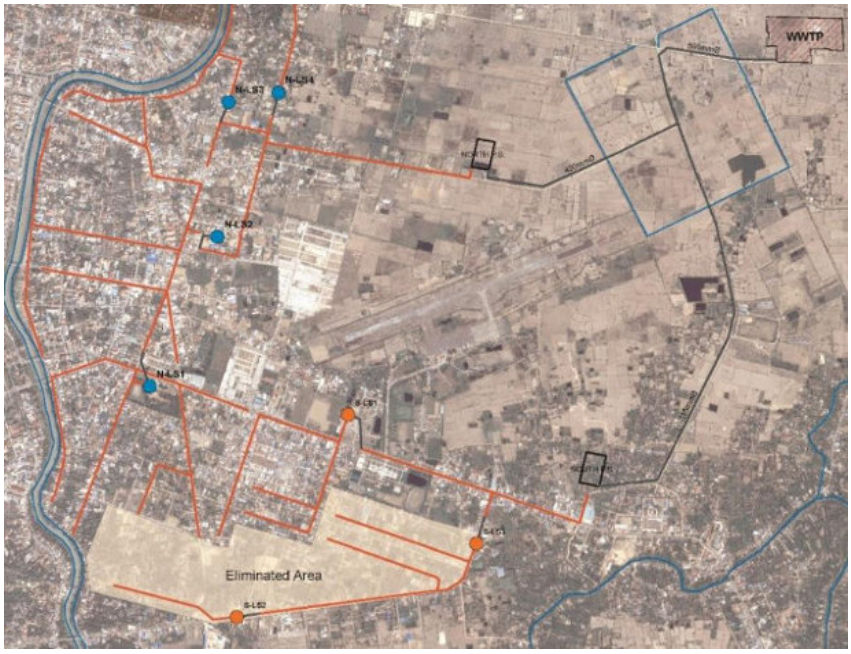
75. The option for the STP site is given in

Figure **21**. The sewer network locations are given in Figure 22.

Figure 21. Battambang STP Site

Source: DDPP Team

Figure 22. Battambang Sewer Network Locations



Note:' eliminated area' is now included in the projectSource: DDPP Team

132. The project design is in the context of an existing project sewage system prepared by the GMS: Southern Economic Corridor Towns Development Project. The drainage and sewage components will be implemented in two stages as follows:

- Stage 1 – Construction of storm-water drainage system under GMS: Southern Economic Corridor Towns Development Project
- Stage 2 – Construction of separate sewer system, including tertiary sewers, service connections, pump stations and sewage treatment plant under this project.

133. With a design period of 20 years, the project components/facilities are planned up to Year 2040. The project will include the following investments:

- Construction of a primary, secondary and tertiary sewer collection network, including SHCs;
  - 28 km gravity sewer pipeline
  - 9.7 km pressurized sewer pipeline
  - 51 km of Ø160mm tertiary sewers for SHCs within project timescale
- Construction of two primary sewer pump stations and associated pumping mains;
- construction of four secondary sewer pump stations and pumping mains;
- Construction of an 8,500 m3/day STP
- Construction of administration, workshop, generator and security buildings at STP;
- Upgrade and raise four km of access road to the STP site;
- Provision of operations & maintenance (O&M) equipment.

134. STP Site. Only one site is selected for consideration at this stage.

135. Effluent Discharge. The effluent will be discharged to the nearby small irrigation canal. As this canal has limited absorption capacity, the effluent should be discharged to the canal through an outfall pipe fitted with a diffuser rather than as an end-of-pipe point discharge. This

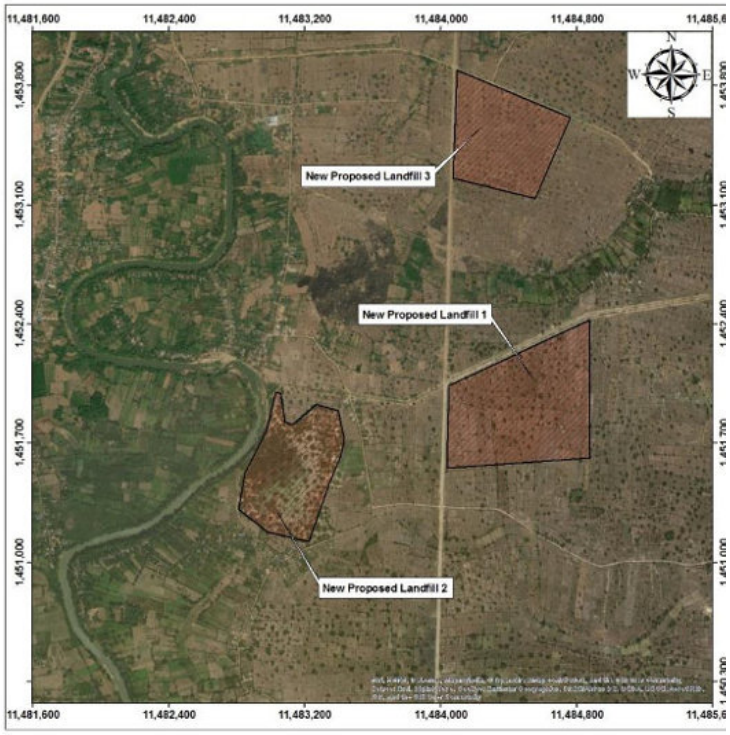
should enhance dilution and dispersion of the effluent plume and promote assimilation into the general canal water.

136. The outfall pipeline and diffuser should be buried into the canal bed and its length would need to be designed to achieve reasonable dilution. As an added public safety measure the canal should be fenced off on both sides for a distance of 200 m downstream from the point of discharge and signs should be erected to warn the public not to enter the fenced off section of the canal. To assist farmers who may be cut off from access to the canal, an offtake point downstream of the fence could be provided for their use.

4.8.3. Sub-Project: Landfill Construction Battambang

137. The options for the landfill sites are given in Figure 23.

Figure 23. Battambang Landfill Site Options



Source: DDPP Team

138. Three siting options are considered for the city, described below, including pros and cons for each site.

- Option 1 is at Prey Torteung, located approximately 22.5 km from the city centre. The sealed dual carriageway main road runs for the first 15 km. A dual lane gravel farm-to-market road then runs for approximately another 6 km before the turnoff to the possible landfill site. This north-south local access road option from this farm-to-market road is approximately 1.4 km long and will have to be significantly improved as it is currently essentially a one-lane track. Also, there is a possibility of alternative east-west access roads that will need to be upgraded. The first east-west option to the north west of the site is about half the length of the north-south option but will

have to be two lanes for the entire length given the number of corners and turns involved. The costs for the 980m long access road to the north west of the site have been assumed at this stage.

- Option 2 (Chay Rumport) is located two kilometres to the west of Option 1. The site is approximately the same distance from the city centre and on a main road so an access road is not required. The site has a good slope away from the access road in the order of 2%. This is ideal for the longitudinal slope of the base of the landfill and therefore would reduce the number of preparatory earthworks required. The soil type is generally similar to that of the private land site being a leached silt with significant quantities of clay being present. The nearest house is virtually adjacent to the proposed site and at least 20 other houses are located in the contiguous village environs. Furthermore, given the recent upgrade to the local section of the access road, significant housing development is currently underway as ribbon development and could be expected to effectively surround the landfill site in the short to medium term.
- Option 3 is at Prey Torteung, one kilometre to the North of option 1, and is located at the South East corner of the gravel road (Farm to Market road) and the proposed upgraded North-South access road to site No 1. It is similar to the Option 1 in terms of use and geology and is flood free. The site is a little over 20km from the city. There is a housing development of at least 10 to 20 houses within the 400 to 700 metres range from the site edge. Some of the houses are workers huts that are only used during crop harvest however. Overall the site will need to be more closely investigated as an option, but the amount of nearby housing will be a major issue requiring detailed assessment.

139. Option 1 (on private land) is adopted at this stage for the purposes of preparing the preliminary landfill development costings subject to further assessment at detailed design stage. The requirements for this option are set out in Table 10.

Table 10. Battambang Option 1 Landfill Requirements

A	EARTHWORKS	UNIT	QUANTITY
	Clearing grubbing of 25% od landfill site	m^2	10,000
	Bulk earthworks for landfill Cell base area of 200m by 200m on average - Stage 1	m^3	40,000
	Trimming of landfill cell base - Stage 1	m^2	40,000
	Compaction of landfill cell base - Stage 1	m^2	40,000
	Bulk earthworks for leachate pump station, monitoring wells and leachate exit pipes	m^3	75
	Levelling and trimming of recycling area, building footprints, etc.	m^2	2,500
B	**BUILDINGS**		
	Administration, ablution, laboratory and storeroom	m^2	60
	Generator building	m^2	12
	Gatehouse (elevated to allow load inspection where possible)	m^2	8
C	**ROADS and HARDSTAND**		
	External access road surface - gravel surface for 2 lanes on East-West access road upgrade option	m	980
	External access road culverts every 250m	Item	8
	Perimeter and internal access road within the landfill around Stage 1	m	840
	Gravel surface for parking areas	m^2	500
D	**SITE INFRASTRUCTURE**		
	HDPE liner and geotech protective layer	m^2	48,400
	Selected soil to protect liner on top (between leachate gravel drains)	m^3	24,000
	Leachate collector pipe - 200 dia HDPE slotted	m	2,600
	Leachate exit pipe - 200m dia HDPE solid wall to pump station	m	130
	Gravel backfill around leachate pipe	m^3	936
	Leachate pump station	Item	1
	Irrigation and reinjection relocatable pipe (75mm HDPE)	m	400
	Construction of Groundwater Monitoring wells	Item	3
	Enclosure fence surrounding all 4 stages on top of dike and buildings, parking areas, etc.	m	900
	Movable litter fence	m	50
	Water supply (well with pump and header tank)	Item	1
	Sanitation (Septic tank and leach field)	Item	1
	Portable dewatering pump for open cells	Item	1
	Weighbridge 60T	Item	1

Source: DDPP Team

140. In conclusion, it is considered that a sustainable landfill could be developed on the preferred site Option 1 at Prey Torteung, for Battambang and surrounding Banon and Sangke districts. This site is preferable due to its distance from sensitive receptors and suitability for access.

141. Current existing dumpsite. The existing disposal site will be remediated and closed after commissioning of the new landfill facility, but this is not part of the current project.

4.9. Associated & Existing Facilities

142. Associated Facilities. SPS 2009 defines associated facilities as “facilities that are not funded as part of a project but whose viability and existence depend exclusively on the project, or whose goods or services are essential for successful operation of the project. This project does not include associated facilites.

143. Existing Facilities. SPS 2009 states that for projects involving facilities and/or business activities that already exist, the borrower/client will undertake an environment and/or social compliance audit, including on-site assessment, to identify past or present concerns related to impacts on the environment, involuntary resettlement, and Indigenous Peoples.

144. A compliance audit will be undertaken on the existing dumpsites to be closed in in Serei Saophoan and Stueng Saen in order to identify legacy issues and inform the detailed engineering design of the dumpsite closure; The Draft Terms of Reference for the audit is in Appendix 3. The compliance audit will not require a specific corrective action plan as the corrective actions will be undertaken during site closure/rehabilitation. The audit report will be disclosed on ADB's website and be available for review in PDPWT's office (summary in Khmer) in accordance with SPS (2009).

5. DESCRIPTION OF THE ENVIRONMENT

5.1. Project Area of Influence

145. All sub-project site options were visited for the preparation of this IEE, with particular attention paid to identifying:

- Sensitive natural environmental receptors such as water bodies, biodiversity and wildlife habitats;
- Sensitive human receptors;
- Cultural and heritage sites; and
- Potential health and safety issues.

146. According to SPS 2009, the area of influence encompasses:

(i) The primary project site(s) and related facilities that the borrower/client develops or controls. The primary project sites for this project include direct construction sites, pipelines, canals, access roads, borrow pits, disposal areas, and construction camps.

(ii) Associated facilities that are not funded as part of the project whose viability and existence depends exclusively on the project. No associated facilities are anticipated for this project.

(iii) Effects from cumulative impacts from further planned development of the project, other sources of similar impacts. No cumulative impacts in this regard are anticipated as a result of this or similar projects.

(iv) Effects from unplanned but predictable developments caused by the project that may occur later or at a different location. As a result of this project, it is anticipated that the development of the urban centers will continue, leading to further developments around the sub-project areas.

147. The area of influence i.e. the area which is affected by the project, also depends on the environmental impact being considered. Local impacts with a narrow area of influence are those impacts arising from noise, dust and amenity issues. A larger area of influence results from impacts which contribute to global issues such as the embodied carbon associated with the manufacture, supply and use of concrete products, and the carbon emissions associated with material transport. SPS 2009 requires the assessment to identify potential transboundary effects, such as air pollution, and global impacts, such as emission of greenhouse gases.

148. For the purposes of this EMP, the area of influence for amenity issues is taken to be 250 m, based on noise levels, as follows:

- WHO Community Noise Limits: One Hour LAeq 55 dBA (Outside; residential receptor, day time limit)
- Construction Noise: Backhoe excavator 80dBA at 15m and concrete mixer 79dBA at 15m. Source: Construction Noise Handbook (www.fhwa.dot.gov), US Department of Transport.
- Noise attenuation factor: a conservative 6 dBA each time the distance from the point source is doubled. Source: US Occupational Safety and Health Administration (www.osha.gov/dts/osta/otm/new_noise/). Note that in soft vegetated environments such as in agricultural fields, the noise attenuation will be significantly increased meaning the area of influence could be narrowed. However, this would not be the case where vegetation is removed.
- Calculation: At 250m the noise at a receptor is approximately 55 dBA (WHO limit).

149. See Annex 2 Site Field Notes & Descriptions for photographs and site descriptions from field visits to all project sites and the areas of influence.

5.2. Baseline Receptor Summary

150. This section of the IEE provides the environmental baseline (description of the environment) for the project facilities. A site-specific summary table for key receptors is provided in Table 11. The receptors and site facilities are also shown on map images in the relevant EMP for each city. The distances given are approximate based on a centre point for each proposed site.

151. These receptors are explored in more detail in the following sections describing the environmental baseline conditions.

152. In addition to these facility specific receptors, housing, businesses and affected people's requirement for access are considered to be receptors. These receptors are found, for example, at locations where any excavations for pipe networks associated with the STPs sub-projects. This is considered in the EMP mitigation measures.

Table 11: Summary of Environmentally Sensitive Receptors for All Subproject Options

City	Sub-Project	GPS	Surface Water Receptors	Socio-Economic & Cultural Receptors	Land Cover/ Ecological Receptors	Protected Area Status
Kampong Chhnang	STP Opt. 1	12°16'23.42"N, 104°40'27.26"E	Tonle Sap river 20m East (effluent),	Mosque, 900m north Housing & Businesses: 20m, Within Proposed ADB funded Tonle Sap 1 embankment, Pagoda 800m south	Flooded area, wet season agriculture	Within TSBR Transition zone
	STP Opt. 2	12°15'8.15"N, 104°40'41.34"E	Within Beoung Thom Lake, Tonle Sap river (effluent)	Lotus planting in lake Pagoda 0.5 km West (Pkampong Os Leur Pagoda) Pagoda 0.8 km North (Samraong Pagoda) Housing within 150m Church 0.5 km South West	Flooded lake area, used for lotus planting in wet season	Within TSBR Transition zone
	STP Opt. 3	12°14'8.16"N, 104°40'57.65"E	Seasonally flooded from Tonle Sap, canal adjacent to East, Tonle Sap river (effluent)	High school 1.2km west, Restaurant opposite site (open air), Housing: 1 km west, Pagoda: 1.2km north west	Flooded areas, lowland, dry season rice	Within TSBR Transition zone
Battambang	STP	13° 6'28.97"N, 103°14'31.62"E	Ou Mony stream 850m (Effluent), Canals 5m surrounding site and conveying effluent to Ou Mony	Nearest housing area: 0.8km East of STP, House adjacent to Pumping Station 2, Preah Kunkud Pagoda west of Pumping Station 1 along access road (260m) 13° 6'7.87"N, 103°13'22.73"E, Distance to town: 4.5km	Lowland rice fields	None
	Landfill Opt. 1	12°55'51.47"N, 103° 9'52.57"E	Sangke River 1.5 km West, Irrigation canal adjacent to west, tertiary canal across site	Nearest housing area: 1 km North East and 300m individual houses to north west, Distance to City: 18 km Pagoda (new): 4 km East	Rice fields, some cultivated shrub/small trees e.g Tamarind, Neem, Bamboo, Sugar Palm, Euphorbia.	None

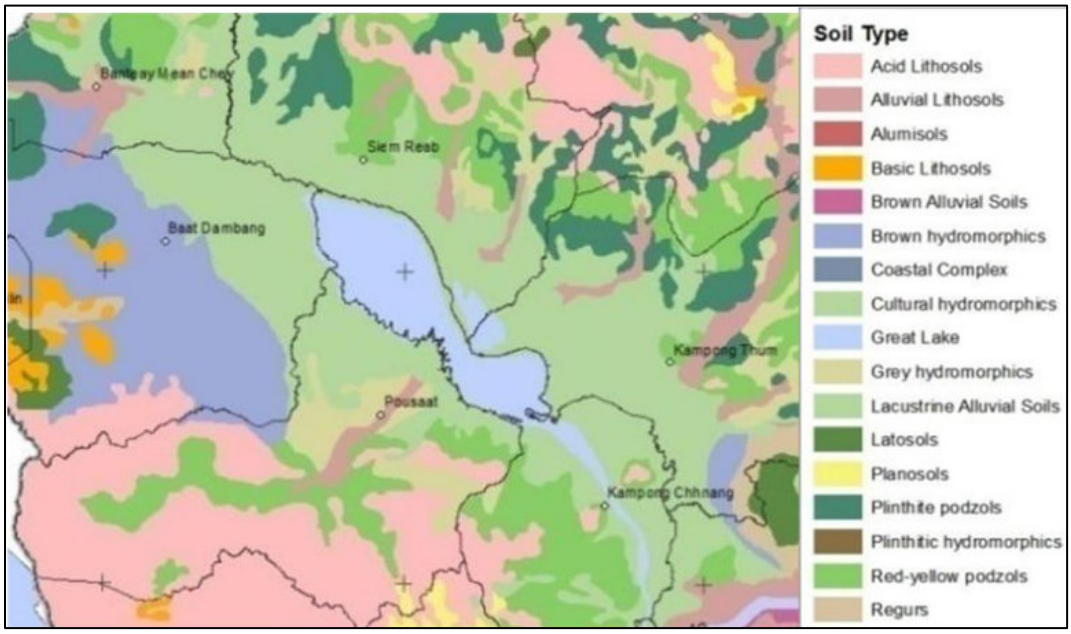
City	Sub-Project	GPS	Surface Water Receptors	Socio-Economic & Cultural Receptors	Land Cover/ Ecological Receptors	Protected Area Status
	Landfill Opt. 2	12°55'37.03"N, 103° 9'20.47"E	Sangke River 0.3 km West	Nearest housing area: 0.2 km South (opposite site) Distance to City: 19 km	Borrow site used for excavation, highly disturbed. Some shrub cover e.g. Bamboo, Euphorbia.	None
	Landfill Opt. 3	12°56'52.45"N, 103° 9'50.83"E	Drainage canal adjacent, Sangke River 1.5 km West	Nearest housing area: 0.5 km North East Pagoda: Wat Banan 3 km West, Distance to City: 16 km	Rice fields, some cultivated shrub/small trees e.g. Tamarind, Neem, Bamboo, Sugar Palm, Euphorbia.	None
Serei Saophoan	Existing Dumpsite / Landfill Opt. 2	13°38'39.97"N, 102°57'19.04"E	Tributary of Serei Saophoan River 1.4km East Groundwater exposed in pits (pits approx.~10m)	Houses 0.5km South East	Excavated borrow sites and existing dumpsite	None
	Landfill Opt. 1	13°38'18.30"N, 102°57'6.46"E	Groundwater exposed in quarry (~10m)	Houses 1 km East	Excavated quarry, surrounded by farms (e.g. Cassava, cashew)	None
	STP Opt. 1	13°35'42.03"N, 102°59'40.45"E	Serei Saophoan River 0.5km South (effluent)	Houses: 300m across river New development proposed 0.5km Distance to City: 2km	Lowland rice fields	None
	STP Opt. 2	13°36'5.96"N, 103° 0'11.08"E	Serei Saophoan River 1km South, (effluent via canal) Stream (tributary to Serei Saophoan River) 0.5km East Seasonal flooding 0.5-1m	Houses: along access road and 500m south Distance to City: 3km	Lowland rice fields	None
	STP Opt. 3	13°36'38.62"N, 103° 0'49.14"E	Serei Saophoan River 2km South, (effluent via canal)	Distance to City: 5km	Lowland rice fields	None

City	Sub-Project	GPS	Surface Water Receptors	Socio-Economic & Cultural Receptors	Land Cover/ Ecological Receptors	Protected Area Status
			Stream/Ditch 0.7km East			
Stueng Saen	Wastewater Treatment Plant	12°41'35.69"N, 104°51'44.75"E	Pond (Effluent), Canals 10m surrounding site	School: 1km North West at Prek Sbov Nearest housing area: 800m North Distance to City: 3 km	Lowland rice fields	None
	Landfill Opt.1	12°37'30.24"N, 104°52'23.31"E	Stueng Saen River 7 km north. Tributary 4 km to East Flooded seasonally 0.5-1m	Distance to City: 8km Nearest housing area: 4.6km East Cultural Site: Kok Roka temple (ancient) 4.5 km east	Lowland rice fields	None
	Landfill Opt. 2	12°47'29.82"N, 104°52'34.28"E	River 1km North leading to Prey Pros lake 5 km West of site Upland site - not flooded, surface run off only	Nearest housing area: 1km South West (access road from NR #62) Distance to City: 10km Pagoda: 2.7km south Grave: adjacent to access road	Cashew trees (farmed), plus natural sparse secondary shrub cover including rattan, bamboo, *Combretum Quadrangutare, Bauhinia Acuminata* (white orchid-tree)	None
	Landfill Opt. 3	12°46'35.92"N, 104°54'52.92"E	River 3km North East leading to Prey Pros lake Upland site - not flooded, surface run off only	Distance to City: 8km Nearest housing area: 2km East, 1.5km North West Pagoda: 3.5km South East Cemetery at site boundary Airstrip (unused) 0.5-1.5km	Sparse secondary shrub cover including rattan, bamboo, Combretum Quadrangutare, Bauhinia Acuminata (white orchid-tree)	None

5.3. Geography, Geology, Topography

153. The project is located in three of the six provinces that surround the Tonle Sap lake basin. The area is dominated by the Tonle Sap lake and this has affected the soil characteristics. As shown in Figure 24 the sub-project areas are dominated by alluvial soils and Battambang is in an area of brown hydromorphic soil which is associated with prolonged water saturation from groundwater and impeded drainage. Stueng Saen in Kampong Thom also has areas of red-yellow podzols from which minerals such as iron have been leached.

Figure 24. Soil Map of Tonle Sap Basin



Source: Dr Seng Vang Deputy Director, MAFF, presentation 2015, with UN FAO[9]

154. The topography of the area is generally flat, forming part of the Tonle Sap floodplain area. As a result, the majority of the sub-projects are in flat low lying areas. Serei Saophoan, south of the current waste site is a hilly area of approximately 120m elevation. In Battambang there are also isolated hills such as one at 140m on which Banan temple is located.

5.4. Meteorology and Climate Change

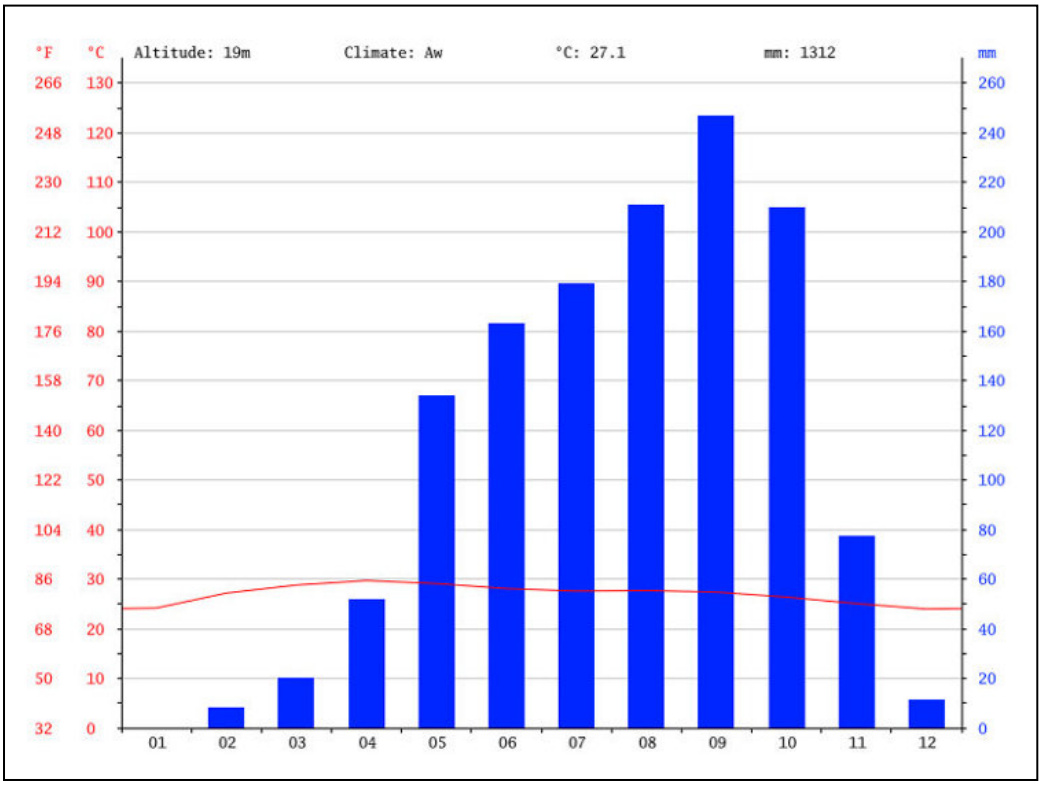
155. Cambodia is situated in a tropical zone, between 10 and 14-degree latitude north of the equator. The climate is dominated by the monsoon cycle, with a distinct dry season and wet season. The northeast monsoon brings in the dry season from November to April. The dry season is cooler from November to January when cool air from Siberia flows in and is dry and hot from February to April. The wet season is from May to October, as southwest monsoon

[9] Asian Soil Partnership Consultation Workshop on Sustainable Management and Protection of Soil Resources 13-15 May 2015, Bangkok, Thailand.

brings in moisture and rains from the Indian Ocean. Average temperature has minimal variations regionally and seasonally; within the Tonle Sap basin (Siem Reap) the average temperature ranges from 24°C in December/January to 31°C in April.

156. Precipitation. Siem Reap is not a sub-project town but is located between the sub-projects to the east and west of the Tonle Sap lake. Rainfall data for Siem Reap indicate that the average rainfall is approximately 1300mm; the distribution of rainfall throughout the year is shown in Figure 25.

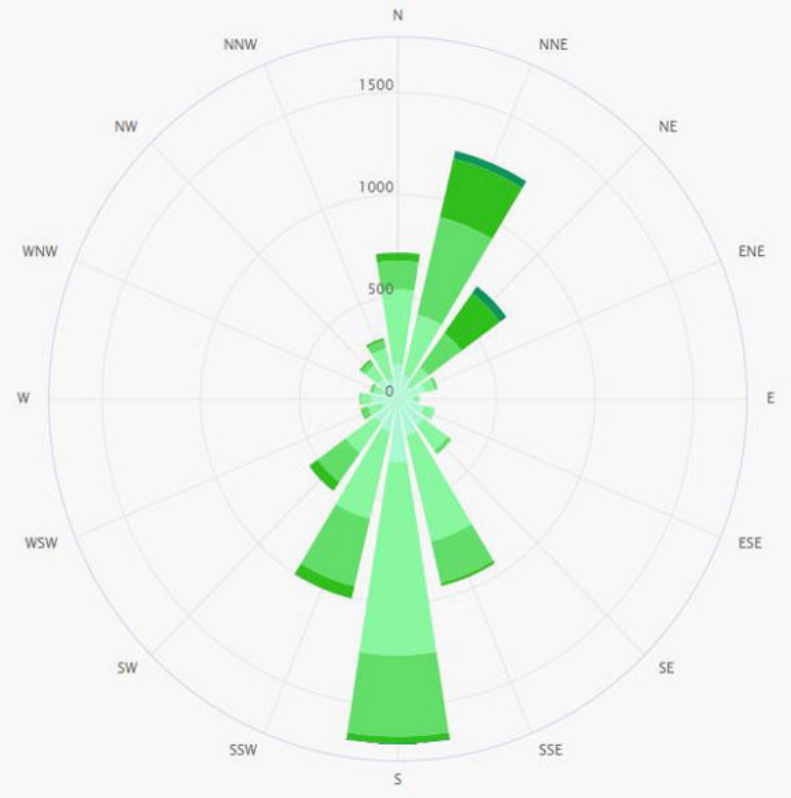
Figure 25. Rainfall Data for Siem Reap



Source : https://en.climate-data.org

157. Wind. Data on wind characteristics is limited for the project area but is available for Phnom Penh. Figure 26 shows there are two distinct wind directions, associated with the seasons. The cooler drier season is characterized by winds from the North, and the majority of winds are from the South, bringing warmer air.

Figure 26. Wind Rose for Phnom Penh



Source: www.meteoblue.com

158. Climate Change Projections. A Climate Risk and Vulnerability Assessment (CRVA) has been undertaken for this project based on site visits and climate change projections for the Year 2050 and RCP 8.5. The CRVA noted that many sites are vulnerable to flooding and as such mitigation measures in the design are required; the most significant climate change risks associated with the sub-projects are during operation. Both STPs and landfill sites can be impacted by heavy rain and flooding. Increased temperatures and droughts can reduce potable water supplies which may directly impact the flows into the STPs. However, if effectively managed, the CRVA notes that new facilities will bring about improvements to the living conditions of the population of the project areas.

159. Table *12* shows the the impacts from climate change on the sub-projects as identified by the CRVA. These issues are managed through design mitigation measures where appropriate.

Table 12: Impacts from Climate Change on Sanitation Infrastructure

Climate Change Factor	Impact
Warmer Temperatures	• Increased operating challenges to biological and chemical processes of treatment facilities. • Increased temperatures and increased evaporation in receiving water bodies, changing chemical balances and increased

	eutrophication. • Reduced capacity to meet wastewater treatment requirements and standards
More Frequent and/or Intense Extreme Weather Events	• Increased risk of direct flood damage to treatment plant, pumping and conveyance, and outfall. • Increased risk of untreated sewage overflows contaminating water supply sources. • Changes in quantity and quality of watershed runoff and in the resulting non-point source pollution loads to receiving waters.

160. Rainfall. The main change in rainfall will occur in the three wettest months of the year, August to September. In low lying areas flooding is generally caused by the rainfall in the wettest months of the year and lasts for several weeks. In such a case, changes in monthly rainfall are of more importance than rain falling over a shorter time period. Projections suggest that the will be little, if any, increase by 2030 but could increase by over 20% by 2070. The CRVA concludes that under Representative Concentration Pathway[10] (RCP) 6.0 with regards to changes in future precipitation:

- Annual rainfall may remain unchanged, but rainfall will increase more in the wettest months by being of stronger duration. This will lead to longer dry periods. There may be "mini-droughts" during the wet season.
- Precipitation will increase most in the south-west and decrease in the north-east.
- Both the maximum 5-day and 1-day storms are expected to increase. The projected increases are 10% for 2030, 20% for 2050 and 30% or more for 2070.
- The relative increase in rainfall is heavier for short durations.
- An increase of 20% on existing IDF curves will allow for a global temperature increase of 2°C. This factor is conservative and is recommended as a design factor

5.5. Hydrology, Surface and Ground Water

161. Water quality is not routinely monitored by MoE however specific projects offer water quality analysis which is relevant to the project areas as shown in Table 13Table *12* and Table 14. These data show national water quality standards were met at the time of sampling; however, it is recognized these data are now relatively old. Additional water chemistry analysis will take place to inform the domestic IEIA/EIA. These data will be incorporated into an updated ADB IEE and EMP during detailed design phase.

Table 13. Surface Water Quality, Battambang Town

No	Parameter	Unit	Standards	Result
Sampling point: in Sangke River, Watkor Commune, Battambang Town, Banan District, close to proposed controlled landfill Site				
1	pH	-	6.5-8.5	7.91
2	Total Suspended Solid (TSS)	mg/l	25-100	96.00
3	Biochemical Oxygen Demand (BOD)	mg/l	1.0-10	0.60
4	Chemical Oxygen Demand (COD)	mg/l	--	2.04

Source: National Road No5 Improvement Project, MoE August 2011

Table 14. Surface Water Quality, Serei Saophoan Town

No	Parameter	Unit	Standards	Result
Sampling point: in Serey Sophorn River, Prey Russei Village, Preah Ponlea Commune, Serei Sophorn Town close to urban centre.				
1	pH	-	6.5-8.5	7.96
2	Total Suspended Solid (TSS)	mg/l	25-100	46.00
3	Biochemical Oxygen Demand (BOD)	mg/l	1.0-10	2.05
4	Chemical Oxygen Demand (COD)	mg/l	--	4.62

Source: National Road No5 Improvement Project, MoE August 2011

162. The closest surface water bodies to the sub-project sites are set out in Table 11: Summary of Environmentally Sensitive Receptors for All Subproject Options. The table shows that there are no protected surface water bodies within the area of influence. There are however man-made canals which are used for irrigation as well as some household uses such as washing and rivers draining to the Tonle Sap lake including Sangke River in Battamang, Serei Saophoan River, andStueng Saen River.

163. The protected Tonle Sap lake will not be impacted on by the project. The closest river to any of the sub-project landfills is the Sangke River in Battamang which is 300m west of landfill Option 2.

164. Groundwater. The depth to groundwater will need to be clarified, particularly at the landfill sites, as the detailed engineering design phase progresses and the relevant surveys are undertaken. Discussions in the field have suggested that the area in which the three landfill sites are located in Battambang has groundwater depth at 40 m. In Serei Saophoan, the proposed landfill site in the existing quarry indicates ground water bearing rock has been exposed at a depth of around 10-12m. In the other landfill site areas, no information was available on depth to groundwater.

5.6. Air Quality and Noise

165. Field visits indicate that air quality in the project sites is good, as the project areas are located in rural areas without significant industrial/commercial zones to cause air quality degradation. Typically, in Cambodia, outside Phnom Penh or town centers there are few industrial pollution sources and the volume of vehicular traffic is low. However, there are limited of existing data of air quality in the project towns as shown in Table 15 to Table 17.

Table 15. Air Quality, Battambang Town

No	Parameter	Unit	National Standards	Result
1	Carbon Monoxide (CO)	mg/m3 N	<20 (8 hours)	1.85
2	Nitrogen Dioxide (NO2)	mg/m3 N	<0.1 (24 hours)	0.019
3	Sulphur Dioxide (SO2)	mg/m3 N	<0.3 (24 hours)	0.013
4	Total Suspended Particles (TSP)	mg/m3 N	<0.33 (24 hours)	0.282
Monitored by MoE laboratory in Beung Raing Village, Omal Commune, Battambang Town, near NR-57 in duration 24 hours from 10:00am to 10:00am next day				

Sources: MoE Laboratory, November 2017.

Table 16. Air Quality, Serei Saophoan Town

No	Parameter	Unit	National Standards	Result
1	Nitrogen Dioxide (NO2)	mg/m3 N	0.1	0.006
2	Sulphur Dioxide (SO2)	mg/m3 N	0.3	0.004
3	PM2.5	mg/m3 N	-	0.242
4	PM10	mg/m3 N	-	0.061
The air quality data was conducted in Serei Saophoan Town near NR-5 by MoE laboratory in duration 24 hours from 6:00am to 6:00am next day				

Sources: National Road Improvement project, MoE April 2011

Table 17. Air Quality, Stueng Saen Town

No	Parameter	Unit	National Standards	Result
1	Carbon Monoxide (CO)	mg/m3 N	<20 (8 hours)	3.00
2	Nitrogen Dioxide (NO2)	mg/m3 N	<0.1 (24 hours)	0.005
3	Sulphur Dioxide (SO2)	mg/m3 N	<0.3 (24 hours)	0.004
4	Total Suspended Particles (TSP)	mg/m3 N	<0.33 (24 hours)	0.035
The air quality data was conducted by MoE laboratory near the Stueng Saen Town in Thnal				

Bambek Village, Trapeang Russei Commune, Kampong Svay District, Kampong Thom for duration 24 hours from 10:00am to 10:00am next day on July 2013.

Sources: MoE Laboratory July 2012.

5.7. Noise

166. Field visits indicate that noise levels in the project landfill sites and STP locations are not significant, due to project areas being located in rural areas without industrial/commercial noise sources. The drainage and sewage network sub-projects are in urban locations which are subject to noise primarily from traffic.

5.8. Natural Disasters

167. Storms and typhoons, are not usually considered a major problem in Cambodia as the country is protected by surrounding mountain ranges. Storms do occasionally affect the country, with most storm-related damage being caused by localized floods associated with heavy rain. Tropical storms can also affect the level of Mekong River flooding experienced in a given year. Greatest damage occurs when these storms arrive during September and October when the seasonal discharge of the Mekong River is already high, and a second significant peak to the annual flood is generated. Also, wind damages property, agriculture and ecological systems.

168. Table 18 presents Natural Disasters occurring between 2012-2014 and shows that the largest impact on the population around the Tonle Sap, in the project area, is flooding. Also, of note is the increase in drought affected households in 2013 and 2014 for the cities of Serei Saophoan and Stueng Saen. In addition, the socio-economic survey undertaken for this project (see Feasibility Study Volume 4)[11] confirmed that 69% of respondents had experienced a flood where they are now living; the main sources of flooding were cited as drainage system (49%), river (27%) and canal (11%).

Table 18. Natural Disasters 2012-2014

City	Type	2012/Families Affected	2013/Families Affected	2014/Families Affected
Battambang	Flood	21	244	50
	Drought	0	7	74
	Storm	3	5	7
Serei Saophoan	Flood	2,977	1,433	80
	Drought	0	1,323	3,113
	Storm	3	8	0

[11] Note the survey cited here is based on aggregated data which includes Kampong Chhnang sub-projects, which have subsequently been removed from the project scope.

City	Type	2012/Families Affected	2013/Families Affected	2014/Families Affected
Stueng Saen	Flood	1,720	453	125
	Drought	0	250	1936
	Storm	547	3	9

Source: Municipality of each city (2015) in IEE for TA-8556 REG: CDIA

5.9. Physical Cultural Resources

169. Around the sub-project areas are a number of places of worship, in particular pagodas, which are within the area of influence for nuisance (approximately 250 m), as shown in Table 19, these include:

Table 19. Cultural Resources in project areas

City	Sub-Project	Cultural Resource
Battambang	STP	Preah Kunkud Pagoda west of Pumping Station 1 along access road (260m) 13° 6'7.87"N, 103°13'22.73"E
Serei Saophoan	All	None
Stueng Saen	Drainage Improvement	Sam Voreak Pagoda (220m) (12°43'12.12"N, 104°53'9.46"E)

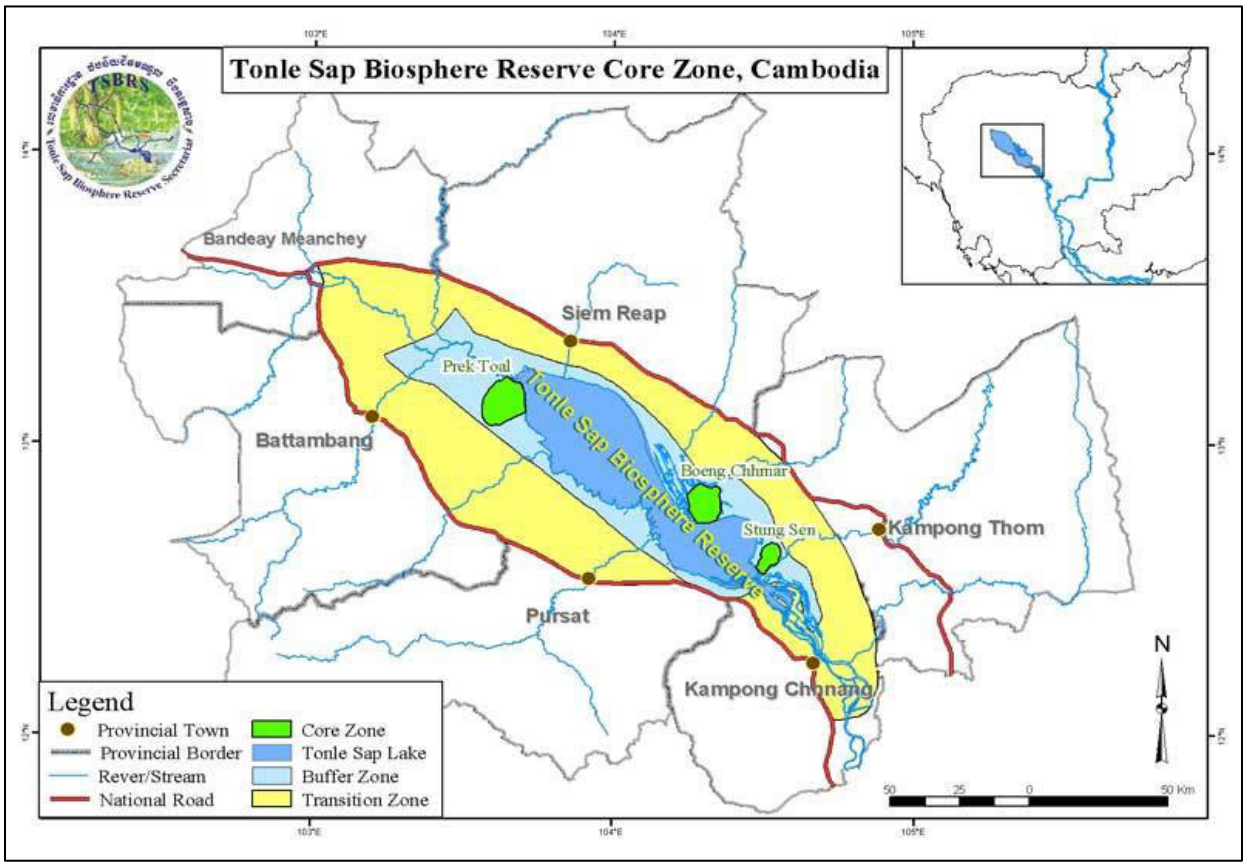
Source: DDPP Team

5.10. Special or Protected Areas

170. Of the 23 Protected Areas in Cambodia, the closest to the project is the Tonle Sap Biosphere Reserve (TSBR) which is located in Kampong Chhnang, Pursat, Battambang, Siem Reap, Banteay Meanchey, and Kampong Thom provinces. The TSBR is classified as a multiple use zone and covers an area of 316,250 ha. It has three core zones which are strictly controlled for biodiversity and conservation. Note that these are not within the area of influence and will not be impacted by the project; the nearest core zone is Stueng Saen, approximately 40 km from Stueng Saen town.

171. The Tonle Sap Authority was established by the Royal Government of Cambodia in 2009. It is mandated to coordinate the management, conservation and development of the Tonle Sap Lake region and TSBR. A map showing the TSBR and core zones in shown in Figure 27.

Figure 27 Tonle Sap Biosphere Reserve



Source: TSBR

5.11. Ecological Resources

172. Flora. Biodiversity screening of the project sites using IBAT was carried out.[12] The project area does not contain any protected areas or habitats of particular biodiversity value. Sub-projects are located in highly disturbed environments dominated by agricultural land use with scattered trees. There are however limited specific areas where trees are present within the project area. This is primarily a number of trees at the sites of Option 2 and 3 landfill sites in Stueng Saen, which includes a number of common species including rattan (Calamus sp), acacia (Acacia Auriculiformis) bamboo (Bambusa Arundinacea), snowy orchid (Bauhinia Acuminata). Also scrub and a number of trees including tamarind are seen on the landfill site options in Battambang. Battambang STP pumping station 2 is adjacent to approximately 3 trees and potential stands of bamboo which may require removal during upgrade of the canal to Ou Mony Stream (and would be compensated through the Resettlement Plan). It is noted that the species observed listed are not threatened, critical or endangered.

[12] IBAT is a central database for globally recognized biodiversity information including Key Biodiversity Areas and Legally Protected Areas https://www.ibatforbusiness.org/.

173. Fish Species. Cambodia is rich in fish biodiversity with at least 500 fish species recorded in the Cambodia's Mekong River and nearly 300 fish species in Tonle Sap Lake. During the preparation of the initial CDIA IEE for this project, interviews were held with local people regarding their understanding of fish species in the project area. The results were similar for all project towns. As an example, in Battambang, 34 species were named, with the most common being (including Khmer name) Trey Riel, Henicorhynchus sp (carp); Trey Andaing Toun, Clarias macrocephalus (catfish); Trey Phtuok/Raws, Channa striata (snakehead); Trey Kranh, and Anabas testudineus (climbing perch). It is noted that these species listed are not threatened, critical or endangered.

174. Bird Species. Cambodia has a number of protected bird habitats, including Prek Toal Core Zone on the Tonle Sap lake. This core zone will not be impacted upon by the project. As with fish species, the initial CDIA IEE preparation team undertook consultation with people resident in all the sub-project areas in 2016 to identify actual bird species which are observed by local people. The people interviewed identified between 22 to 29 species of birds observed in their locality, with the majority being seen in Stueng Saen. Table 20 lists the species noted for Stueng Saen. *Heliopais Personata* is the only endangered species. It is classified as endangered due to degradation of wetland and riverine lowland forest habitats in Asia. The favoured habitat is well vegetated wetlands, including swamps and lake edges;[13] these types of habitat are not within the area of influence for the project; the closest most recent sighting of the species around the Tonle Sap is at Boung Chma (in 1998) which is approximately 65 km from Stueng Saen city.[14]

Table 20. Locally observed bird species, Stueng Saen Residents

No	Khmer Name	English Name	Scientific Name	IUCN Status
1	Brocheav	Not known		
2	Chab krouch	Yellow-vented Bulbul	*Pycnonotus blanfordi*	LC
3	Chreng	Not known		
4	Ka-ek	Large-billed Crow	*Corvus macrorhynchos*	LC
5	Khlom	Not known	Not known	
6	Khvek	Not known	Not known	
7	Kleng Srak	Barn Owl	*Tyto alba*	LC
8	Kok	Great White Egret	*Egretta alba*	LC
9	Kreal	Not known	Not known	
10	Kro Sapropes	Grey Heron	*Ardea cinerea*	LC
11	Kroling Kroloung	Black-collared Starling	*Sturnus nigricollis*	LC
12	Kruoch Art	Barred Buttonquail	*Turnix suscitator*	LC

[13] https://www.hbw.com/ Handbook of Birds of the World.
[14] http://birdbase.hokkaido-ies.go.jp/rdb/rdb_en/helipers.pdf.

No	Khmer Name	English Name	Scientific Name	IUCN Status
13	Lo Lok	Red Collared Dove	*Streptopelia chinensis*	No Data
14	Mann Teuk	White-breasted Water hen	*Amaurormis phoenocures*	No Data
15	Meam touchprey	Asian Barred Owlet	*Glaucidium cucloides*	No Data
16	Popich Thmar	Blue Rock Thrush	*Monticola solitarius*	LC
17	Popoul Teuk	Masked Finfoot	*Heliopais Personata*	Endangered
18	Preap	Not known	Not known	
19	Pro Vek	Lesser Whisling Duck	*Dendrocygna Javanica*	LC
20	Raneal	Not known	Not known	
21	Sa Rikakeo	Common Myna	*Acridotheres Tristis*	LC
22	Sek Kheav	Not known	Not known	
23	Stang	Black-shouldered Kite	*Elanus coeruleus*	No Data
24	Tea Prey	Garganey	*Anas querquedula*	LC
25	Tituy	Not known	Not known	
26	Toum	Purple Swamphen	*Porphyrio porphyrio*	LC
27	Tro Cheakkam	Barn Swallow	*Hirundo rustica*	LC
28	Trodok	Not known	Not known	
29	Tung Propes	Spot-billed Pelican	*Pelecanus philippensis*	NT
Key: LC = Least Concern, NT = Near Threatened, No Data = taxon has not yet been assessed for the IUCN Red List				

Source: Adapted from CDIA, IEE, 2016 survey.

5.12. Socio-Economic Conditions

175. Socio-economic data were obtained from Commune/sangkat discussions with the DDPP team. Table 21 presents a summary of the socio-economic situation in the project areas and shows the number of affected communes on which these data are based.

Table 21. Socio-Economic Data

Project City	No. Communes	Total Population	No. Female Headed HH	Khmer Islam Pop.	Vietnamese Pop.	Poor Level 1 HH*	Poor Level 2 HH*	% Poor (1+2)
Stueng Saen	8	57216	2471	121	46	882	1342	17%
Battambang	10	150312	5603	4005	305	2502	4255	22%
Serei Saophoan	7	87885	2576	1175	55	1159	2260	15%
* Ministry of Interior classification HH= Household								

Source: DDPP Team (2017)

176. Poverty rates. Based on the information provided from the Communes during the CDIA study, the percentage of level one and two poor households in each project area ranges from 15% in Serei Saophoan, to 35% in Kampong Chhnang, noting that these are in the communes for which the DDPP team obtained data.

177. Socio-Economic Survey. A survey of 1478 respondent was undertaken during this DDPP. A full analysis of the results from the survey is provided in Volume 4 of the Feasibility Study. The analysis of this survey is not repeated here, however, a few key points relevant to environmental safeguards are summarized here, combined for all provinces:

- Electricity / Infrastructure. 97% of households are connected to the electricity grid
- Sanitation. 63% of respondents have access to a latrine or WC/Bathroom, outside their house. 11% of respondents do not have a latrine. Where no latrine is available, the alternatives used include a neighbor's latrine (72%) a dug hole in the yard (11%) and open fields (9%). 93% of latrines are pour flush.
- Sewage. 5% of respondents said they are connected to the sewer system for water from their bathroom. The majority of responses are to the ground (37%), a separated septic tank (19%) and pit latrine (23%). 9% of the sewage goes to water bodies including canals, rivers, streams or ponds.
- Waste Collection. 55% of respondents are aware of a waste collection service in their area, the remainder no not have the service offered. Of those who have a service available, 36% use it. 92% of respondents have waste materials which they do not throw away. Of this, 99% of respondents sell recyclables to door to door collectors.

178. Water Users. The Socio-Economic survey identified that 57% of households are connected to a piped water supply, of which 63% are connected to the public water supply and the remainder to a private connection. The responses showed that in the dry season, for those who are not connected to a piped water supply, some of the respondents use water from ponds and lakes and three responses stated ''canal''; as a water source. This indicates that there is potential for a small number of community residents to use the canal network as a water source. It is not known what subsequent treatment the resident may then undertake on the water, such as boiling, chemical or UV treatment.

5.13. Dumpsite Environment

179. Dumpsites. The existing dumpsite in each project area are impacting on the environment primarily through the expression of leachate into water bodies and the contamination of land with degrading waste. Figure 28 and Figure 29 show examples of the baseline environment around two dumpsites in the project area. In addition, the dumpsites have evidence of waste fires which cause localized air pollution and impacts on human health, particularly for waste pickers and residents near by the sites.

Figure 28. Stueng Saen Dumpsite

Figure 29. Battambang Dumpsite

Source: DDPP Team

5.14. Wastewater Treatment Plant Environment.

180. The project towns are subject to ineffective wastewater treatment, in many places around the urban core, there is evidence of sewage contamination of waterways. Field visit discussions with residents confirm that such ditches and canals which are polluted by sewage are a nuisance to the local population and odor can be a problem. As an example, Figure 30 shows a ditch contaminated by sewage near the centre of Stueng Saen town.

Figure 30. Stueng Saen Sewage Contaminated Ditch

6. ANTICIPATED IMPACTS AND MITIGATION MEASURES

6.1. Project Environmental Benefits

181. The project is anticipated to have significant localized environmental benefits. Field visits show that the current environment is being contaminated with both sewage and leachate and the growing pressures on the urban areas means that this is likely to continue.

182. The development of well engineered waste management and wastewater treatment facilities will mean that the pollution of the environment should be reduced and therefore the risks to human health and water quality, will be less.

183. These benefits will be dependent on the services and facilities being maintained and operated at the standard to which they are designed.

6.1.1. Landfill Gas

184. SPS 2009 states that

- The borrower/client will promote the reduction of project-related anthropogenic greenhouse gas (GHG) emissions in a manner appropriate to the nature and scale of project operations and impacts.
- During the development or operation of projects that are expected to or currently produce significant quantities of GHGs, the borrower/client will quantify direct emissions from the facilities.
- The borrower/client will evaluate technically and financially feasible and cost-effective options to reduce or offset project-related GHG emissions.

185. The significance threshold for these requirements is set out in SPS 2009 as ''generally 100,000 tons of carbon dioxide equivalent per year for the aggregate emissions associated with electricity purchased for own consumption''. In this case, the most significant GHG emissions would be the annual emissions for all landfill sites; electricity use is not a major component of any of the project interventions. Note GHG emissions associated with STP operations are not included in the scope of this IEE.

186. An estimation of GHG emissions for project landfills is provided in Table 22.

Table 22. Greenhouse Gas Emissions from Project Landfills

Factor	Calculation	Unit	Reference
Daily Project Landfill Gas	92,000	m^3/day	Feasibility Study Report, Volume 2 – Engineering Design
Annual Project Landfill Gas	33,580,000	m^3/year	
Assume 50% CH4	16,790,000	m^3/year	
Assume 50% CO2	16,790,000	m^3/year	
CH4 Density	0.6	kg/m^3	http://cdm.unfccc.int/methodologies/inputsconsmeth/MGM_methane.pdf
CH4 total	10,074	tonne/yr	
CO2-E (CH4)	250,000	tonne/yr	https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
CO2 DENSITY	1.8	kg/m^3	http://theengineeringmindset.com/properties-of-carbon-dioxide-at-atmospheric-pressure/
CO2 TOTAL	30,222	tonne/yr	
TOTAL CO2-E	280,222	tonne/yr	

Source: DDPP Team

187. GHG emissions are challenging to quantify given the phased nature of waste degradation i.e. phases of aerobic and anaerobic degradation and methangenosis. Direct field measurements of landfill CH4 emissions at small scale can vary over seven orders of magnitude (0.0001– >1000 g CH4 /m2/d) depending on variables including waste composition, cover materials, soil moisture and temperature[15].

188. The current status of GHG emissions from dumpsites in the project cities is uncontrolled and includes a combination of aerobic and anaerobic degradation as well as combustion, through the fires common at most dumpsites. The project interventions will allow for the venting of GHG emissions from landfill through the installation of gas collection pipes for passive venting as the development of the landfill phases progresses.

189. Given the relatively low quantities of waste produced in each city and the cost and complexity of gas utilization and flaring systems, with an estimated cost of around $1.8 million USD[16] in total, it is considered that venting is an option which is appropriate to the nature and scale of project operations and impacts.

190. Venting is technically and financially feasible and cost-effective in order to manage landfill gas emissions which would have occurred with or without the project; the project does not influence the quantity of waste generated and therefore is not directly adding to the GHG emissions associated with waste management. Through installation of slotted gas collection pipes, the project approach allows for retrofitting gas flaring technology as the landfill phases progress, should the operator consider it technically and financially viable to do so in the future.

6.2. Environmental Impact Screening

191. The following discussion on environmental impacts screens the potential impacts according to the following factors and recommends mitigating activities on this basis:

(i) “Receptor”: the resource (human/natural environment/economic/social) which is potentially going to receive and have to cope with an impact.

(ii) “Sensitivity”: ability to cope with an impact and/or its importance to Cambodia. It is generally accepted that human health is always a high sensitivity receptor, however in terms of environmental/natural resources, the sensitivity varies according to the receptor e.g. scrubland with no significant biodiversity is considered less sensitive than a water body which supports ecosystems and livelihoods through fishing.

(iii) “Magnitude”: the size of the potential impact. Impacts may be short term and considered low magnitude (e.g. noise or temporary reduction of income during a

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[15] Bogner, J., M. Abdelrafie Ahmed, C. Diaz, A. Faaij, Q. Gao, S. Hashimoto, K. Mareckova, R. Pipatti, T. Zhang, Waste Management, In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[16] DDPP Team.

short construction project) or high magnitude and long term (e.g. the pollution of groundwater).

192. Where an impact may occur, if there is no receptor to potentially receive the impact, then mitigating actions will not be required. This follows the source-pathway-receptor model, whereby in order for there to be an impact, the pollutant or issue (source) needs to be present, the pathway to a receptor is needed (such as fissures in rocks, or water for human consumption) and a receptor must be present to receive the impact, such as humans, flora or fauna.

6.3. Impacts Associated with Project Location, Planning and Design

193. Measures and Actions during design and pre-construction. The mitigation of impacts from these design issues includes the following measures:

(i) Institutional set up and strengthening. (a) appointment of a Safeguards Focal Point within each PIU (PIU-SFP) (b) appointment of Environmental Safeguards Officer in the PMU (PMU-ESO)[17]; and (b) contracting of international and national Project Management Consultant for Environmental Safeguards (PMC- I/NES) will be carried out. Prior to the start of construction, an environmental capacity building and training program will be delivered by the PIC. The training will focus on ADB's and Cambodia's relevant environmental, health and safety laws, regulations and policies; implementation of the EMP, environmental monitoring, requirements for information disclosure, public consultation and the project GRM. Training will be provided to the PIUs, and contractors.

(ii) Grievance Redress Mechanism. In accordance with the GRM (see Environmental Management Plan), the PIU-SFPs will be responsible for day to day monitoring of the GRM and the PMU-ESO will assume overall responsibility for co-ordinating and reporting on GRM. The PIUs/PMU will issue public notices to inform the public within the project area of influence of the GRM contact information (GRM website address, PIU/PMU address and telephone number, PIU/PMU contact point email address) and local entry points (e.g. contractors and country-system via Grievance Redress Committee.

(iii) Updating the IEE and EMP (if required): Mitigation measures defined in this IEE and the associated EMPs will be updated based on final technical design. This will be the responsibility of the PMC with support from PMU. The revised documents will be submitted to ADB/PMU for approval and disclosure on ADB's website if updated.

(iv) EMP in bidding document. The sub-project specific EMP will be incorporated in the bid documents and construction contracts to provide basis for Contractors to develop package specific construction EMPs (CEMPs).

(v) Disclosure and Consultation: Information disclosure and consultation activities will be continued with affected people and other interested stakeholders, including but

[17] CAM: Fourth Greater Mekong Subregion Corridor Towns Development Project will fund a full-time ESO position within PMU that can also support this project and TS1 during implementation.

not limited to the project implementation schedule, key construction activities (in particular those that result in disturbance or nuisance) GRM and status of compensation (if relevant).

(vi) Site selection. A critical issue for the management of impacts on receptors, particularly a) residential areas, b) surface water including rivers and canals, and c) groundwater for landfill sites. The potential sites in this IEE are discussed in detail in terms of suitability in the Feasibility Study Report Volume 2 – Engineering Design.

(vii) Environmental Quality. Undertake key baseline surveys to inform detailed design and domestic IEIA including water analysis of receiving waters for STP effluent, groundwater at landfills sites and water bodies down gradient of landfill sites.

(viii) Environmental compliance audit. Audit of existing dumpsites to inform detailed design of Serei Saophoan and Stueng Saen dumpsite closure. See Annex 3 of this IEE for a Terms of Reference for the audit.

6.4. Environmental Impact and Mitigation Measures during Construction

194. Air Quality. Moderate temporary air quality impacts during the construction stage of the project are anticipated because of fugitive dust generation associated with construction works, earth works and waste movement. For Serei Saophaon, it is proposed that waste from the existing dumpsite is moved to a new site during rehabilitation. The receptors for lower air quality are businesses and residents within the local area particularly downwind of the construction activities, and waste pickers working on dumpsites during upgrade/movement of waste. Also, dust will be generated during the installation of pipe networks through excavations in urban areas which are by their nature, densely populated.

195. Air quality impacts during construction are likely to result from the following sources:

(i) Emissions from construction machinery and equipment, movement of haulage trucks will lead to minor increases in levels of nitrogen oxides (NOx) and sulfur oxides (SOx);

(ii) Asphalt for road pavement reinstatement will produce fumes containing small quantities of toxic and hazardous chemicals such as volatile organic compounds (VOC) and poly-aromatic hydrocarbons (PAH);

(iii) Fugitive dust from borrow pits and all excavations;

(iv) Fugitive dust from loading, unloading and haulage of construction materials;

(v) Fugitive dust and bioaerosols from movement of waste within existing dumpsites and to new sites; and

(vi) Fugitive dust from concrete batching plants.

196. The mitigation measures to protect sensitive receptors from air quality issues are:

(i) Asphalt and concrete batching facilities will be located at least 500m downwind from the nearest dwellings in order to reduce the impact of fumes on humans and to be fitted with necessary equipment such as bag house filters to reduce fugitive dust emissions.

(ii) Water will be sprayed for construction sites, material handling areas, and borrow pits where fugitive dust is generated.

(iii) Trucks carrying dry construction materials such as earth or waste will be covered with tarpaulins or other suitable cover.

(iv) Construction vehicles and machinery will be maintained to a high standard to minimize emissions.

(v) Waste pickers and all residential areas within 500m of existing dumpsites will be informed in advance of when waste movements will take place.

(vi) Areas in which road excavations are required for sewage and drainage pipe works will be notified adequately 1 month in advance of works starting.

197. Noise. Noise impacts will be temporary and localized at all construction sites as construction machinery and vehicles generate noise as they operate. Other noise sources include loading and unloading of equipment and materials and the construction of boreholes for landfill groundwater monitoring. As set out in 5.1 (Area of Influence) receptors within a 250 m are likely to be subject to intermittent noise impacts above the WHO limit of One Hour LAeq 55 dBA. Significant noise impacts will be experienced by construction site operators. Construction machinery may produce noise levels up to 90 dB(A). For the project, no receptors other than construction workers will be this close to the machinery for extended periods of time.

198. Potential impacts from noise will be mitigated through the following measures:

(i) Maintain all exhaust systems in good working order; undertake regular equipment maintenance;

(ii) Restrict construction activities using heavy machinery work between 8am-6pm;

(iii) Provide advance warning to the community on timing of noisy activities. Seek suggestions from community members to reduce noise annoyance particulary related to noise sensitive activities at receptors such as periods of worship for pagodas. Public notification of construction operations will incorporate noise considerations; information procedure of handling complaints through the Grievance Redress Mechanism will be disseminated.

(iv) Ensure noise monitoring is undertaken near sensitive receptors, particularly dwellings when construction machinery is operational;

(v) All construction workers will use appropriate Personal Protective Equipment (PPE) including ear defenders when operating machinery;

(vi) Use of mobile noise barriers in densely populated areas where excavations are taking place

199. Flora and Fauna. The baseline indicates that impacts on terrestrial flora and fauna will be negligible because the sub-projects are in highly disturbed environments, including an existing quarry and dumpsite and monoculture rice paddies. There are few mature trees likely to be impacted upon by the project sites. At preparation stage of this IEE, the locations of borrow sites are not known; during implementation, these sites may lead to loss of vegetation dependent on the site-specific location.

200. Potential impacts on terrestrial flora and fauna will be mitigated through the following measures:

(i) All trees over 3m in construction sites or access areas to be protected from construction activities if they are not required to be removed;
(ii) Where possible, material from existing licensed borrow and quarry sites will be used. If new sites are needed, they will be subject to due diligence and approval by ADB and the relevant PDoE to ensure that sensitive habitats are avoided and that an appropriate restoration plan usingnative species is agreed following re-contouring.

201. For impacts on aquatic flora and fauna, see Impacts on Surface Water.

202. Surface Water. Construction will take place in areas which have a network of irrigation canals, used for both household water requirements such as laundry and bathing as well as for fishing. Short term construction impacts may be seen in terms of increased turbidity, when access roads improvement or other construction is taking place adjacent to the canals and canals are dredged. Also, some construction activity will be required at the river bank where outfalls for STP effluent or drainage are required.

203. Potential impacts on surface water will be mitigated through the following measures:

(i) Provision of adequate short-term drainage away from construction sites to prevent contaminated run off entering water bodies including canals.
(ii) Installation of temporary storm drains or ditches for construction sites to manage and control the flow and direction of surface water run off
(iii) Maintenance of irrigation water supplies during dry season works within or around irrigation canals.

204. Stockpiles and materials will be stored at least 50m from surface waters with drainage directed away from the irrigation canals or drainage channels

205. All construction fluids such as oils, and fuels should be stored and handled on a bunded impermeable surface; a bund will be provided around any above ground fuel storage tanks with a capacity of 110% of the largest single tank.

(i) No washing or repair of machinery within 50m of surface waters including irrigation canals.
(ii) Pit latrines (for workers camps if required) to be located at least 200m from surface waters, and in areas of suitable soil profiles and above the groundwater levels.

206. Groundwater. Groundwater is not anticipated to be affected by construction activities from the project. However, in order to ensure a contamination pathway is not created during construction, a method statement on the construction of groundwater monitoring wells and water supply wells will be required from the contractors pre-construction (landfill site only).

207. Soil and Land. Soil erosion is not anticipated given the nature of the sub-projects and their flat locations however borrow sites will cause local impacts to the land. The sub-projects are in fertile agricultural locations and fertile top soil is a valuable resource which requires protection measures, particularly for the all construction areas which are located in and around rice fields where encroachment from inappropriate spoil disposal could have detrimental impacts.

208. Potential impacts on soil and land resources will be mitigated through the following measures, as defined in a Spoil and Borrow Site Management Sub-Plan A as set out in the EMP:

(i) Site specific spoil and borrow site management plan will be developed and approved by the relevant Municipal authority;
(ii) A map of all borrow sites will be developed and maintained with copies held by the Contractor and PIU;
(iii) Safety measures, if required, will be implemented to prevent access by members of the public and livestock;
(iv) Measures to rehabilitate the borrow sites include contouring of the slopes within each site and replanting sites with native species;
(v) Top soil present on construction sites will be removed and stockpiled in a labeled area for use on rehabilitation of the site post-construction or rehabilitation of borrow sites;
(vi) No disposal of spoil or dredged material on agriculturally productive land or within 50 m of a water course.
(vii) Construction working areas will be clearly demarcated and encroachment onto adjacent areas avoided.

209. Solid waste management. Impacts on resource use and impacts associated with disposal will arise from waste generated during construction. This includes generation of inert wastes e.g. spoil, biodegradable wastes e.g. cleared vegetation, and hazardous wastes e.g. oily wastes. Impacts of disposal and wind-blown litter will be seen at the disposal sites and construction areas, whereas the impacts of resource use are national and global.

210. Potential impacts from waste arisings will be mitigated through the following measures as defined in the Solid and Liquid Waste Management Sub-Plan B set out in the EMP:

(i) Preparation of a Waste Management Plan before construction which applies the waste hierarchy to ensure efficient use and management of resources with a priority to prevent waste at source as much as possible;
(ii) Effective management of materials on site through good house-keeping and work planning;
(iii) Clear arrangements for storage and transportation of all hazardous and non-hazardous waste to an authorized and approved disposal point as set out in the Waste Management Plan;
(iv) Prohibit burning of waste at all times;
(v) Provide all vehicles/drivers with plastic bags for waste collection and prevent any unauthorized waste disposal with particular attention paid to prevention of waste entering water ways including irrigation canals.

211. Community and Occupational Health and Safety. Construction sites and access roads will present health and safety risks not only to construction workers, but also to people living and working around the sites. Community risks come from unauthorized access to construction sites and construction traffic i.e. heavy vehicles which the community may not be used to on their neighborhood roads. Occupational risks come from a range of activities including the use of heavy machinery, earth moving, and use of chemicals.

212. Potential impacts on community and occupational health and safety will be mitigated through the following measures as defined in the Community and Occupational Health and Safety and Emergency Response Sub-Plan C, set out in the EMP:

(i) Appropriate fencing, protective barriers, and buffer zones will be provided around all construction sites including barriers where needed on access roads and populated.
(ii) Sufficient signage giving health and safety warnings and information disclosure at all sites.
(iii) Worker education and awareness seminars for construction hazards will be given. A construction site safety program will be developed and distributed to workers.
(iv) Conduct daily toolbox meetings (safety briefings)
(v) An accident record book will be maintained where all major or minor accidents and incidents are recorded with actions taken.
(vi) Ensure that all workers are equipped with and use Personal Protective Equipment.
(vii) Each Contractor to appoint an Enviornment, Health and Safety Officer who is qualified engineer. Adequate first aid equipment will be made available on site.
(viii) Provision will be made for safety precautions when using 220 to 240V Electric Power tools if the workers are likely to be working within wet or flooded environments.
(ix) Warning signs will be set up if mud is likely on public roads. Mud will be removed at the end of each day. Other spillages on public roads will be removed immediately.
(x) The Contractor will set out an Emergency Response Plan.

213. Worker / Laborer Impacts. Construction sites worker camps can impact on the environment if not adequately managed or located. This will include impacts from latrines, waste and social impacts if an external (national or international) labor force is used.

214. Potential impacts on the community and environment from work camps and external labor supplies will be mitigated through the following measures:

(i) If a camp for construction workers is required the contractor will set out a management plan which includes a map showing camp lay out, adequate accommodation and sanitation for male and female workers, relevant training and a plan of how camp areas will be restored to original condition after construction completed.

(ii) If a construction camp is not required, the contractor will set out a management plan which includes: Provision of adequate waste disposal facilities, welfare facilities, and sanitation for both male and female workers.

(iii) Priority given to use of local labor and retain evidence of how local labor recruitment efforts were undertaken.

215. Socio-Economic Impacts (accessibility). The installation of sewage pipes will require the excavation of parts of the road network. This is in urban areas where businesses and other activities take place. The community in and around these areas will be disrupted by the noise and dust, as described above, and by potentially impaired access (for themselves and their customers) to their properties and businesses.

216. Potential socio-economic impacts from road excavations will be mitigated through the following measures:

(i) Warning given to residents 4 weeks in advance of any excavations

(ii) Adequate traffic management to ensure routes for vehicles are not blocked and signage is provided to reduce speeds and show drivers in advance of any changes to road surface or traffic direction

(iii) Adequate and safe pedestrian and vehicular (motorbike) access to enter buildings across any open trenches.

(iv) Restoration of any damage at expense of contractor.

(v) Consideration and management of potential localised flood impacts.

6.5. Environmental Impact and Mitigation Measures during Operation

217. The largest risks posed to the environment by the sub-projects are during the operation phase. This is particularly the case for the operation of STPs and the landfill sites. These types of facilities can cause environmental pollution if they are not managed and maintained effectively. Such pollution can include long term risks to groundwater from liner failure and poor leachate management and medium-term risks to water quality from STP effluent.

218. The demonstration controlled landfill facility in Serei Saophoan will provide an opportunity for learning and adopting good operating practices that could be repeated at other controlled landfill sites in Cambodia.

219. The management of an operation and maintenance (O&M) budget for these facilitates is outside the scope of this IEE however the key mitigation measures for operational risk management relate to the capacity development of the operating staff and national and municipal governments who provide the budget for O&M.

220. As a result, the Environmental Management Plans for the sub-projects include capacity building and awareness raising on the management of environmental risks during operations.

221. Waste pickers at the existing dumpsites will be impacted on by the construction of new sites. The budget for site development has allowed for provision of sanitation facilities, potable water supply, PPE, training and support on health and registration of waste pickers to prevent unauthorized access. This is further defined in the resettlement plan for the project.

222. Details of potential impacts during operation are as follows:

223. Surface Water. Discharge of effluent including leachate and wastewater which does not meet required standards may cause pollution to surface water. Also, effluent entering a low flow receiving water body in the dry season may impact on aquatic life and the user of the water body, such as residents using the water for household uses.

224. Potential mitigation measures will include:

(i) Final design to ensure that the absorptive capacity of the receiving waterway is not exceeded and health risks to users of the waterways are minimized[18].

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[18] The EMP pre-construction requirements specify that during the detailed design stage the receiving water should be sampled (preferably minimum three consecutive non-rainfall days) to at least get an indication of the ambient water quality (in particular coliforms, biochemical oxygen demand, nutrients –

(ii) Meeting required operating standards to ensure effluents and leachate are treated effectively prior to discharge (see Annex 8 for technical specifications in respect of leachate management);

(iii) Provision of budget for O&M.

(iv) Monitoring and reporting on quality of receiving water for effluent discharge from STP.

225. Groundwater (landfill). Groundwater contamination may arise from ineffective containment within the landfill cell or failure of the liner. This may occur throughout the lifespan of the landfill and may be exacerbated by deposition of waste outside the landfill cells, damage to the landfill liner for example if a clay liner is allowed to dry and crack, and poor maintenance of any leachate management system.

226. Potential mitigation measures will include:

(i) Meeting required operating standards to limit water infiltration and therefore the generation of leachate including compaction of waste, management of run off and use of (frequent) cover materials;

(ii) Ensuring any effluents from leachate management are treated effectively prior to discharge (see Annex 8 for technical specifications for leachate management); and

(iii) Provision of adequate budget for O&M including monitoring three groundwater wells (locations to be identified during geotechnical investigation) and addressing liner integrity failure (if identified through groundwater monitoring)

227. Odor, Dust and Pests (landfill). Landfill sites will generate nuisance impacts without adequate attention to good practice. This includes dust and odor from movement of degrading wastes, dust from vehicle movements on access roads and pests such as rats and flies attracted by organic wastes.

228. Potential mitigation measures will include:

(i) Compaction of waste within the day it is deposited at the site and cover the waste weekly;

(ii) Weekly litter collections and removal of any wastes which are not deposited in cells, including waste at the boundary and access roads to the site;

(iii) Washing wheels of vehicles before they leave site if they are muddy from accessing the landfill cells to prevent dust increasing to nearby houses;

(iv) Quarterly meetings with residents and / or their representatives to identify odor or nuisance issues;

(v) Maintenance of a tree screen at the site boundary to reduce noise, dust and odors;

(vi) All waste loads to be covered; and

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nitrogen and phosphorus). Based on that, an indicative estimate should be made of the absorptive capacity of the waterway that is commensurate with its primary use (e.g. rice paddies, vegetable farming, ablutions, etc.) and to stay within the safe limits recommended in the WHO guidelines for water quality.

(vii) Provision of adequate budget for O&M.

229. In addition, mitigation measures for households, living within 500 m of the landfill site boundary will be offered as it is recognized that it is neither appropriate nor practical to resettle all households within 500m but those within this distance will be subject to nuisance impacts.

(i) Installation of opening glass windows into all windows within the house.

(ii) Provision of enough viable tree or shrub saplings (native species, to be determined through consultation) to provide a vegetation screen around the front or back, and sides of the property; the resident is responsible for aftercare.

230. Odor (wastewater treatment). STPs will generate odors which will impact on local residents near the site and near any sludge disposal sites, and odors will be exacerbated if the STP is not operating effectively.

231. Potential mitigation measures will include:

(i) Quarterly meetings between Operator and DPWT with residents and / or their representatives to identify odor or nuisance issues;

(ii) Movement of any sludge materials off site on days of low wind speed;

(iii) Provision of adequate budget for O&M.

232. Agricultural Yield. Effluent used for crop irrigation may not be appropriate for all crops; high nitrogen application followed by a dry period can cause high levels of biomass and low yields19. This is supported anecdotally during IEE preparation consultation, where it is reported that rice yields were low, but leaf biomass was high following use of effluent. Several of the STPs will discharge into irrigation canals and Stueng Saen is specifically discharged into a pond for agricultural use. Potential mitigation measures include:

(i) Provision of effluent analysis to the Provincial Department of Agriculture on a regular basis.

7. ANALYSIS OF ALTERNATIVES

7.1. No Project Alternative

233. The Rationale for this project (Section 0) sets out the need for this project. The project is required to meet the infrastructure and service provision requirements in secondary urban centers, which are currently lagging behind the capital region in particular.

234. Evidence from field work shows that the current state of wastewater treatment and waste management in the project cities is lacking, and that the situation is leading to environmental risks and reducing the sustainability of the cities. In order for the cities to become more 'liveable' and improve their urban environmental situation, the project is required thus the 'do

[19] http://www.fao.org/docrep/006/Y5146E/y5146e09.html.

nothing' alternative would lead to an increasingly lower quality urban environment for the residents of the Tonle Sap region.

7.2. Solid Waste Management Design and Technology Alternatives

235. Alternative technological solutions for waste management are considered in detail in the Feasibility Study Report - Volume 2, Engineering Designs. A summary is provided here.

236. Four options ranging from uncontrolled open dumping to a fully engineered sanitary landfill are available to the project. A brief summary of the key arguments for each option are as follows:

- Option 1 open dumping. This is essentially the 'do nothing' option as it is what is happening at present at all the current disposal facilities and cannot be supported in the future.
- Option 2, a controlled dump. This still does not have waste compaction and soil covering, leading to significant ongoing environmental impacts. This option also could not be supported.
- Option 3, a controlled landfill. This has most of the environmental and operational benefits of Option 4 but without the technical complexities of leachate treatment plants for example, and social impacts of banning all waste pickers from site. The controlled landfill option can be upgraded with scale-appropriate additional interventions for leachate and gas management, but not burdened with the additional constraints of the full sanitary landfill option which are undesirable and unnecessary for such relatively small operations.
- Option 4, an engineered sanitary landfill. This compulsorily includes the following requirements in addition to those of a Controlled Landfill (the third level of complexity)
  - A leachate treatment plant;
  - Mechanized material recovery facilities;
  - Mandated removal of all waste pickers from the site; and
  - full Gas control and use.

237. Given that there is little difference in cost or operational difficulty between a controlled dump and a controlled landfill, but the controlled landfill has significantly more environmental benefits, a controlled landfill is the most appropriate disposal system for the project interventions. This could be upgraded over time to a higher standard if later mandated. It is important that the basic infrastructure (such as liners and leachate collection systems) are put in place initially to protect the surrounding environment (including groundwater), as these systems cannot be retrofitted later on.

238. Option 4 is considered too expensive for the relatively small cities and far too complex to operate sustainably without ongoing external technical support at least for some years. Also, the additional operating costs for items like the leachate treatment plant are significant but yield little environmental gains at this scale. Furthermore, the required removal of all waste scavenging activities from the site would likely have significant social impacts at this time.

7.3. Wastewater Treatment Design and Technology Alternatives

239. Alternative technological options are considered for wastewater treatment in detail in the Feasibility Study Report - Volume 2, Engineering Designs; a summary is provided here.

240. The assessment of the most appropriate technology is affected by factors including:

- Physical location – such as land availability and topography;
- Cost – including cost of construction and operation;
- Environmental performance – including impact on receiving water of effluent and obtainable effluent standards; and
- Technical capacity – operator experience within Cambodia.

241. Alternative options are considered for the STP technology and sludge management.

- Constructed Wetlands. This option was discussed with each city's PDPWT. The option was rejected due to operational and maintenance challenges associated with the technology which includes; Maintaining the embankments; Checking the water flow rate to the constructed wetland, to determine conformance with design; Replacing plants as required; Removing any unwanted weed species; Checking the plants for any sign of diseases; Prevention of invasive species plants impacting farmers on rice growing on adjacent agricultural land; Correcting erosion and slumping; and Checking for any signs of over-flooding for sub-surface flow constructed wetlands.
- Ponds-based technology. This option was agreed as the least capital cost, least O&M cost, lowest energy requirements, greatest ease of operations and shall produce a high-quality effluent with 95% reduction in pollutants. Environmentally, the requirements for a high standard of effluent and lowest energy requirements means this option is appropriate.

242. Options for sludge management included:

- A sludge stabilization and drying pond for stabilization, treatment and drying of sludge taken from the anaerobic lagoon;
- A sludge drying reed bed is an autochthonous macrophytes planted bed used for drying sludge taken from the anaerobic lagoon.
- A Small Anaerobic Lagoon used for septage primary treatment is similar to Option 1 for sludge stabilization, without the under-drains component of Option 1 Pond.

243. A sludge stabilization and drying pond is recommended because it provides effective, low cost treatment and dewatering of sludge. It is similar to option 3, small anaerobic lagoon, but also provides dewatering. a septage receiving station will be installed with chamber and coarse screening, ahead of the automatic fine screen, with screened sewage flow then transferred to the anaerobic ponds for further treatment as part of the STP waste stream.

244. Combined versus separate sewer system. Separate systems offer greater pollution control than combined systems. Separate systems convey all the wastewater to the treatment plant, while in combined systems, during high rainfall periods, overflows allow all pollutants to be discharged to the water bodies.

245. Under the urban sanitation policy of the Cambodia National Guidelines on Water Supply and Sanitation (2003) Item 4 states "The use of separate sewerage and drainage systems should be promoted and encouraged particularly in new installation areas". Consistent with the national policy, the design of a separate sewage system will be developed in the central key areas of the sub-project cities.

246. Environmentally, the preferred option is a separate system; this negates the need for treatment of storm water flow and therefore its associated energy and carbon costs. In addition,

the enhanced level of control over sewage contaminated wastewater offered by a separate system is preferred.

8. INFORMATION DISCLOSURE AND PUBLIC CONSULTATIONS

8.1. Public Consultations during Project Preparation

247. During Project Preparation, meetings were held with stakeholders to obtain views and opinions on the project and this also assisted the project team with development of the sub-project outline designs.

248. CDIA Preparation Phase. During the preparation of the first IEE and EMPs for the sub-project, consultation took place within each sub-project area. An outline of the consultation meetings held is provided in Table 23. The details of these consultations are not repeated here but are available in the disclosed IEE documents for the CDIA phase. In general, the consultations found the sub-projects to be welcomed for the positive benefits they will bring, however concerns were raised regarding impacts during implementation, arising primarily from construction. In Serei Saophoan, the issues of land availability and land titles were raised at a number of meetings.

Table 23: CDIA Phase Consultations Held

Location	Dates	Stakeholders or Groups Met*	
Serei Saophoan	From 28/12/16 To 05/01/2017	Sangkat Tuek Thla Sangkat Ou Ambel Sangkat Kampong Svay Sangkat Preah Ponlea Local Authority Group Vulnerable Group Women's Group	Waste collection Company PDoP PDLMUP PDWRM PDoE PDPWT
Battambang	From 15/12/16 To 03/01/2017	PDPWT PDoE PDLMUPC Municipality of Battambang Waste collection Company Women Group Vulnerable Group	Local Authority Group Sangkat Tuol Ta Aek Sangkat Chamkar Samraong Sangkat Kdol Doun Teav Sangkat Ou Mal Sangkat Voat Kor
Stueng Saen	From 16/12/16 To 17/01/2017	PDPWT PDoE PDWRAM PDLMUP Waste collection Company Local Authority Group Women Group Vulnerable Group	Sangkat Ou Kanthor Sangkat Kampong Thom Sangkat Kampong Roteh Sangkat Damrei Choan Khla Sangkat Kampong Krabau Sangkat Achar Leak

Location	Dates	Stakeholders or Groups Met*
* PDoE	Provincial Department of Environment	
PDPWT	Provincial Department of Public work and Transportation	
PDWRAM	Provincial Department of Water Resources and Minerals	
PDLMUP	Provincial Department of Land Management and Urban Planning	
PDoP	Provincial Department of Planning	

249. Preparation of this IEE. Further consultations were undertaken in two formats during this IEE preparation: (i) a household socio-economic survey which was undertaken by a trained team of researchers, and which included a number of questions to inform this IEE; and (ii) consultation focus groups, undertaken by collaboration of the environmental and social team members and aimed to inform the project team on concerns people may have and how they may wish to see their concerns mitigated.

250. Household socio-economic surveys were undertaken for this project in January 2018 and included a number of questions relevant to environmental safeguards. The respondents' views are summarized below. Where appropriate, corresponding mitigation measures are included in the EMP.

Table 24. Socio-Economic Survey Questions

Household Question	Response	EMP Response
Concerns over construction impacts (Dust, Noise, Water Quality, Other suggestions) – Rank two responses	Combining the two scores, 75% of responses included dust as a concern, 41% included noise, 15% included water quality and no other suggestions for concerns were given.	Mitigation measures for noise and dust Control of construction near water bodies
Connection to piped water supply	57% of households are connected to a piped water supply, of which 63% are connected to the public water supply and the remainder to a private connection	-
What is your main water sources during dry season? – Rank two responses	The majority of responses confirm piped water as the main water supply (833 responses) with the primary alternatives being bottled water (147 responses) own well (104 responses). No respondents use water from public or private ponds/lakes or a public well.	Measures to prevent water pollution in all surface water bodies during operations in particular where the risk to receptors is higher
What is your main water sources during wet season? (if have piped water) – Rank two responses	The majority of responses confirm piped water as the main water supply (815 responses) with the primary alternatives being bottled water (80 responses) own well (46 responses) and the river (32 responses).	Measures to prevent water pollution in all surface water bodies during operations in particular where the risk to receptors is higher
If you are not connected to pipe water supply, What is your main water sources during dry	The majority of responses confirm their own drilled well is used as a water supply (290 responses) with the primary alternatives being own drilled well (290) responses, own open well	Measures to prevent water pollution in all surface water bodies during operations in particular where the risk to receptors is higher

Household Question	Response	EMP Response
season? Rank two responses	(128 responses), water seller (120 response), bottled water (121 responses) pond/lake (109 responses), rain water (92 responses). 3 responses were also 'canal' as an alternative water source.	
If you are not connected to pipe water supply, what is your main water sources during WET season? Rank 2 responses	509 responses confirmed rain water to a water source. The remainder being own drilled well (275) responses, own open well (125 responses), water seller (51 responses), bottled water (66 responses) pond/lake (68 responses), own pond (13responses).	Measures to prevent water pollution in all surface water bodies during operations in particular where the risk to receptors is higher
During Construction, what mitigation measures would you like to see to reduce any potential impacts on you and your environment	The main responses are spray water on the road (to avoid dust) (62%), Ensure the security of road traffic (lighting) (17%) Limit the hours of work during the day (noise) (10%). 8% had no concerns. Alternative responses include concerns over construction safety, traffic safety (10 responses) and concern over impact to land or access (9 responses).	Traffic management to be implemented by contractor via the Community and Occupational Health and Safety and Emergency Response Sub-Plan Noise and dust control measures to be used.
If you are living close to the new landfill site, would you be interested in mitigation measures?	Glass in windows 35% Tree screens 22% Fly screen 26% 'Other' responses include operational requests to bury waste after it is deposited (28 responses) and requests for odor control.	Mitigation measures and budget for house improvements included for houses close to landfill sites.

251. Focus group discussions (FGD). FGDs were conducted by the DDPP social and environmental team in 9th-12th February 2018 at the project sites. The objectives of the FGDs were to:

- Present to the stakeholders and affected people the sites for subprojects in the provincial towns and inform them of the project activities;
- Understand the main issues that may occur in the proposed sub-project areas, as raised by local people;
- Understand the potential social and environmental resources located/used in the subproject sites;
- Receiving issues, feedback, and comments from stakeholders or affected people regarding social, gender and environmental issues/resources in the proposed sites; and
- Receiving comments and suggestions for mitigation measures to improve adverse impacts from project design, construction, and operation stages.

252. Inclusion of Affected People's Views. The mitigation measures in the EMPs for this project reflect the result of the consultations during IEE preparation. The results of the consultation discussions are summarized in the following tables (Table 25 toTable *27*). Where appropriate, a response to the comment or concern is signposted in the EMP.

Table 25. Consultation FGD Battambang

Consultation in Prek Preah Sdach Commune, BTB Town (Landfill Sub-Project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
Waste: - In our commune the solid waste and waste water are the major problems (i) waste collector (CINTRI Company) can't collect from all the households and the waste truck comes is about 1week/time. (ii) some areas are small access roads, waste truck cannot access them (iii) lack involvement from communities, a few households do not pay for waste collection fee, so they dump their waste instead	Project will improve waste management with institutional / tariff improvements
Waste water - Waste water is a problem too caused by very old culverts without maintenance. Some villages do not have culverts and have seasonal flooding due to run-off and waste water.	Project STP and network improvements will support this
- This project is important for our commune as same as for BTB Town to manage our environment and sanitation, we support to this project, because BTB Town is developing.	None required
- The people use Town Water Supply for households, and use pond water for crops, farming, and washing 20%) - There are no sensitive ecological resources in this area – it is an urban village area. Some people they plant vegetable and irrigate with pond water.	None required – project will not impact on water supply
Waste: - Awareness on Environmental waste management and promote public involvement. - Increase the member waste truck 2-3 time/week - Provide small truck or cart for waste collection - All the families agree to pay for solid waste collection service, if service is good.	None required
- Enforcement environmental waste laws, the penalty should be implemented	Included in Awareness Raising Campaign, defined in proposed TA Package
Consultation in Rotanak Commune, BTB Town (Landfill, Drainage and STP Sub-Project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
We support this project for improvement our environment and sanitation as well as run-off (flooding) and waste management in BTB Town.	None required
- The key problem is waste water and waste: (i) the drainage system is poor and causes flooding. Old and not maintained. (ii) Solid waste – many problems with CINTRI e.g. Limited capacity and equipment (collecting only on main roads (1 time/week) and small roads are in accessible (Rumchak1, 2, and 3 Village). A few houses do not want to pay for waste collection fee.	None required
All the people in Rottanak Commune use water from Town Water Supply for households use	None required
There are no sensitive impacts of improving landfill and STP, because Rottanak Commune is located in the Town area, far from project locations. But can be impacts can occur from truck transport of waste (without covering trucks may drop waste or wastewater)	Mitigation measures request waste (operation) and construction materials to be covered during transport
- This project will benefit for our commune for waste water and solid waste management.	None required
- Please provide suitable and enough drainage/culverts for waste water in BTB Town. Increase the capacity and equipment of waste collection company.	Designed for population predictions

	and climate change predictions
Awareness of waste laws and enforcement is lacking	Included in Awareness Raising Campaign, defined in proposed TA Package
Consultation in Norea Commune, Sangke District, BTB Province (STP and Drainage Sub-Project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- In Norea Commune most houses are not on the drainage system, a few have for some houses are near the road (own culverts). - There some houses with access to solid waste collections for those houses which are near the access road and Sangke River.	None required
STP suggestions: (i) The rice is around the STP. (ii) need water quality which allows people to use water for rice crops; the STP needs a protection dam to manage the flood/water in and out of the STP site. (iii) Use the proper technique for operating the STP to reduce pollution to downstream water quality.	Design includes run off control. Training for operators is included in capacity development.
- During operation stage, the waste water from STP will discharge via Ou Mony Stream. Consider the waste water discharge quality from STP, because some people use water from this stream for households and vegetable farm.	Training for operators is included in capacity development.
smell/odor from STP can impact on people are near the subproject site management of waste water discharge to protect rice field during operation	Training for operators is included in capacity development.
- Plant trees around the STP site to reduce odors	Site includes buffer zone
- The impacts of construction stage on social and environment is small and temporary (moving equipment, air and noise) because the STP is far from villages and now there are no houses near the construction site.	None required
Consultation in Svay Por and O Char Commune, BTB Town (Landfill sub-project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- In Svay Por Commune is located in central urban area of Town, so all houses have access of solid waste collection by CINTRI Company. But the waste collection time is limited (1 time/week). - Some solid wastes is seen on the streets. A few people still dispose waste on the streets - Most households in O Char Commune have solid waste collection and a few not yet, because of no access road and people do not want to pay for waste collection fee. However most of families agree to pay for solid waste collection service, if good service	None required
During rainy season some streets in Town are flooded by rainy water 2-3 days. During raining the waste flows in to the drainages, culverts, and river (some drainage is jammed). So, the drainage, canal, and culvert for waste water should be improved too	None required
The improvement of landfill for BTB Town is very important of our environment and public health, for us we are very happy with project. So the project should collaborate with concerned agencies and CINTRI Company for improving waste collection system.	Training for operators is included in capacity development – will include collection issues
The environmental and laws awareness should be conducted first and enforcement laws (penalty).	Included in Awareness Raising Campaign, defined in proposed TA Package
Consultation in Baydamraim, Kanteu Mouy, and Kanteu Pir Commune, Banan District, BTB Province	

(Landfill sub-project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- The use water from Sangke River and wells for households and from canals for irrigation - There are no forest resources, only rice field around the landfill sites. - We support to Government project to select these sites to build the landfill. But this project should: (i) understand when the project starts construction and where? (ii) Collaborate with local authorities to negotiate with land owners before construction. (iii) Build a dam around the landfill site to protect from water flow in and out of landfill, during operation. (iv) Use technical approach to reduce the impacts on ground and surface water quality, especially canal water quality that people use for irrigation of rice crop	Consultation before implementation and GRM dissemination Design includes control of surface water
- The main points, we are worried of increasing dust, air pollution (odor), pests, and water quality. - Provide green place (tree planting) around the landfill site to reduce smell/odor. - Waste truck is covered truck, limit driving speed in village and urban areas, and the maintaining of road access to landfill should be provided for mitigate the negative impacts. - During construction small issues and short time from noise and air of construction activities. - The laterite roads mean dust will increase from transportation of materials during construction.	Landfill includes buffer Waste transport to be defined in Working Plan and Operator training provided Dust suppression measures (construction)
- We are not received benefits from project, we are affected. So, the project should provide any services for our communities such as: tree planting, improving road, water well, water supply, and or sanitation toilet.	Mitigation measures included for affected households

Table 26 Consultation FGD Serei Saophoan

O Ambel and Preah Ponlear Commune, Serei SaophoanTown, BMC Province (Landfill sub-project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- Most people in O Ambel Commune use Town Water Supply for households and access electricity. - The solid waste collection services some houses, and some are not serviced, due to number of waste truck are limited, some people do not pay the collection fee, some areas have no truck access - In Preah Ponlear Commune, solid waste is a problem in our area. About 30% of total houses receive waste collection service, the remaining burn and dump waste - For households the waste truck comes 1 time/week, the poor sanitation and odor can be impact on environment and health.	None required
- In this Town public drainages is located only on main roads. Not on the small streets and no connection to houses. Some houses build own drainage/culvert without standards.	None required
- They are support the sub-project for improving Landfill and STP for Serei Sophon Town - Most agreed with solid waste collection services but should collect 2-3 time/week. .	None required
- There small impacts air and noise from movement equipment, we can accept them. - The main impacts for project activities are considered to environmental-social	Environmental and social mitigation measures included in

resources are in and near the sub-project sites of landfill and STP. - Provide the toilet or connect their toilet pipe to main/public sewage/drainage system. - For our people, if the sub-project will start soon is very good for urban area	EMP
Kampong Svay and Teuk Thla Commune, Serei Sophorn Town, BMC Province(Landfill, STP and Drainage sub-project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- The landfill is located in Kangva Village, kampong Svay Commune, in the upland area, and no houses are near the site. - Kampong Svay is located in urban area of Serei Sophorn Town. Most houses have solid waste collection service and a few houses are not this service, due to no access road (far from main road, and don't pay for waste collection fee). - They support improvement to the Landfill - this area is an upland site, far from houses, and no sensitive ecological resources in this area. - This landfill will improve our solid waste management in town, sanitation, good environment, and safety health.	None required
- SWM problems: Capacity of management and collection is limited (for household, the collection:1 time/week). Lack involvement from communities. We have old existing dumping site (no sanitation landfill) - The impacts of landfill sub-project on environment and social by odor, pest, fly, waste water discharge, more we consider to operational landfill is long time operation. - During operation, this landfill should comply with new technology to reduce negative impacts on environment. Protection the environment from waste water discharged from landfill (leachate). - Use mitigation measures to reduce smell, fly, and smoke from landfill. Use cover landfill for reducing smell. - Provide more sanitation waste trucks for collection solid waste from town to new landfill site, so the waste will not remain on the streets. - Most families agree to pay for solid waste collection service, if good service. - The Impacts during construction stage from dust, noise, and air pollution from construction is small issues, we think is no problem (short time in construction period only).	Training for operators is included in capacity development. Will include use of cover and measures to reduce nuisance
- Laws enforcement is lack (some people dispose solid waste on the pubic area or on streets). Public awareness and penalty should be implemented.	Included in Awareness Raising Campaign, defined in proposed TA Package
Phneat Commune, Serei Sophorn Town, BMC Province(STP sub-project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- The STP for Serei Sophorn Town is proposed 3 sites. All these proposed site is private land (rice field). - Phneat Commune is located in rural area, no drainage/culvert and no solid waste collection service to this commune.	None required
- The commune is located the downstream of Serei Sophorn River. During dry season this river water quality is polluted by waste water from Serei Sophorn Town. - This STP sub-project is important for the urban town and for Phneat Commune too, because people in Phneat Commune use water from River for households use and irrigation. There are very a few people use water from ponds.	None required
- The solid waste in Phnea Commune is not problem (no waste collection service, the people burn waste and use for fertilizer). But there are a few waste dumps on the road and stream – probably from urban town houses.	None required
- The impacts are most concerning during operation stage. Is will increase odor that can be polluted to air quality.	Operator training on achieving effluent

- I think, STP will impacted to our people in Phneat Commune, but we support this sub-project, because if we have STP will not pollute the water quality in river is good the aquatic life. Most people are fishing in this river.	standards
During construction there are minor impacts from air, noise and movement equipment (not significant) because is temporary only during construction, the proposed site is located in the rice file and far from souses - STP is located far from Village (houses) - Provide the connection drainage from toilet pipe of Phneat Commune to main/public sewage/drainage and to STP.	None required

Table 27. Consultation FGD Stueng Saen

Srayov Commune, Stueng Saen Town, KPT Province (landfill site sub-project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- We understand that the provincial authorities proposed the one site in Srayov Commune for the Landfill. - Srayov Commune is rural commune of Stung Sen Town, we don't have solid waste collection service (people burn, dispose in the ground, and use as fertilizer).	None required
- We support landfill improvement in our area, but the project should study to check that this site is suitable for landfill. The proposed site is located in a lowland area, wet rice fields (private land) and this area is flood by rainy water during rainy season (0.5-1m deep).	Design considers flood issue
- During operation stage, we are considering the impacts of project on: water quality for rice crop, soil quality, increasing dust on the access road to landfill, increasing flies, pests – all affect communities.	Training for operators is included in capacity development. Will include use of cover and measures to reduce nuisance
- The impacts of project during construction (from air, noise, and dust) are small and short time, not big issues. - The general we support to this sub-project for management our environment, because now solid waste in Stung Sen town is lacking management and no sanitary landfill yet.	None required
- The waste truck is covered truck, limited driving speed in village and urban areas. - Provide maintenance of access road from NR-6 to landfill and watering to reduce dust. - The Srayov Commune lacks water supply and electric power for households use.	Speed limits will be adhered to Waste trucks will be covered Dust suppression measures are included
O Kanthor Commune, Stung Sen Town, KPT Province (STP sub-project))	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- The STP site is located in Prek Sbov Village, O Kanthor Commune. It is in the lowland area of small lake (Chhum Nik Lake) and some areas are belong to private. - The rice field is round the site and the irrigated canals are near the proposed site (the farmers pump canal water for wet and dry rice). - There are not sewage drains in this village. 50% of households have solid waste collection service.	None required
- We think during operation stage there some impacts on natural and social resources near the project site such as: (i) the odor from STP will increase (ii)	Training for operators is included

water quality in this area can be changed by discharged waste water from STP – this will be affect rice crops around the sub-project. - Bad smell from STP will affect workers and human health (Prek Sbov Village is near the site). The project should prepare proper mitigation policies for reducing negative impacts like air pollution, smell, water pollution, land use and public safety	in capacity development
During construction, the impacts are small e.g. air and noise from movement of materials/ equipment. The main impact is considered land use during clearing and excavating the site. So the project should negotiate with land owners before the construction starts.	Dust and noise mitigation measures are in EMP Land ownership outside EMP scope.
STP is important for our Town to protect our environment as well as waste water management.	None required
Trapaeng Russey Commune, Kampong Svay District, KPT Province (landfill sub-project)	
Issues/Comments/Suggestions raised by the Stakeholders	EMP Response
- The Kampong Svay Commune is located in a rural area, far from Stung Sen Town about 12 km. There are no sewers and no solid waste collection service in this commune (solid waste is dumped in the ground, burned, and used as fertilizer for crops). - There are 02 proposed landfill sites are located in Trapaeng Russei Commune (in private land). These proposed landfills are located in upland areas of Kampong Svay Commune. There is small farm and most is scrub land. All the land areas are private land. - We support these proposed sites for improvement new landfill for dumping solid waste from Stung Sen Town, now the town has no landfill	None required
- During construction, the main issue is land use, because these landfills belong to private owners. Small impacts of dust, air, and noise from construction equipment, but are short term so not a big problem.	Dust and noise mitigation measures are in EMP Land ownership outside EMP scope.
- The impacts are more concerning during operation stage: (i) increasing dust on the access road to landfill, (ii) increasing odor, (iii) increasing air pollution from landfill (smell and smoke), and flies-pests (public safety). The project and the implementing agencies should consider negative impacts and prepare mitigation policies especially impacts on social and human health	Training for operators is included in capacity development. Will use soil cover to reduce odor and nuisance.
Provide maintenance of access road from NR-6 and NR62 to landfill site and provide watering to reduce dust pollution from waste trucks, during operation STP. Use sound technology for reducing the flies, pests, and smell from STP A dam should be built around the landfill site for protection from flooding	Training for operators is included in capacity development Run off control measures included in design

8.2. Public Consultations during Project Implementation

253. Consultation during implementation. The Consolidated IEE for this sub-project contains details of the consultation undertaken during preparation of these sub-projects. In addition, consultation will take place during implementation. The PIU Safeguard Focal Point (PIU-SFP) will undertake consultation following the finalisation of the detailed design, and again will conduct consultation interviews within 4-6 weeks of construction starting and then again every 3

months until the end of construction. This is set out in the Environmental Monitoring Plan provided in the Environmental Management Plan for each sub-project.

254. It is suggested that the consultations take the form of meetings and site-based discussions and include the following:

- Environmental impacts of civil works (e.g., solid & liquid waste, erosion, local flooding, pollution);
- Any unforeseen impacts caused accidentally e.g. through spillages;
- Civil nuisance (e.g., noise, dust, disrupted business & farming activity, social issues, community health and safety);
- Impaired use of access road to landfill site (e.g. traffic issues and access); and
- GRM and its procedures including details of persons to contact and contact details

255. In summary, informal monitoring interviews with affected people will focus on complaints about community disturbance from construction activities, as well as public concerns about ecological protection, soil / land concerns and access issues. A sample Environmental Monitoring Interview Form is in the EMPs for this project. This will contribute to project monitoring.

8.3. Consultation during Operation

256. The mitigation measures for this IEE specify that the STP operators, in collaboration with PDPWT undertake quarterly consultation with local residents to discuss any operational impacts or concerns.

8.4. Information Disclosure

257. Environmental information on the project, including the IEE and other safeguards information will be disclosed in accordance with ADB's Public Communications Policy (2011) and SPS (2009). This includes:

(i) The EMP will be translated into Khmer and be available for review PDPWT offices;

(ii) The IEE will be disclosed on ADB's project website (www.adb.org);

(iii) Copies of the IEE are available upon request; and

(iv) Semi-annual environmental reports on project's compliance with the Environmental Management Plan (EMP) and other necessary information will be available at www.adb.org.

9. Grievance Redress Mechanism

258. A grievance redress mechanism (GRM), consistent with the requirements of the ADB Safeguard Policy Statement (2009) will be established to prevent and address community concerns, reduce risks, and assist the project to maximize environmental and social benefits. In addition to serving as a platform to resolve grievances, the GRM has been designed to help achieve the following objectives: (i) open channels for effective communication, including the identification of new environmental issues of concern arising from the project; (ii) demonstrate

concerns about community members and their environmental well-being; and (iii) prevent and mitigate any adverse environmental impacts on communities caused by project implementation and operations. The GRM is accessible to all members of the community.

259. The Access Points to the GRM are critical for ensuring it is useable for affected people (APs). The GRM Access points for this project, as set out in this GRM Mechanism will be:

- The Contractors
- District and Commune Councils
- The PIU office
- The Provincial Department of Public Works and Transport (PDWT)

260. Full details of the GRM, its access points, and responsible parties are found in the EMP documents for each sub-project city.

10. Environmental Management Plan

261. A detailed EMP is provided for each sub-project. The EMPs aim to avoid impacts where possible and mitigate those impacts which cannot be eliminated to an acceptable and minimum level. The EMP includes detailed requirements for:

- Mitigation and monitoring measures;
- Institutional arrangements and project responsibilities;
- EMP budget for implementation
- Caapacity building and training requirements
- Public consultation and information disclosure
- GRM including clearly defined timescale and responsibilities.

262. The overall responsibility for EMP implementation and compliance with loan assurances lies with the Executing Agency, the Ministry of Public Works and Transport (MPWT). The EA will establish a Project Steering Committee (PSC) and Project Management Unit (PMU) based in Phnom Penh, responsible for general project implementation. The Implementing Agency is the Provincial Department of Public Works and Transport (PDPWT) in each sub-project city. The PDPWT will establish a Project Implementation Unit (PIU) in each province, comprising relevant provincial government representatives including the Provincial Department of the Environment.

263. A summary of the key functions for project implementation and therefore environmental safeguards is presented in Table 28:

Table 28 Key Roles for Project Implementation

Role	Abbreviation	Location	Summary of Overall Function
Project Steering Committee	PSC	Phnom Penh	Policy and technical guidance for subproject implementation
Project Management Unit	PMU	Phnom Penh within MPWT	Responsible for general project implementation and reporting

PMU Environment Safeguards Officer	PMU-ESO	Phnom Penh within PMU	EMP compliance across the sub-projects for environmental and social safeguards
Project Implementation Unit	PIU	Provinces within PDPWT	Responsible for sub-project implementation
PIU Safeguards Focal Point	PIU-SFP	Provinces within PIU	Responsible for sub-project environmental and social safeguard monitoring
Contractor Environmental Health & Safety Officer	C-EHS	Construction Site	Mitigation measure implementation and reporting
Project Management Consultant	PMC	Phnom Penh	Project final design and implementation, support and capacity development
International and National Environment Specialists	PMC-I/NES	Phnom Penh within PMC team	Environmental safeguards and reporting support during design and implementation
Asian Development Bank	ADB	-	Review project progress, compliance with covenants and advise on corrective actions.

264. The EMP for each sub-project is in a separate document.

11. Conclusions and Recommendations

11.1. Conclusions

265. The EMP, if implemented as directed, will mitigate impacts on the natural environment and affected people to an acceptable level. The key parties for mitigation and monitoring measure implementation are the construction contractors and the operators. The implementation of the EMPs will be closely monitored and reported on by the relevant stakeholders in the project.

266. The most significant impacts from the project will arise from facility operation, for both the STP and the landfills. As a result, there is a comprehensive training and capacity building component to the project which is essential for ensuring the investment is both financially and environmentally sustainable and beneficial.

267. A robust Grievance Redress Mechanism will be established, as outlined in this IEE and the EMPs. It will ensure that all unplanned impacts which cause grievances for affected people are managed and a satisfactory outcome brought about swiftly.

268. Overall, the project is anticipated to bring environmental benefits to the populations of the project cities. It will serve to improve sewage and waste management, reduce pollution impacts and will provide long term environmental improvements and health benefits.

11.2. Recommendations

269. The project will include assurances that the key risks from the sub-projects will be mitigated as set out in the EMP. In particular the segregation of effluent from STPs from publicly accessible irrigation canals, and the provision of adequate O&M budgets to ensure operation in accordance with the design recommendations.

Annex 1 Environmental Quality Standards

(1) Ambient Air Quality Standards
Source: Sub-decree No. 42 ANRK.BK on Air Pollution Control and Noise Disturbance, MoE 2000.

Parameter	Averaging Period	Standard	
		Unit	Value
Nitrogen Dioxide (NO2)	24 hours	mg /m3	0.1
Sulfur Dioxide (SO2)	24 hours	mg /m3	0.3
Carbon Monoxide (CO)	24 hours	mg /m3	20
PM 2.5	24 hours		-
PM 10	24 hours		-

(2) Ambient Noise Standards
Source: Sub-decree No. 42 ANRK.BK on Air Pollution Control and Noise Disturbance, MoE , 2000.

Areas	Time Period (24 hours)	Standard	
		Unit	Standard Value
Area is not identified	Day time (from 6:00am to 6:00pm)	Noise Level dB(A)	70.0
	Evening Time (from 6:00pm to 11:00pm)	Noise Level dB(A)	65.0
	Night time (from 11:00pm to 6:00am)	Noise Level dB(A)	50.0

(3) Surface Water Quality Standard

Referring to Sub-decree No. 27 ANRK.BK on Water Pollution Control, MoE, 1999, the standards of water quality are divided as follows:

Annex 2 of Sub-decree on Water Pollution Control

Effluent standard for pollution sources discharging wastewater to public water areas or sewer

No	Parameters	Unit	Allowable limits for pollutant substance discharging to	
			Protected public water area	Public water area and sewer
1	Temperature	0C	< 45	< 45
2	pH		6 – 9	5 - 9
3	BOD5 (5 days at 200 C)	mg/l	< 30	< 80
4	COD	mg/l	< 50	< 100
5	Total Suspended Solids	mg/l	< 50	< 80
6	Total Dissolved Solids	mg/l	< 1000	< 2000
7	Grease and Oil	mg/l	< 5.0	< 15
8	Detergents	mg/l	< 5.0	< 15
9	Phenols	mg/l	< 0.1	< 1.2
10	Nitrate (NO3)	mg/l	< 10	< 20
11	Chlorine (free)	mg/l	< 1.0	< 2.0
12	Chloride (ion)	mg/l	< 500	< 700
13	Sulphate (as SO4)	mg/l	< 300	< 500
14	Sulphide (as Sulphur)	mg/l	< 0.2	< 1.0
15	Phosphate (PO4)	mg/l	< 3.0	< 6.0
16	Cyanide (CN)	mg/l	< 0.2	< 1.5
17	Barium (Ba)	mg/l	< 4.0	< 7.0
18	Arsenic (As)	mg/l	< 0.10	< 1.0
19	Tin (Sn)	mg/l	< 2.0	< 8.0
20	Iron (Fe)	mg/l	< 1.0	< 20
21	Boron (B)	mg/l	< 1.0	< 5.0
22	Manganese (Mn)	mg/l	< 1.0	< 5.0
23	Cadmium (Cd)	mg/l	< 0.1	< 0.5
24	Chromium (Cr)+3	mg/l	< 0.2	< 1.0
25	Chromium (Cr)+6	mg/l	< 0.05	< 0.5
26	Copper (Cu)	mg/l	< 0.2	< 1.0
27	Lead (Pb)	mg/l	< 0.1	< 1.0

28	Mercury (Hg)	mg/l	< 0.002	< 0.05
29	Nickel (Ni)	mg/l	< 0.2	< 1.0
30	Selenium (Se)	mg/l	< 0.05	< 0.5
31	Silver (Ag)	mg/l	< 0.1	< 0.5
32	Zinc (Zn)	mg/l	< 1.0	< 3.0
33	Molybdenum (Mo)	mg/l	< 0.1	< 1.0
34	Ammonia (NH3)	mg/l	< 5.0	< 7.0
35	DO	mg/l	>2.0	>1.0
36	Polychlorinated Byphemyl	mg/l	<0.003	<0.003
37	Calcium	mg/l	<150	<200
38	Magnesium	mg/l	<150	<200
39	Carbon tetrachloride	mg/l	<3	<3
40	Hexachloro benzene	mg/l	<2	<2
41	DTT	mg/l	<1.3	<1.3
42	Endrin	mg/l	<0.01	<0.01
43	Dieldrin	mg/l	<0.01	<0.01
44	Aldrin	mg/l	<0.01	<0.01
45	Isodrin	mg/l	<0.01	<0.01
46	Perchloro ethylene	mg/l	<2.5	<2.5
47	Hexachloro butadiene	mg/l	<3	<3
48	Chloroform	mg/l	<1	<1
49	1,2 Dichloro ethylene	mg/l	<2.5	<2.5
50	Trichloro ethylene	mg/l	<1	<1
51	Trichloro benzene	mg/l	<2	<2
52	Hexaxhloro cyclohexene	mg/l	<2	<2

Remark: The Ministry of Environment and the Ministry of Agriculture, Forestry and Fishery shall collaborate to set up the standard of pesticides which discharged from pollution sources.

Annex 4 of Sub-decree on Water Pollution Control

Water Quality Standard in public water areas for bio-diversity conservation

Source: Sub-decree No. 42 ANRK.BK on Water Pollution Control, MOE, 1999.

a) River

Parameter	Standard	
	Unit	Value
pH	mg/l	6.5 – 8.5
BOD5	mg/l	1 – 10
Suspended Solid	mg/l	25 – 100
Dissolved Oxygen	mg/l	2.0 - 7.5
Coliform	MPN/100ml	< 5000

b) Lakes and Reservoirs

Parameter	Standard	
	Unit	Value
pH	mg/l	6.5 – 8.5
COD	mg/l	1 – 8
Suspended Solid	mg/l	1 – 15
Dissolved Oxygen	mg/l	2.0 - 7.5
Coliform	MPN/100ml	< 1000
Total Nitrogen	mg/l	1.0 – 0.6
Total Phosphorus	mg/l	0.005 – 0.05

Annex 5 of Sub-decree on Water Pollution Control:

Water Quality Standard in public water areas for public health protection

Source: - Ground water quality monitoring MoE, 2016.

- The CNDWQS Standard is National Standard of the Ministry Industry and Handicraft.

No	Parameter	Unit	Standard Value
1	Carbon tetrachloride	µg/l	< 12
2	Hexachloro-benzene	µg/l	< 0.03
3	DDT	µg/l	< 10
4	Endrin	µg/l	< 0.01
5	Diedrin	µg/l	< 0.01
6	Aldrin	µg/l	< 0.005
7	Isodrin	µg/l	< 0.005
8	Perchloroethylene	µg/l	< 10
9	Hexachlorobutadiene	µg/l	< 0.1

10	Chloroform	µg/l	< 12
11	1,2 Trichloroethylene	µg/l	< 10
12	Trichloroethylene	µg/l	< 10
13	Trichlorobenzene	µg/l	< 0.4
14	Hexachloroethylene	µg/l	< 0.05
15	Benzene	µg/l	< 10
16	Tetrachloroethylene	µg/l	< 10
17	Cadmium	µg/l	< 1
18	Total mercury	µg/l	< 0.5
19	Organic mercury	µg/l	0
20	Lead	µg/l	< 10
21	Chromium, valent 6	µg/l	< 50
22	Arsenic	µg/l	< 10
23	Selenium	µg/l	< 10
24	Polychlorobiohenyl	µg/l	0
25	Cyanide	µg/l	< 0.005

(4) Groundwater Quality Standard

No	Parameter	Standard	
		Unit	Value (CNDWQS Standard)
1	pH	-	6.5-8.5
2	Turbidity	NTU	5.0
3	Dissolved Oxygen (DO)	mg/l	NV
4	Total Suspended Solid (TSS)	mg/l	NV
5	Chloride (Cl-)	mg/l	250
6	Nitrate (NO3)	mg/l	50
7	Phosphate (PO4)	mg/l	NV
8	Sulphate (SO4)	mg/l	250
9	(BOD)5	mg/l	NV
10	(COD) Mn	mg/l	NV
11	Aluminum (Al)	mg/l	0.2
12	Arsenic (As)	mg/l	0.05
13	Copper (Cu)	mg/l	1.0
14	Iron (Fe)	mg/l	0.3

15	Lead (Pb)	mg/l	0.01
16	Manganese (Mn)	mg/l	0.1
17	Mercury (Hg)	mg/l	0.001
18	Zinc (Zn)	mg/l	3.0
19	Total Coli form	MPN/100mlml	0

(5) Effluent Quality Standard
(Effluent from WWP and from Leachate Treatment Facility at the controlled disposal facility)
Source: Sub-decree No. 42 ANRK.BK on Water Pollution Control, MOE, 1999.

No	Parameter	Standard (Allowable limits for pollutant substance discharging) to		
		Unit	Value (Protected public water area)	Value (Public water area and sewer)
1	Temperature	0C	< 45	< 45
2	pH		6 – 9	5 - 9
3	BOD5 (5 days at 200 C)	mg/l	< 30	< 80
4	COD	mg/l	< 50	< 100
5	Total Suspended Solids	mg/l	< 50	< 80
6	Total Dissolved Solids	mg/l	< 1000	< 2000
7	Grease and Oil	mg/l	< 5.0	< 15
8	Detergents	mg/l	< 5.0	< 15
9	Phenols	mg/l	< 0.1	< 1.2
10	Nitrate (NO3)	mg/l	< 10	< 20
11	Chlorine (free)	mg/l	< 1.0	< 2.0
12	Chloride (ion)	mg/l	< 500	< 700
13	Sulphate (as SO4)	mg/l	< 300	< 500
14	Sulphide (as Sulphur)	mg/l	< 0.2	< 1.0
15	Phosphate (PO4)	mg/l	< 3.0	< 6.0
16	Cyanide (CN)	mg/l	< 0.2	< 1.5
17	Barium (Ba)	mg/l	< 4.0	< 7.0
18	Arsenic (As)	mg/l	< 0.10	< 1.0
19	Tin (Sn)	mg/l	< 2.0	< 8.0
20	Iron (Fe)	mg/l	< 1.0	< 20

21	Boron (B)	mg/l	< 1.0	< 5.0
22	Manganese (Mn)	mg/l	< 1.0	< 5.0
23	Cadmium (Cd)	mg/l	< 0.1	< 0.5
24	Chromium (Cr)+3	mg/l	< 0.2	< 1.0
25	Chromium (Cr)+6	mg/l	< 0.05	< 0.5
26	Copper (Cu)	mg/l	< 0.2	< 1.0
27	Lead (Pb)	mg/l	< 0.1	< 1.0
28	Mercury (Hg)	mg/l	< 0.002	< 0.05
29	Nickel (Ni)	mg/l	< 0.2	< 1.0
30	Selenium (Se)	mg/l	< 0.05	< 0.5
31	Silver (Ag)	mg/l	< 0.1	< 0.5
32	Zinc (Zn)	mg/l	< 1.0	< 3.0
33	Molybdenum (Mo)	mg/l	< 0.1	< 1.0
34	Ammonia (NH3)	mg/l	< 5.0	< 7.0
35	DO	mg/l	>2.0	>1.0
36	Polychlorinated Byphemyl	mg/l	<0.003	<0.003
37	Calcium	mg/l	<150	<200
38	Magnesium	mg/l	<150	<200
39	Carbon tetrachloride	mg/l	<3	<3
40	Hexachloro benzene	mg/l	<2	<2
41	DTT	mg/l	<1.3	<1.3
42	Endrin	mg/l	<0.01	<0.01
43	Dieldrin	mg/l	<0.01	<0.01
44	Aldrin	mg/l	<0.01	<0.01
45	Isodrin	mg/l	<0.01	<0.01
46	Perchloro ethylene	mg/l	<2.5	<2.5
47	Hexachloro butadiene	mg/l	<3	<3
48	Chloroform	mg/l	<1	<1
49	1,2 Dichloro ethylene	mg/l	<2.5	<2.5
50	Trichloro ethylene	mg/l	<1	<1
51	Trichloro benzene	mg/l	<2	<2
52	Hexaxhloro cyclohexene	mg/l	<2	<2

(6) Soil Quality Standard

Source: Cambodia National Quality Standards for Agriculture, Ministry of Agriculture, Forest, and Fishery (MAFF).

Parameter	Standard	
	Unit	Value
pH		
Salinity	ppt	6-8
Oil & Grease	mg/kg	-
Chloride	mg/kg	-
Petroleum Hydrocarbons		
Kerosene hydrocarbons (c10-c14)	mg/kg	-
Diesel hydrocarbons (c15-c28) (mg/L)	mg/kg	-
Heavy oil hydrocarbons (c29-c36) (mg/L)	mg/kg	-
BTEX		
Ethylbenzene	mg/kg	0.018
Benzene	mg/kg	0.0068
Toluene	mg/kg	0.08
Xylene	mg/kg	2.4
Metals		
Nickel	mg/kg	50
Copper	mg/kg	63
Zinc	mg/kg	200
Arsenic	mg/kg	12
Cadmium	mg/kg	1.4
Lead	mg/kg	70
Iron	mg/kg	-
Chromium	mg/kg	64
Mercury	mg/kg	6.6

Annex 2 Site Field Notes & Descriptions

1. Serei Saophoan

Date: Thursday 01 February 2018

A. Key points of Meeting and field visits

STP Sub-project

1. STP Site-1

This proposed STP site-1 is located in Kantout Village, Phneat Commune, Serei Sophorn Town, BMC province. This area is flooded during raining season and the land area is belongs to private owners.

This was proposed by DPWT many years ago, but now the land price is increasing and near the town development area.

The new residential development is near this proposed site.

The rural road is near the site and the Kantout Village with houses.

This site is located in downstream of Serei Sophorn River. There are not sensitive forest or ecological resources near the site. The location is located from:

- National Road 6 is about 1 km.
- Serei Sophorn Town is about 2 km
- The new residential development is about 0.5 km
- Is near the Serei Sophorn River in the downstream.
- In and around the area is paddy fields.

2. STP Site-2

The proposed STP site-2 is located in Kantout Village, Pheat Commune, Serei Sophorn Town, BMC province. This area is rice field (wet rice field) during raining season, floods from 0.5 to 1 m deep in wet season There are not any sensitive resources and forest resources in / near the site. This site is located from:

- National Road 6 is about 1.5 km.
- Serei Sophorn Town is about 3 km
- Kantout Village with houses is about 0.5 km
- Serei Sophorn River is about 1 km in the downstream.
- In and around the area is paddy fields.

3. STP Site-3

The proposed STP site-2 is located in *Kantout Village and bordering with Kampring Village,* Pheat Commune, Serei Sophorn Town, BMC province. This area is covered by rice fields (wet rice field) during raining season, and floods from 0.5 to 1 m deep in wet season.

There are not any sensitive resources and forest resources are in and near the site. This site is located from:

- National Road 6 is about 1 km.
- Serei Sophorn Town is about 5 km
- Kantout Village with houses is about 2 km

- Serei Sophorn River is about 3 km in the downstream.
- Small stream is located near the site on the East side.
- The rural road is close to the site (Acasia and Palm Tree on both side of road)
- In and around the area is paddy fields

3. Pictures of STP Sites



The existing environmental condition in proposed STP site-1



The existing environmental resources in and around STP site-2



The rural road in Kantout Village and access road from village to STP site-2

Rice filed condition is around the STP site-2



The existing environmental condition (all rice fields) in STP site-3



The existing access road in STP from NR6 to Kantout Village, STP site-3

The existing rural road in Kantout Village, STP site-3

Landfill Sub-project

1. Proposed Landfill Site Option 1.

The proposed site for landfill sub-project is located in Kanva Village, Kampong Svay Commune, Serei Sophorn Town, BMC Province. This site is in upland area or hilling area (no flood).

This proposed site is an existing quarry, used for excavation of laterite and rock materials for any construction. This site is located from:

- National Road 56 is about 1.5 km
- Kangva Village (residential area) is about 1.0 km
- Serey Sophorn Center Town is about 5 km
- There are no river, water sources, and ecological and social sensitive resources located in the landfill proposed site.
- A few farms are located near the proposed site such as: cassava, corn, and cashew farms.
- No forest or other sensitive receptors near the proposed site.

2. Proposed Landfill Site Option 2.

In Serei Sophorn Town has 1 existing dumping site near the National Road 56. This site is small and not managed and is on existing quarry/borrow site pits.

- This site is already contaminated, and groundwater exposed
- The site is close to the National Road (300m) and a housing area (400m)
- Serey Sophorn Center Town is about 5.5 km

2. Pictures of proposed landfill site option 1



The existing proposed site for improving landfill in borrow pit areas



The corn and cassava farm near the site and access road from NR-56 to proposed site

2. Stueng Saen Town, Kampong Thom Province

Date : Friday 02 February 2018

A. The result of field visits

1. STP Sub-project

The proposed site for STP is located in Beung Chhumnich Lake, Prek Sbov Village, O Kantor Commune, Stung Sen Town, KPT Province. This site is in a lowland area and is flooded during raining season, so the farmers grow the rice crops (wet-dry rice) is around the site.

This proposed STP site is located as follows:

- Prek Sbov Village when houses and school are there is about 0.7 km
- Stung sen River is about 1 km
- Stung Sen Town is about 4 km
- National Road 6 is about 2 km (bypass road)

- The irrigation canals are near the STP site and the rice file is around this site, so the farmers grow rice crops: wet rice use raining water and dry rice use water from irrigating canals.
- There are no sensitive resources and sensitive ecology located in / near the STP site.
- The condition of this area from the town is sloping and reaching to the lowland area of Tonle Sap Lake to the west.

Pictures of STP Sites



The existing environmental condition in proposed STP in Stung Sen Town



The existing irrigated canals, rice field, and access road are near STP in Stung Sen Town



The visiting drainage system in some villages and main drainage flow to STP site



Discussion with local people and visiting the existing canal for proposed waste water flow direction from Stung Sen Town to STP site

2. Landfill Sub-project

- Proposed Landfill Site-1

The proposed landfill site-1 is located in Srayov Tboung Village, Srayov Commune, Stung Sen Town, Kampong Thom Province. This site belongs to private land and located from:

- from Stung Sen Town is about 10km
- Srayov Tboung Village (where there are schools, pagoda, and houses) is about 3-4 km
- National Road 6 is about 4 km and from road (laterite road) is about 1-2 km
- The site is covering by wet rice field and flood during raining season (0.5-1m deep).
- There are no water sources, and sensitive ecological/ social resources are located near the proposed site.

- Proposed Landfill Site-2

The proposed landfill site-2 is located in Trapaeng Russey Village, Snor Commune, Kampong Svay District, KPT province. This land area belongs to private land (government will buy, if project approves) and locate in upland (no flood, only runoff from heavy rain in rainy season). This proposed site-2 is located from:

- Stung Sen Town is about 12 km
- National Road 6 is about 2 km and from National Road 62 is about 4 km
- Trapaeng Russey Village (where are houses, school, and pagoda) is about 2-3 km.
- The site is private land and the small area in this site is cashew tree farm located in site.
- There are not any sensitive receptors in/near proposed site. Some locations of this site are shrub land with some small trees/vegetation. (Name of vegetation/trees in this site is presented in table below).

- Proposed Landfill Site-3

The proposed landfill site-3 is located in a same, Trapaeng Russey Village, Snor Commune, Kampong Svay District, KPT province too. The site-3 is on the south of site-2. This land is private land (government will buy, if project approves). Is upland site and no flood (only run off when heavy rain during rainy season). This proposed site-3 is located from:

- Stung Sen Town is about 12 km
- National Road 6 is about 4 km and from National Road 62 is about 2 km
- Trapaeng Russey Village (where are houses, school, and pagoda) is about 2-3 km.

- The existing airport area is about 0.5 km.
- Local Grave Area is bordering with proposed site-3
- There are not any sensitive receptors in/near proposed site. Some locations of this site are shrub land with some small trees/vegetation (as young trees). (some vegetation's names in this site is presented in table below).

Trees/vegetation in the proposed landfill site 2-3

During site visits of proposed landfill sites 2-3, the team found the following vegetation resources are in and near the sites:

No	Scientific Name	English Name	Khmer Name	Family Name	Remarks
In landfill site 2 and 3					
1	Bambusa Arundinacea Wild	Bamboo	Reussey Prey	Gramimeae	
2	Combretum Quadrangutare	Sangke	Sangke	Combretaceae	
3	Dipterocarpus Intricatus Dyer	No	Trach	Dipterocarpaceae	
4	Dipterocarpus Obtusifolius	No	Tbeng	Dipterocarpaceae	
5	Dipterocarpus Tuberculatus Roxb	No	Khlong	Dipterocarpaceae	
6	Lagerstroemia Florbunda Jack	Wild Guava	Trabek Prey	Lythraceae	
7	Bauhinia Acuminata	Cheung Kou	Cheung Kou	Leguminosae	
8	Phy Llantus Emblica	Cactus Tree	Kantuot Prey	Euphorbiaceae	
9	Calamus sp.	Vine/Rattan Specy	Voir/Pdav	Palmae	
10	Sindora Cochinchinensis H. Baill	Ko Koh Tree	Ko Koh	Leguminosae	
On the access roads near the sites					
1	Acacia Auriculiformis	Acacia	Acacia	Mimosaceae	
2	No	Eucalyptus	Prag Khyal		
3	No	Rain Tree	Chamkiri		
4	No	Palm Tree	Tnort		

Source: Field visits and List of tree species, FA/DANIDA, 2004

Pictures of proposed landfill sites



The existing environmental resources of proposed landfill site-1



The existing natural environmental resources in proposed site-2



The existing tree/vegetation resources in the proposed landfill site-2

		
The existing environmental resources (vegetation) in proposed landfill site-3		

		
The existing access road and trees in proposed landfill site-3		The Grave place in landfill site-3

3. Battambang Town, Battambang Province

Date : Tuesday 31 January, 2018

A. Key points of Meeting and field visits

STP Sub-project

1. Site Condition

- The STP is located in Bang Village, Norea Commune, Sangke District, BTB Province.
- The site is lowland area and flood by rainy water during raining season. Most of areas is rice filed (wet rice crop) covering around the proposed site.
- There are no sensitive receptors and sensitive forest or ecological resources near the proposed site. The location is located as follows:

  - Sangke River is about 4-5 km.
  - BTB Town is about 5-6 km
  - Norea Primary-Secondary School and Christian School is about 1.5 km
  - Cultural resources is about 3-4 km
  - Provincial Road-609 is about 3-4 km

2. Pictures of STP Site

		

The existing environmental condition in proposed STP, BTB Town		

		
The existing access road to site		Christian School

		
Norea primary and secondary school	Cultural Resources in Runchek Village, Rotanak Commune	

Landfill Sub-project

1. Proposed Landfill Site-1

This proposed site is located in Chhay Rumpoit Village, Kanteur-2 Commune, Banan District, BTB Province.

- There are no sensitive receptors and sensitive forest resources in or near the site. In and around the site is rice field (flooded by rain water). The site is located as follows:

- The irrigation canals are near the site
- Houses and village is about 1 km
- Sanke River is about 1.2 km
- Anduong Svay Pagoda is about 4 km.
- For vegetation – see table below

2. Proposed Landfill Site-2

- The proposed site is located in Svay Beidem Village, Kanteur-1 Commune, Banan District, BTB Province. This site is located in upland area, no flood and is public land owner and there are a few and small existing laterite borrow pits are remaining as small ponds.

- The proposed site is near the village area. The site is located as follows:

- Bordering with the main rural laterite road (local name is Chhay Rumpoit Road).
- Near the Sangke River and near the Svay Beidem Village and near a few houses about 0.2 km
- Banan Temple is about 5 km.
- There are no sensitive forest and ecological resources are located near the site. There is small shrub-land in this site – see table below)

3. Proposed Landfill Site-3

- This proposed site is located in Ta Douk and Kapang Village, Bay Damraim Commune, Banan District, BTB Province. The rice field (wet rice crop) is in and around the site.

- The land is private land, but if project selects, the government will buy from people. Local government negotiated with people, they agree to sell to project. The site is located as follows:

- The rice filed is around the site and near the irrigation canals
- A few houses of village area are about 0.5 km
- The Banan Temple is about 2.5 km
- The existing rural road (laterite road) is about 1 km and small access rural road is near the site
- The Sangke River (where, there are residents and business activities) is about 2.5 km
- There are not sensitive receptors and sensitive forest, or ecological resources are near the site. (There is small shrub-land in this site - see table below).

Tree and forest are setting in the proposed landfill sites

The landfill site areas for Battambang contain the following species, which are cultivated or are common species in Cambodia.

No	English Name	Khmer Name	Family Name	Remarks
				Landfill site
1	Tammarind	Ampil	*Leguminosae*	Site 1, 2 and 3
2	Palm Tree	Tnort		Site 1, 2 and 3
3	Bamboo	Reussey	*Gramimeae*	Site 2
4	Neem Tree	Sdao	*Meliaceae*	Site 1, 2 and 3
5	Sangke	Sangke	*Combretaceae*	Site 1, 2 and 3
6	Cheung Kou	Cheung Kou	*Leguminosae*	Site 2
7	Euphorbia	Kantuot Prey	*Euphorbiaceae*	Site 2
8	Vine/Rattan species	Voir/Pdav	*Palmae*	Site 2
				In nearest village
10	Mango	Svay		
11	Coconut	Duong		--
12	Orange	Kroch		--
13	Jack tree	Khnor		--

14	Sugarcane	Ampoav		--
15	Banana	Cheak		--
16	Morum	Morum	*Moringaceae*	--
17	Angkea Dey	Angkea Dey	*Leguminosae*	--
				On the access road
18	Acacia	Acacia	*Mimosaceae*	
19	Eucalyptus	Prag Khyal		
20	Rain Tree	Chamkiri		

Source: Field visits and List of tree species, FA/DANIDA, 2004

2. Pictures of proposed landfill sites

The existing environmental resources (rice field, Tamarind Palm Tree, and Neem Tree) on site-1

Rice filed and irrigated canals on and near the landfill site-1

Access road to site-1

The houses condition landfill site-1

The existing environmental condition in proposed landfill site-2

The existing access road and social resources condition in proposed landfill site-2

The existing environmental resources in the proposed landfill site-3

The existing canals, road, and social resources neat the proposed landfill site-3

Annex 3 Environmental Compliance Audit

Solid Waste Dumpsite in Serei Saophoan and Stueng Saen, Cambodia
Environment Compliance Audit

March 2018

Terms of Reference (DRAFT)

1.0 Background:

The project will improve urban environmental services in Battambang, Serei Saophoan and Stueng Saen, three of Cambodia's provincial cities located around the Tonle Sap lake. The project will also improve institutional effectiveness to provide sustainable services and support an improved policy and planning environment for wastewater and solid waste management

The project will construct controlled landfills in all three cities with sufficient volume capacity to accommodate waste from the existing dump sites as well as new waste for the next 10 years. The landfill sites (to be purchased after loan approval) will be sized to serve the needs of the cities until at least 2040, to allow for development of additional landfill cells in the future.

An alternatives analysis concluded that the selected option of a controlled landfill was the lowest life-cycle cost solution, which, in the local context, has most of the environmental and operational benefits without the technical complexities of a fully engineered sanitary landfill. For treatment of leachate, alternatives (including lagoons, constructed wetlands, and reinjection and recirculation) were considered, and the selected option (reinjection and recirculation) is considered appropriate for local conditions and capacity (see Annex 8 for technical specifications for leachate management).

The project will provide training to ensure sustainable O&M of project facilities. The project will also prepare a landfill closure plan for all sites, and finance the closure and rehabilitation of the two dump sites located on public land (in Stueng Saen and Serei Saophoan).

2.0 Purpose and requirement of Environmental Compliance Audit

The dumpsites are an *Existing Facility*[20] of the project which necessitates Environmental Compliance Audit (ECA) to be conducted of that facility pursuant to the SPS (2009), para 10 of Appendix 1 and para 12 of Appendix 4. Specifically, para 12 of Appendix 4 of SPS (2009) states:

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[20] Existing Facilities 12. For projects involving facilities and/or business activities that already exist or are under construction, the borrower/client will undertake an environment and/or social compliance audit,
including on-site assessment, to identify past or present concerns related to impacts on the environment, involuntary resettlement, and Indigenous Peoples. The objective of the
compliance audit is to determine whether actions were in accordance with ADB's safeguard. Appendix 4 principles and requirements for borrowers/clients and to identify and plan appropriate measures to address outstanding

……for projects involving facilities and/or business activities that already exist or are under construction, the borrower/client will undertake an environment and/or social compliance audit, including on-site assessment, to identify past or present concerns related to impacts on the environment, involuntary resettlement, and Indigenous Peoples. The objective of the compliance audit is to determine whether actions were in accordance with ADB's safeguard principles and requirements for borrowers/clients and to identify and plan appropriate measures to address outstanding compliance issues. Where noncompliance is identified, a corrective action plan agreed on by ADB and the borrower/client will be prepared. The plan will define necessary remedial actions, the budget for such actions, and the time frame for resolution of noncompliance. The audit report (including corrective action plan, if any) will be made available to the public in accordance with the information disclosure requirements of the SPS (2009).

Because the subproject involves upgrading an existing dumpsite [the existing facility], the SPS (2009) calls for the preparation of an environmental assessment and a compliance audit of the existing dumpsite. However, in this case the ECA along with the IEE of the subproject will suffice as the environmental assessment.

3.0 Scope of the ECA for the dumpsites

Pursuant to the ADB SPS (2009) the consultant will conduct an ECA of the existing dumpsites. To complete the ECA the Consultant will obtain and report on the detailed information and data where available for the existing dumpsites listed in Table 1.

Table 29. Information requirements of ECA of Serei Saophoan and Stueng Saen Dumpsites

1. Location of dumpsite (latitude and longitude coordinates); 2. Size of dumpsite (ha); 3. Date dumpsite was commissioned (became operational); 4. Current operator and responsible authority of dumpsite;

compliance issues. Where noncompliance is identified, a corrective action plan agreed on by ADB and the borrower/client will be prepared. The plan will define

necessary remedial actions, the budget for such actions, and the time frame for resolution of noncompliance. The audit report (including corrective action plan, if any) will be made available to the public in accordance with the information disclosure requirements of the Safeguard Requirements 1–3. For environment category A projects involving facilities and/or business

activities that already exist or are under construction, the borrower/client will submit the audit report to ADB to disclose on ADB's website at least 120 days prior to ADB Board approval. If a project involves an upgrade or expansion of existing facilities that has potential impacts on the environment, involuntary resettlement, and/or Indigenous Peoples, the requirements for

environmental and social impact assessments and planning specified in Safeguard Requirements 1-3 will apply in addition to compliance audit.

5. Types of solid waste disposed in dumpsite (e.g., domestic, hospital, construction, industrial);

6. Rate of solid waste disposal at dumpsite (tonne/day or tonne/month);

7. Determine if government issued permits/licenses for dumpsite operation exist, and whether dumpsite operation is in compliance with permits or licenses

8. For each government regulation and law listed below clarify whether the design and operation of existing dumpsite is in compliance, and clarify any non-compliance issues. Identify any regulation or directive for solid waste management that is missing from list below.
    a) Sub-decree on Water Pollution Control (Sub-decree No. 27 ANRK/BK) 2009;
    b) Guidance on Selection of Landfill Sites (2016)
    c) Sub-decree on Solid Waste Management (Sub-decree No. 36 ANK/BK) 1999

9. For each regulation or law in #8 above define remedial corrective measures that are required for dumpsite to be compliant especially for non-compliance issues with community, and occupational health and safety regulations.

10. Clarify actual design and operation of the existing dumpsite by obtaining following information:
    a) the number and depth of waste cells;
    b) underlying waste cell lining material if any;
    c) extent of active surface runoff collection and drainage;
    d) extent of leachate and gas collection and treatment;
    e) extent of septage disposal and management;
    f) waste recycling process used by local waste pickers;
    g) equipment used to collect and transport solid waste from where it is produced vicinity to dumpsite; and
    h) scheduling of transport of solid waste to dumpsite

11. Obtain existing data on groundwater (well) quality near the dumpsites from PDoE (if available);

12. Determine distance of nearest surface waters (stream, lake) that could be affected by the dumpsite, and obtain existing surface water quality data

13. Determine distance of nearest homestead or business from dumpsite;

14. Determine number of full-time and part-time waste pickers that work and live at dumpsite

15. Consult surrounding community and waste pickers to determine if there are past or present environmental, social, or human health issues with the operation of the existing dumpsite.

4.0 Site Visit and Interview of PDPWT

A site visit to existing dumpsites is required. The staff at the Provincial Departmment of Public Works and Transport must be interviewed to obtain the required information listed above.

5.0 Report on ECA

Prepare a report on the ECA which details the information and data requirements listed in section 3.0 above. The report should have the following general sections:

(i) Executive Summary.

(ii) Brief description of dumpsite with 1-2 photographs.

(iii) A table or set of tables which clearly provide the detailed information and data requirements identified in Table 1. All available groundwater or surface water quality data should be tabled separately.

(iv) List of people and institutions contacted for information and data.

(v) Recommendations for managing risks from dumpsite.

Annex 4 Consultation During IEE Preparation

Public Consultation Meetings: Focus Group Discussion (FGD)

The main objectives of FGDs are to:

- Present to the stakeholders and affected people the sites for subprojects in the provincial towns and inform them of the project activities
- Understand the main issues that may occur in the proposed sub-project areas, as raised by local people.
- Understand the potential social and environmental resources located/used in the subproject sites.
- Receiving issues, feedback, and comments from stakeholders or affected people regarding social, gender and environmental issues/resources in the proposed sites.
- Receiving comments and suggestions for mitigation measures to improve any adverse environmental and social impacts from project design, construction, and operation stages.

Identification of Participants to Consultation Meeting

Stakeholders invited to attend FGDs were identified by National Social Specialist and National Environmental Specialist with assistance from commune chiefs of subproject areas. These focus group members come from:

- Representative of communities or affected communities (men and women)
- Chiefs/ deputy village chiefs, the villages are located in and close to the subproject sites
- Commune chiefs/deputy commune chiefs and commune council members. These communes are located in and around the proposed subprojects sites.

The discussion questions concerned:

- Physical Resources: Water resources and water quality, soil quality, and air quality (noise and odor)
- Ecological Resources: forest/vegetation, wildlife and fish.
- Social Issues/Resources: Land use, water use, agricultural activities, cultural resources, infrastructure, utility services, education, and cultural-touristic resources.

The format of the FGD is summarized as follows:

1. Introduction to the project - describe the project and potential construction activities.
2. Mitigation Measures. Describe potential mitigation measures (EMP) and monitoring
3. Consultation Discussion. Discussion on topics and questions:

- A. How does the community use the environment & natural resources? Example: what are water sources (drinking, washing etc). Vegetation/Fish/Forest , land use etc
- B. What are the community's concerns regarding Construction Impacts?
- C. What are the community's concerns regarding Operation Impacts?
- D. What are the Mitigation Measures the community would like during Construction?
- E. What are the Mitigation Measures the community would like during Operation?

Summary of the results of consultations

On 09 to 12 February the National Social and Gender Specialist and National Environmental Specialist of the TA 9203-CAM: Second Urban Environmental Management in The Tonle Sap Basin Project undertook FGDs in the proposed sub-projects areas for *Battambang, Serei Sophorn, and Stung Sen Town.* The key points from the consultation meetings are presented in Section 8 of this IEE.

I. Consultations for Battambang Town, Battambang Province

- Consultation pictures in BTB Province



Consultation in Prek Preah Sdach Commune, BTB Town



Consultation in Rotanak Commune, BTB Town

Consultation in Norea Commune, Sangke District, BTB Province



Consultation in Svay Por and O Char Commune, BTB Town

Consultation in Kanteu Pir Commune, Banan District, BTB Province

- Participants List for Consultations in BTB Province

1. Consultation in Rrek Preahsdach Commune, BTB Town, BTB Province

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Leuk Sam Ath	Rrek Preahsdach Commune	Villager	092 752 092
2	Mr. Thean Phong	Rrek Preahsdach Commune	Villager	092 265 019
3	Ms. Seng Lyna	Rrek Preahsdach Commune	Villager	
4	Ms. Oun Rany	Rrek Preahsdach Commune	Villager	
5	Ms. Om Naran	Rrek Preahsdach Commune	Villager	
6	Ms. Tim Sokhom	Rrek Preahsdach Commune	Villager	
7	Ms. Heng Bunthay	Rrek Preahsdach Commune	Village Chief	092 254 963
8	Ms. Houm Pisin	Rrek Preahsdach Commune	Deputy Village Chief	
9	Ms. Van Sarum	Rrek Preahsdach Commune	Villager	
10	Ms. Pin Saveun	Rrek Preahsdach Commune	Villager	
11	Ms. Soun Touch	Rrek Preahsdach Commune	Villager	
12	Ms. Om Maly	Rrek Preahsdach Commune	Villager	
13	Ms. Ros Sreyneth	Rrek Preahsdach Commune	Village Member	070 920 598
	Total: 13 persons (female: 11 persons)			

2. Consultation in Rottanak Commune, BTB Town, BTB Province

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Reas Son	Rumchak-4 Village, Rottanak	Village Chief	092 738 831
2	Ms. Kao Sras	Rumchak-4 Village, Rottanak	Villager	
3	Mr. Chan Oeun	Rumchak-4 Village, Rottanak	Villager	
4	Mr. Teu Savoun	Rumchak-5 Village, Rotatnak	Village Chief	017 340 509
5	Mr. Chham Lap	Rumchak-5 Village, Rotatnak	Deputy Village Chief	078 964 923
6	Mr. Bun Nann	Rumchak-5 Village, Rotatnak	Villager	

7	Mr. Real Sambo	Rumchak-1 Village, Rottanak	Villager	
8	Ms. Pem Poa	Rumchak-1 Village, Rottanak	Villager	
9	Ms. Theun Theap	Rumchak-1 Village, Rottanak	Villager	
10	Mr. Leap Chhorn	Rumchak-1 Village, Rottanak	Villager	
11	Mr. Sim Samnang	Rumchak-2 Village, Rottanak	Deputy Village Chief	012 263 475
12	Mr. Leng Dy	Rumchak-2 Village, Rottanak	Villager	
13	Ms. Chhay Phary	Rumchak-2 Village, Rottanak	Villager	
14	Mr. Ngorn Sam Ol	Rumchak-3 Village, Rottanak	Deputy Village Chief	
15	Ms. Phan Sophorn	Rumchak-3 Village, Rottanak	Villager	
16	Mr. Mork Neth	Rumchak-3 Village, Rottanak	Villager	
17	Mr. Liv San	Rumchak-3 Village, Rottanak	Villager	
18	Mr. San Vuthchheun	Rumchak-3 Village, Rottanak	Villager	
19	Mr. Chheum Chheat	Rumchak-3 Village, Rottanak	Villager	
20	Ms. Song Piseth	Rottanak Coomune	Commune Clerk	092 505 559
21	Mr. Touch Phany	Rumchak-3 Village, Rotanek	Village Chief	071 777 826
	Total: 21 persons (female: 06 persons)			

3. Consultation in Norea Commune, Sangke District, BTB Province (STP subproject)

No	Name	Agency Village/Commune	Position	Phone
1	Ms. Teuk Samneang	Balath Village, Norea	Villager	098 851 492
2	Ms. Kram Salin	Balath Village	Villager	
3	Ms. Keo Sokunthea	Balath Village	Villager	
4	Ms. Phal Sopheap	Takok Village, Norea	Village Member	086 966 690
5	Mr. Oun Khim	Balath Village, Norea	Villager	
6	Mr. Hap Seub	Balath Village, Norea	Villager	
7	Mr. Chea Lork	Takok Village, Norea	Village Chief	095 726 172
8	Mr. Ril Mann	Norea Commune	Deputy Commune Chief	077 831 621
9	Mr. Hou Sarum	Norea-1 Village, Norea	Village Chief	092 925 628
10	Ms. Mou Yann	Norea Commune	Commune Clerk	016 712 311
11	Ms. Hing Chantaleang	Norea Commune	Commune Assistant	078 903 623
12	Ms. Ngeap Viet	Takok Village, Norea		
	Total: 12 persons (female: 07 persons)			

4. Consultation in Svay Por and O Char Commune, BTB Town, BTB Province

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Yous Sareun	Kamakar Village, Svay Por	Village Chief	012 536 506

2	Ms. Chhun Sothy	--	Community Leader	012 542 937
3	Ms. Lot Sokhunthea	--	Community Member	
4	Mr. Hing Bunla	Svau Por Commune	Commune Clerk	017 945 662
5	Mr. Oun Sophy	O Char Village, O Char	Village Chief	012 977 219
6	Mr. Teav Vuthy	Prek MohaTep, Svay Por	Village Chief	012 974 235
7	Mr. Mean Sophal	Svay Por Commune	Village Chief	
8	Mr. Lim Sokhan	--	Villager	
9	Mr. Khoun Teuk	--	Commune Assistant	012 680 650
	Total: 09 persons (female: 02 persons)			

5. Consultation in Kanteu-2 Commune, Banan District, BTB Province (landfill subproject)
The people came from: Kanteu-2, Kanteu-1, and Baydamraim Commune, Banan District

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Hap Hamp	Baydamraim Commune	Village Chief	078 288 809
2	Mr. Path Yout	Baydamraim Commune	Village Member	090 717 674
3	Mr. Hov Vith	Baydamraim Commune	Deputy Village Chief	088 583 0835
4	Mr. Ly Sakhan	Baydamraim Commune	Deputy Village Chief	088 713 8812
5	Ms. Chhun Hak	Kanteu-1 Commune	Village Member	095 458 388
6	Mr. Song Chea	Kanteu-2 Commune	Commune Assistant	088 704 4411
7	Ms. Chhoun Vary	Baydamraim Commune	Village Member	089 955 025
8	Mr. Thy Vannak	Kanteu-1 Commune	Villager	
9	Mr. Chhum Phy	Kanteu-1 Commune	Villager	
10	Mr. Sar San	Kanteu-2 Commune	Commune Police	O97 522 4876
	Total: 10 persons (female: 02 persons)			

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II. Consultations for Serei Sophorn Town, BMC Province

- Consultation pictures in BMC Province



Consultation in O Ambel and Preah Ponlear Commune, Serei Sophorn Town






Consultation in Kampong Svay and Teuk Thla Commune, Serei Sophorn Town



Consultation in Phneat Commune, Serei Sophorn Town

- Participants List for Consultations in BMC Province

1. Consultation in O Ambel and Preah Ponlear Commune, Serei Sophorn Town

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Pen Im	O Ambel Commune	Village Chief	095 537 337
2	Mr. Moun Chhay	O Ambel Commune	Villager	

3	Mr. Kong Vey	O Ambel Commune	Villager	
4	Mr. Rin Reul	O Ambel Commune	Villager	
5	Mr. Seum Yeung	O Ambel Commune	Villager	
6	Mr. Chhorn Vannak	O Ambel Commune	Villager	
7	Mr. Yeun Oun	O Ambel Commune	Deputy Commune Chief	011 678 677
8	Mr. Oung Dara	O Ambel Commune	Deputy Commune Chief	097 363 2082
9	Mr. Lim Samnang	Preah ponlear Commune	Village Chief	012 447 283
10	Mr. Chhon Sileap	Preah ponlear Commune	Village Chief	092 271 746
11	Ms. Chhung Chamreun	Preah ponlear Commune	Villager	
12	Ms. Thong Youn	Preah ponlear Commune	Villager	
13	Ms. Yim Sithouy	Preah ponlear Commune	Villager	
14	Ms. Mom Sophorn	Preah ponlear Commune	Villager	
15	Mr. Lim Ky	Preah ponlear Commune	Villager	
16	Ms. Soa Bory	Preah ponlear Commune	Villager	
17	Ms. Eag Kunthear	Preah ponlear Commune	Villager	
18	Ms. Sok Lon	Preah ponlear Commune	Villager	
	Total: 18 persons (female: 07 persons)			

2. Consultation in Kampong Svay and Teuk Thla Commune, Serei Sophorn Town

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Kong Sath	Kampong Svay Commune	Villager Chief	092 780 206
2	Ms. Long Srey Neat	Kampong Svay Commune	Deputy Village Chief	
3	Ms. Poa Yang	Kampong Svay Commune	Villager Chief	012 964 098
4	Ms. Son Yeum	Kampong Svay Commune	Deputy Villager Chief	
5	Ms. Touch leang	Kampong Svay Commune	Villager	
6	Mr. Chan Seur	Kampong Svay Commune	Villager	
7	Mr. Son Yim	Kampong Svay Commune	Villager	
8	Ms. Dein Solida	Kampong Svay Commune	Commune clerk	012 672 199
9	Mr. Tor Mouth	Kampong Svay Commune	Villager	
10	Mr. Chap Ron	Teuk Thla Commune	Village Chief	081 812 424
11	Mr. San Sivathan	Teuk Thla Commune	Village	
12	Mr. Ma Chheun	Teuk Thla Commune	Villager	
13	Mr. Chhun Savan	Teuk Thla Commune	Villager	
14	Ms. Thang Sareth	Teuk Thla Commune	Deputy Village Chief	092 604 838
15	Ms. Yim Channa	Teuk Thla Commune	Villager	
16	Ms. Noy Maleya	Teuk Thla Commune	Villager	

17	Ms. Soung Samei	Teuk Thla Commune	Villager	
18	Ms. Chhut Sareun	Teuk Thla Commune	Villager	
19	Ms. Muth Rin	Teuk Thla Commune	Villager	
	Total: 19 persons (female: 11 persons)			

3. Consultation in Phneat Commune, Serei Sophorn Town

No	Name	Agency Village/Commune	Position	Phone
1	Ms. Pouth Mary	Phneat Commune	Village Member	017 696 508
2	Mr. Tan Chhouy	Phneat Commune	Deputy Village Chief	012 199 1328
3	Ms. Mok Kim Ath	Phneat Commune	Villager	
4	Mr. Chhuth Polo	Phneat Commune	Village Chief	012 237 628
5	Ms. Bour Sareun	Phneat Commune	Villager	
6	Ms. Phath Youm	Phneat Commune	Villager	
7	Ms. Khim Buntha	Phneat Commune	Villager	
	Total: 07 persons (female: 05 persons)			

III. Consultations for Stung Sen Town, Kampong Thom Province

- Consultation pictures in Kampong Thom Province



Consultation in Srayov Commune, Stung Sen Town, Kampong Thom



Consultation in O Kanthor Commune, Stung Sen Town, Kampong Thom Province



Consultation in Trapaeng Russey Commune, Kampong Svay District , Kampong Thom Province

- Participants List for Consultations in Kampong Thom Province

1. Consultation in Srayov Commune, Stung Sen Town, KPT Province

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Harm Chheav	Srayov Commune	Group Leader	O88 850 4809
2	Mr. Srey Nhel	Srayov Commune	Village Chief	092 628 046
3	Mr. Seang Yeung	Srayov Commune	Group Leader	
4	Mr. Chean Cheam	Srayov Commune	Villager	
5	Mr. Porn Phit	Srayov Commune	Villager	
6	Ms. Chhun Nath	Srayov Commune	Villager	
7	Mr. Chhup Darith	Srayov Commune	Villager	
8	Mr. Chhup Ron	Srayov Commune	Villager	
9	Mr. Horn Kea	Srayov Commune	Villager	
10	Mr. Chhup Lim	Srayov Commune	Villager	
11	Mr. Sim Lim	Srayov Commune	Villager	
12	Ms. San Sineth	Srayov Commune	Villager	
	Total: 13 persons (female: 02 persons)			

2. Consultation in O Kanthor Commune, Stung Sen Town, KPT Province

No	Name	Agency Village/Commune	Position	Phone
1	Mr. Chhiv Kim Oun	O Kanthor Commune	Commune Chief	012 214 628
2	Mr. Seng Vankim	O Kanthor Commune	Commune Council	097839 5552
3	Mr. Din Sok	O Kanthor Commune	Deputy Village Chief	
4	Mr. Samreth Ron	O Kanthor Commune	Villager	

5	Ms. Sos Ho	O Kanthor Commune	Villager	
6	Ms. Thou Thouk	O Kanthor Commune	Villager	
7	Ms. Phon Tho	O Kanthor Commune	Villager	
8	Ms. Hing Sin	O Kanthor Commune	Villager	
9	Ms. Nao Sok	O Kanthor Commune	Villager	
10	Ms. Phon Pao	O Kanthor Commune	Villager	
11	Mr. Sim Sophal	O Kanthor Commune	Villager	
12	Mr. Chheum Kreun	O Kanthor Commune	Villager	
13	Mr. Sim Chhun	O Kanthor Commune	Villager	
14	Mr. Douch Samith	O Kanthor Commune	Villager	
15	Mr. Muth Vung	O Kanthor Commune	Villager	
16	Mr. Ou Hay	O Kanthor Commune	Villager	
17	Mr. Mes Chan	O Kanthor Commune	Villager	
18	Mr. Hing Kimtry	O Kanthor Commune	Villager	
19	Mr. Kin Chheun	O Kanthor Commune	Village Chief	
20	Ms. Im La	O Kanthor Commune	Villager	
	Total: 20 persons (female: 07 persons)			

3. Consultation in Trapaeng Russei Commune, Kampong Svay District, KPT Province

No	Name	Agency Village/Commune	Position	Phone
1	Ms. Seng Pich	Trapaeng Russei Commune	Village Member	
2	Mr. Hong Khoth	Trapaeng Russei Commune	Deputy Village Chief	097 699 8723
3	Ms. Hing Neng	Trapaeng Russei Commune	Villager	
4	Mr. Ving Sandap	Trapaeng Russei Commune	Villager	
5	Ms. Seng Veun	Trapaeng Russei Commune	Villager	
6	Mr. Chhorn Yeun	Trapaeng Russei Commune	Villager	
7	Mr. But Phorn	Trapaeng Russei Commune	Villager	
8	Mr. Rim Rithy	Trapaeng Russei Commune	Villager	
9	Ms. Khe Sokha	Trapaeng Russei Commune	Villager	
10	Ms. Sem Mom	Trapaeng Russei Commune	Villager	
11	Ms. Van Ne	Trapaeng Russei Commune	Villager	
12	Ms. Chheng Ngip	Trapaeng Russei Commune	Villager	
13	Ms. Dem Khan	Trapaeng Russei Commune	Villager	
14	Mr. Nang Nem	Trapaeng Russei Commune	Village Chief	012 162 6981
15	Ms. Pin Kao	Trapaeng Russei Commune	--	
16	Ms. Sem Khom	Trapaeng Russei Commune	--	

17	Ms. Van Vanna	Trapaeng Russei Commune	--	071 708 8357
18	Ms. Ngim Navy	Trapaeng Russei Commune	--	
19	Ms. Kong Vy	Trapaeng Russei Commune	--	
20	Ms. Tea Teang	Trapaeng Russei Commune	--	
	Total: 07 persons (female: 05 persons)			

Annex 5 Environmental Management Plan – Stueng Saen

See EMP

Annex 6 Environmental Management Plan – Serei Saophoan

See EMP

Annex 7 Environmental Management Plan – Battambang

See EMP

Annex 8 Leachate Management Details

[This Annex has been extracted from Consultant Report Technical Overview – ADB Solid Waste Management Projects in Cambodia and Laos, April 2018]

Leachate composition

Leachate Characteristics

Leachate strength is highly variable and depends upon waste type and composition, landfill waste age, temperature, moisture content, rainwater or groundwater infiltration, re-injection of leachate and so on. The possible range of leachate strengths for the key parameters is listed below, based on international data:

- BOD – 4 to 60,000mg/L
- COD – 4 to 100,000mg/L
- Ammonia – 2 to 3,000mg/L
- pH – 4.5 to 9.0

A COD of 20,000 mg per litre is commonly adopted for the raw effluent quality for design. As the waste ages, the organic strength of the leachate reduces.

For comparison, the latest monitoring results collected from the Payatas landfill in Manila indicated a COD of 1140 mg per litre in June 2017, and a BOD of approximately half this. Most of the waste in the site is at least 10 years of age, and therefore the leachate strength emanating from this stage of waste is significantly reduced beyond that of fresh waste.

Parameter	**Unit**	***Design Value***		***Typical Effluent Standards***
pH	-	5 – 8.5		5.5 –9.0
		Average	**Maximum**	
COD	mg/l	20,000	30,000	<100
BOD	mg/l	12,000	20,000	<50
TSS	mg/l	500	1,000	<100
Ammonia.N	mg/l	200	800	<1
Nitrate.N	mg/l	25	40	-
Total N	mg/l	-	-	<60
Total P	mg/l	10	30	<6
Alkalinity (as $CaCO_3$)	mg/l	500	1000	-
Coliforms (MPN/100mL)	MPN/100 ml	10^7	10^8	10,000

Values or ranges are typically not provided for heavy metals, organics including biocides and

other contaminants such as generic solvents and oils because these are so highly variable ranging from zero to possibly high concentrations in some cases.
The cities within TS2 all have very low to no industrial activity. The worst case is some cottage industry with garment manufacturing and also shoes. None of these activities would generate particularly toxic leachate, however this may change in the future as the cities become more industrialised.

Industries generally of most concern are metal plating works when the plating bath is emptied and the waste is taken to landfill rather than to a hazardous waste site. Similarly, biocide manufacturing facilities and other organics such as solvents can be of concern if taken to and dumped indiscriminately in the landfill. At present there are no plans for such manufacturing facilities in the region.

With the move away from the very persistent organochlorine pesticides to the organophosphates and other less stable compounds, the concerns about partially empty pesticide containers being disposed of in the landfill is also greatly reduced.
Similarly, waste oil at present is not taken to the landfill but is used within the city. As the quantity of waste oil increase, then small recycling facilities can be established to reuse the oil rather than dispose of it.

In any case if and when these heavy industrial facilities may be developed within the landfill catchments, it is expected that better controls would be required by the city and the Environment Department such that any toxic or hazardous waste generated therein will be appropriately managed, reprocessed and then disposed of in a suitably registered facility.
Overall, leachate discharging from landfills developed and operated many decades ago is generally far more toxic than the leachate coming from modern landfill facilities, even in developing countries. However, this does not mean that leachate is innocuous and it still must be appropriately managed to prevent impacts on the water and soils environment.

Acid and methane landfill stages and impact on mobility

The biggest issue with landfill leachate strength and toxicity relates to the age of the landfill.
When a new landfill is being developed, the facility goes through a number of stages with the first being the development of acid forming bacteria within the waste mound. This can last from 6 to 24 months and is the period when the metals within the landfill are most mobile due to the acid phase significantly reducing the bond strength of metals to the various attachment sites including carbonates, organics and the cation exchange capacity overall.

Following the acid phase, methane forming bacteria dominate and the pH rises resulting in greatly reduced mobility of the metal ions within the landfill mound.
As the biochemical breakdown of the organics within the waste mound continues further, the resulting leachate strength significantly reduces until it becomes innocuous as the waste mound becomes effectively inert. This can take up to 20 years in many cases.

Front end controls

The landfills operation manual will provide details on the four waste categories to assess the acceptance or otherwise of waste being allowed into the landfill. This applies equally to organic and inorganic heavy-metal contaminants as well as other material such as hot loads or potentially explosive waste.

This landfills operation manual will provide guidance on each of the four waste categories in terms of how to identify them, whether they are always or sometimes acceptable and whether they are classed as difficult wastes that will require specific management interventions. The final category is of course unacceptable waste which is never allowed into the landfill.
By ensuring that the landfill staff member at the front gate has been suitably trained to identify and reject unacceptable loads, then the quantity of highly toxic or hazardous waste entering the site and therefore potentially further contaminating the leachate will be significantly reduced.

Leachate strength summary

Modern day leachate is far less toxic than historical leachate flows given the significantly better control over highly contaminated waste which previously was disposed of in landfills, such as metal plating wastes as well as biocides and various solvents and other refractory organics.

As the landfill goes through various stages from acid forming through to methane forming to finally inert, the leachate characteristics change significantly. One advantage of the reinjection system proposed is that this accelerates the biochemical activity throughout the leachate mound thereby significantly reducing the acidic phase period when metals are highly mobile. This biochemical acceleration also means that the period over which leachate is generated is also significantly shortened.

Leachate flow balance

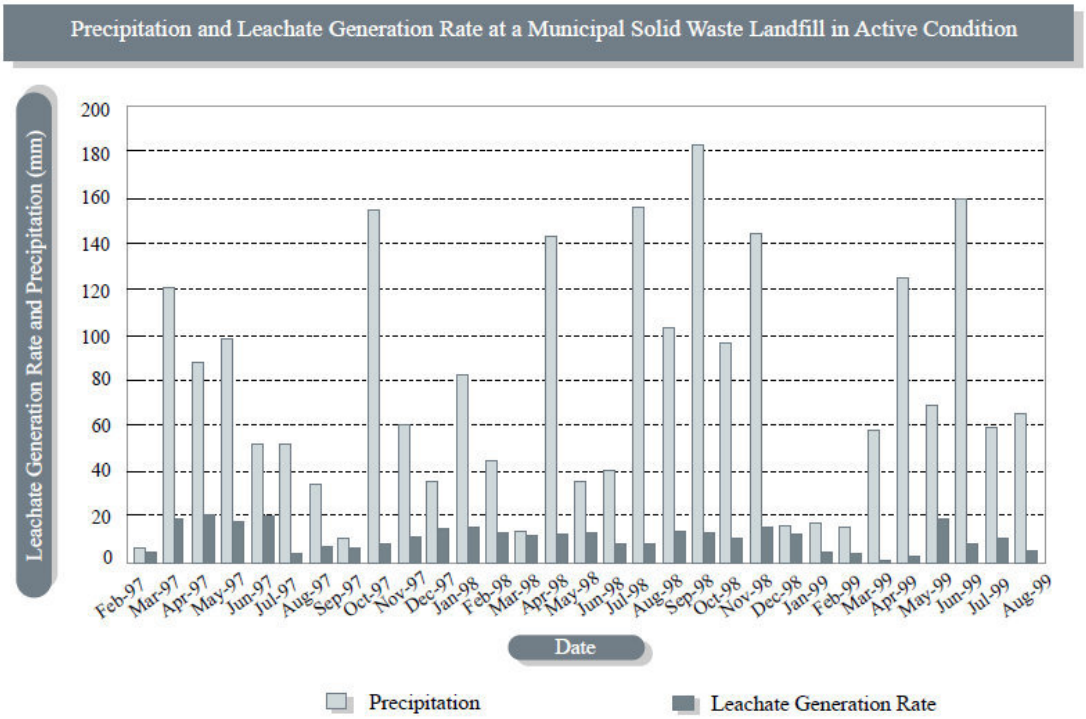
Battambang Example

Leachate management is a key factor in any landfill design. The system proposed consists of a series of slotted pipes in the landfill base leading to leachate pumping station. Leachate will then be pumped either to be reinjected at the top of the mound in wet weather or irrigated in dry periods.
The average moisture content of municipal waste ranges from about 20 to 45 percent, with most of the moisture being held in foodstuffs and green waste. Commercial and industrial waste mixed with non-putrescible municipal waste has a moisture content of less than 20 percent.
The degradation of the organic component of the waste mass produces a small quantity of liquid leachate and gaseous by-products. The leachate produced is partially absorbed into the dry waste mass and partially lost as vapour due to the heat of the biodegradation process. Under these conditions virtually no free liquid is produced.
Due to unavoidable direct rainfall entry over operational areas of the landfill, the volume of liquid within the waste mass increases. The direct entry of rain is expressed as a percentage of the rainfall on the site. Well run sites with excellent surface water controls have limited their annual leachate production to less than 5 percent of annual rainfall. Poorly run sites where even external runoff water from adjoining catchments has not been excluded have an annual leachate production in excess of 100 percent of annual rainfall.

Once the moisture content of the waste mass approaches 60 to 70 percent or so, the waste becomes saturated and any water excess becomes free to move by gravity. Under these conditions, leachate collects at the base of the landfill or above low permeability soil layers within the waste mass and expresses itself in springs around the toe of the landfill or even up the sides of the perimeter batters.

The external final batters will become grassed in any case as the soil becomes covered with seeds and external sources of sward generation. The proposal to irrigate external batters will further encourage sward growth in any case, particularly in the drier periods.

Precipitation and Leachate Generation Rate



Ref: "Qian, X., R. M. Koerner, and D. H. Gray, "Geotechnical aspects of landfill design and construction, upper Saddle River, New Jersey". Prentice-Hall, 2002

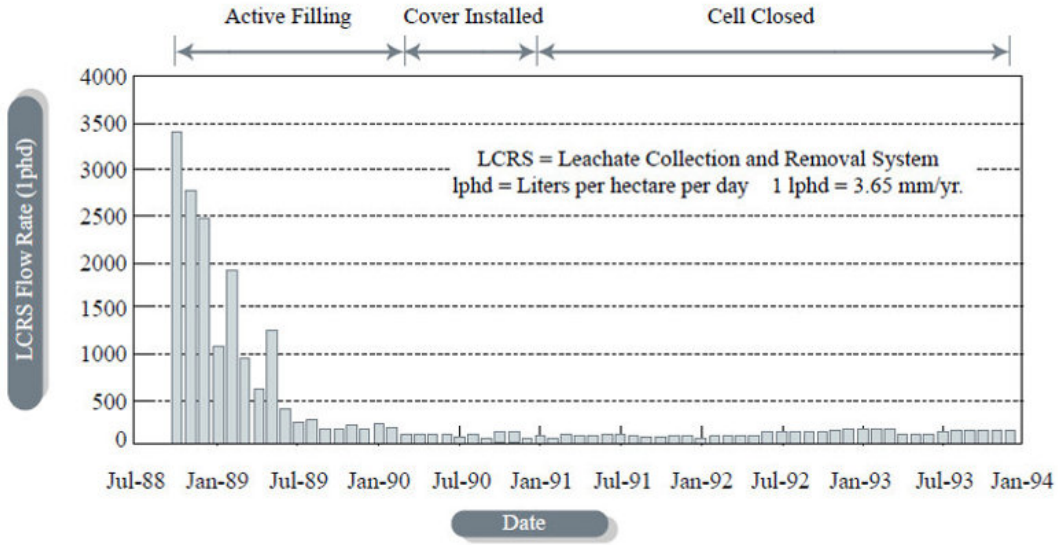
Once Stage 1 is complete, the potential infiltration of rainwater is expected to be totally lost by evapotranspiration (depending upon the lushness of the ground cover), retention in available pore space and absorption/vaporization. This does not include the allowance for irrigation of the completed and undeveloped stages to enhance vegetation cover, or the allowance for leachate losses in the saturated landfill gas emissions, which provides a further buffer against leachate migration.

However, if for some reason the recommended leachate reinjection and irrigation systems were not implemented, the average leachate production has been determined below. This essentially is a reversion to the old traditional system of simply collecting all leachate and treating it, rather than proactively managing leachate generation as recommended herein.

The design flow for the leachate system should be based on the net leachate flow rate, allowing for the porosity retention ability of the landfill to attenuate leachate flows during the annual production cycle. The net flow requiring management should therefore be based on the long-term average net leachate flow.

There are many theoretical design models for determining the quantity of leachate generated, but all require extensive data inputs which rely on numerous assumptions that may or may not happen in reality. Given the many factors affecting leachate generation rates mentioned above, and the correspondingly numerous methods of disposing of the untreated leachate, the only real determination of leachate flow rates possibly requiring treatment must be empirical.

Leachate collection and Removal Rates



Ref: Qian, X., R. M. Koerner, and D. H. Gray, "Geotechnical aspects of landfill design and construction. upper Saddle River, New Jersey": Prentice-Hall, 2002.

Well run landfills with appropriate stormwater diversion controls can achieve a leachate generation rate of 5-15% of annual rainfall. Conservatively this equates to say 10% of 1,306mm of annual rainfall over the final landfill area within the long-term period of this study (Stages 1 through 4) of approximately 16.0ha, or 20,000 m^3 per year, or say 57 m^3/d. This is approximately 0.66 litre per second.

One of the most comprehensive studies measuring actual leachate flows from landfills receiving similar annual rainfall amounts is "Qian, X., R. M. Koerner, and D. H. Gray. Geotechnical Aspects of Landfill Design and Construction. Upper Saddle River, New Jersey: Prentice-Hall, 2002." They measured long-term leachate formation rates of 200L/ha.d once final cover had been installed and over 2,000L/ha.d during initial landfill development. This later (maximum) rate equates to 32 m^3/d over the 16-ha final landfill.

Therefore 45 m^3/d (0.5L/s) has been adopted as the conservative design flow rate for the leachate management systems, but expect to only operate the management options such as reinjection and irrigation intermittently following protracted wet weather. Well operated landfills even in wetter climates do not need to operate the leachate pumping system for many months in the dry seasons.

In physical terms at the end of Stage 1, the landfill will consist of 348,000 m^3 of waste and soil. With a porosity of about 30 percent, it has the capacity to accept 104,000m^3 of liquid into the voids prior to leachate flowing. This pore capacity equates to approximately 6.5 years leachate flow at the estimated total site leachate flow rate of 45m^3/d. This ignores the capacity of the paper, cardboard and some other components to absorb leachate.
In terms of a theoretical water balance for Stage 1:

- Stage 1 surface area = 40,000 m^2
- Average annual rainfall = 1,306 mm

- Average annual evaporation = 1,540 mm
- Infiltration coefficient = 0.25
- **Infiltration** = 40,000m^2 x 1,306mm x 0.25 =>**13,000 m^3/year**

Evapotranspiration:

- 40,000m^2 x 1,540mm x 0.625 => 38,500m^3/yr. (for lush grass cover)
- 40,000m^2 x 1,540mm x 0.35 => 21,600m^3/yr. (for moderate grass)
- 40,000m^2 x 1,540mm x 0.15 => 8,200m^3/yr. (for no grass cover)

Therefore, the **annual net potential infiltration** is theoretically as follows:

- zero for sealed, grassed site (vigorous /lush grass cover)
- zero for sealed, grass site (moderate grass cover),
- **4,800 m^3/yr. for sealed, non-grassed site**, or 13 m^3/d (or 0.15 L/s).

It is critical that the external landfill batters are grassed as quickly as possible and then irrigated to maximise grass sward growth in the otherwise dry periods.
In summary, the void space in Stage 1 could retain over 6 years theoretical leachate generation from the total site. Provide that the final batters are grassed, there will not be any net leachate yield requiring additional management beyond reinjection and irrigation. If other areas within the landfill are irrigated, such as future development areas, then the likelihood of having excess leachate is even further reduced.

Leachate flow balance summary

The results of the of the above very conservative calculation for Battambang is typical of the results for the other two TS2 cities using local rainfall and the transpiration data.
Similar results have been derived in many other countries, whereby even during the critical first stage, there will be no need for leachate to be discharged provided that the external batters of previously completed areas are grassed as quickly as possible. This is a very essential component of satisfactory landfill operation in any case as the grass prevents erosion of the soil cover by wind and especially by water run-off.

Irrigation areas/EMMP controls

The introductory sections above note that the toxicity of modern day leachate is greatly reduced from that which resulted in serious concerns about the potential for health and environmental impacts. However, the waste still must be classified as a potentially hazardous liquid.

As a result, untreated leachate should only be irrigated on areas which are within the landfill site boundary which should be registered as a contaminated site and therefor would be unsuitable for growing crops for human consumption such as vegetables or rice.

The Environmental Monitoring and Management Plan would also specify irrigation protocols in terms of when leachate can be irrigated as opposed to having to be reinjected into the top of the landfill mound.
Typical irrigation constraints would be that less than 10 mm of leachate would be applied per day to any of the external batters, previously worked areas or future landfill cell sites. There would also be the obvious requirements that leachate should not be applied when the soil has a high moisture content which would encourage leachate run-off rather than infiltration with

subsequent evapotranspiration.
The landfill operator would also be required to take account of weather predictions and would obviously not irrigate when a large storm event was expected in the short term.
The types of soils that can be irrigated would also typically be specified. However, being a landfill, then there should not be large areas of highly permeable low organic soil such as sands, gravel or glacial tills. These soils would not be expected to be present both as the natural soil around the site prior to cell development nor used as final cover material on the external batters. Therefore, infiltration rates should only be moderate given the low permeability of the soil profile and also the very low head applied in terms of irrigant depth.
The EMMP would also specify controls relating to worker safety and health which is discussed in later subsections.

Contaminant movement

Organics

The above section notes that the cities within this study do not have extensive industrial precincts and therefore the likely generation of toxic organics such as biocides, solvents, paints and so forth would generally be only from individual users rather than bulk volume is associated with the manufacturing process.
Therefore, it is considered extremely unlikely that large volumes of these organic waste would enter the landfill at any one time thereby significantly contaminating the leachate flow. There will always be opportunities for illegal dumping of small quantities of organic liquid wastes associated the with partially full used containers which may pass unnoticed at the front gate screening.
However, based on the analytical results from many modern landfills, elevated levels of these organics would be most unlikely as they are either absorbed by the paper and cardboard within the waste mound or highly diluted during the slow process of percolation from the upper mound down to the leachate interception system at the landfill base.

Heavy metals

The mobility of selected heavy metals such as Cu, Pb, Zn, Cr, Fe and Mn depends not only on the permeability of the soil but also potential attachment sites such as those resulting from the soluble/exchangeable sites (cation exchange capacity), carbonates, Fe and Mn oxides, and organic matter fractions.

Typically, Copper and Pb are largely adsorbed by the organic and oxide fractions, while a significant amount of Zn is extracted by the carbonate fraction. The potential mobility and biological availability of the metals in many soils generally shows Zn is greater than Cr, Cu and Pb, which are all very similar in terms of movement through a soil profile.

As noted above, the local soils both in terms of the natural profiles and cover material used on the batters will typically not be gravels or sands, so these soils which contain silt and clay fractions will have a lower permeability thereby giving more time for the leachate as it moves through the soil to attach to one of the bonding mechanisms described above.

Furthermore, the landfill sites and external batters will not be saturated for protracted periods. The resulting unsaturated zones provide improved bonding potential from CEC and carbonates as well as from the iron and manganese oxides. These are the most common attachment methods for the key metals and therefore the local soil will provide significant attachment sites

for any heavy metals associated with the leachate migration.

Whilst not a key attachment mechanism, the presence of organics or humus always improves the retention of metal ions. As noted above, it will be essential to provide a growing medium (which is usually rich in humus) on the final batter slopes as well as any compost provided by the degradation of the grass sward over time. The organics and humus material will provide further attachment sites limiting the migration of the metal ions off-site.
The cation exchange capacity of the local soils, regardless of the other bonding mechanisms, will be elevated as both the local soils and cover material will have some clay components providing elevated CEC bonding sites. A lot of the soil in the region contains quantities of laterites which are extremely rich in iron. This provides not only attachment sites through the initial oxides but also the opportunity for the formation of very stable sesquioxides which essentially permanently lock the metal ions into a complex iron matrix preventing any future leaching and subsequent migration.

Based on all the above factors, it is expected that there will be high retention rates of the heavy metals potentially in the leachate. These will be retained by the various ionic bonding mechanisms to be followed by incorporation into a complex iron matrix sesquioxide which will prevent any liberation of metals in the future. These bonding mechanisms are somewhat contingent upon the soil remaining unsaturated which will be a requirement of the EMMP in terms of leachate irrigation and also general site location requirements whereby the groundwater table must be some metres below the base of the landfill.

The standard toxic characteristics leaching procedure (TCLP) undertaken on many contaminated soils generally indicates that zinc is the most mobile metal in these types of soils. Environmental and health risk assessments undertaken at some landfills have concluded that the site did not represent a risk, despite “Total” concentrations of some metals being up to 40 times the investigation threshold value stated in many international guidelines such as the Dutch B standards.

Monitoring results – East Timor dumpsite

A 10-ha uncontrolled dumpsite which has served Dili in East Timor for over a decade was investigated on another ADB project. Less than 10% of the entire waste mound has ever been covered, and the waste has not been profiled nor effectively compacted resulting in significant potential for leachate migration through the waste to the base of the site, which is unlined.

The soil type at the site was similar to those noticed in the current project area with the presence of laterites in some soils as well is the presence of highly leached soils in other areas. In general, the soil types from Dili in East Timor and the three sites under consideration in theTS2 project are somewhat similar.

A dozen test pits were excavated through the waste in Dili and into the soil underneath. Soil samples were taken at various steps and then analysed for a comprehensive range of parameters in a registered laboratory internationally.

The laboratory testing of the soils samples from below the waste layers indicated that the soil at the very base of and essentially touching the lowest waste layers had detectable amounts of hydrocarbons (oil) and phenols in a few isolated samples but no pesticides, PCBs or PAHs/MAHs. The heavy metals were generally above detection limits but mostly below the

guideline levels for using such a soil as clean fill.

None of the results exceeded the investigation threshold levels for Category B or C contaminated soils investigation protocols.
The results of samples collected one or more metres below the actual bottom of the waste layer in all areas of the site indicated that the soil here is uncontaminated. This ties in with the visual observations.

The soil of depth had increasing clay content so the lack of vertical migration of the metals and organics is as would be expected.

Contaminant movement summary

The combination of local soils types at the TS2 cities (not highly permeable, low CEC and organics sands and gravels), the need for landfills to be located well above the local groundwater level, the ongoing improved front end controls on waste acceptance procedures, the significant decrease in the toxicity of waste entering landfills and the implementation of appropriate environmental Management and Monitoring Programs would suggest that the likelihood of significant ground water pollution due to leachate migration is unlikely, even if leachate is irrigated without treatment.

Soils impacts

Irrigating high biological strength wastewater and soils can result in damage to the soil structure and soil chemistry. As a result, there has been significant investigations of irrigation of animal waste water, especially ponded piggery effluent, on a wide variety of soil types. The BOD of ponded piggery effluent is similar to that of a strong raw leachate.
These studies indicate that the application of 10mm / day of irrigant during dry periods does not result in anaerobic conditions developing in the upper soil layers, thereby potentially leading to higher rates of metals movement. Similarly these reasonably low effluent irrigation rates do not appear to damage the soil structure.

One issue that requires monitoring however is potentially elevated TDS in the leachate causing grass sward burn – in essence the leachate is too salty for good grass growth. There have been cases where the raw leachate has in fact had to be diluted with groundwater to reduce the TDS to a suitable level for healthy grass growth.

This potential sensitivity of some species, be it grass or small shrubs, to elevated levels of TDS or other contaminants, supports the landfill management approach of avoiding monocultures in the greening program. It is better to aim for wide mix of species including some which are specifically planted and some which occur naturally as the green area matures. Natural selection will favour the more tolerant species over time.

Because there are large areas at a landfill site that can be irrigated in addition to just the previously worked areas, the overall effluent application rate remains low which ensures that the majority of the water requirements of the grass and shrubs can be provided through normal rainfall events. These wet weather periods provide relief from the leachate organic load as well.

Soils impacts summary

The proposed very low application rates together with the suitability of the soil types indicates that soil structure will not be a concern. This is supported by detailed studies undertaken with similar high organic strength waste have been irrigated at much higher rates over protracted

periods from animal husbandry activities.

Health Risks

A range of interventions would be implemented to protect worker and public safety and generally minimise health risks.

For example, the general public would not be allowed onto parts of the landfill where leachate was or had been recently irrigated.

The irrigation system would consist of a HDPE or similar pipe with 5 to 10 mm holes drilled along one face at say 500 mm spacings. Effluent would be pumped into this pipe which would be laid along the contour of a previously worked and grassed area, and the leachate would merely trickle down the face of the external batter. The pressure would not be sufficient to form mist or airborne droplets which may drift away from the immediate irrigation area.

All workers would be provided with training on the safe operation of such a system and would obviously be provided with the requisite PPE such as gloves and masks, as well as waterproof footwear.

There have been a number of studies on the concentration of pathogens within raw leachate. A major study in France indicated that the faecal coliforms levels are typically 1 X 10^4 plaque forming units per hundred millilitres. Other pathogens such as helminths, protozoa and moulds were not detected.

By comparison raw sewage has a faecal coliform count commonly in the order of 1 X $10^{6 \text{ to } 7}$ plaque forming units per hundred millilitres. Sewage which has been secondary treated but not specifically disinfected would have a faecal coliform level similar to that of raw leachate.

It should also be noted that faecal coliforms can be produced by any warm-blooded animal. Therefore, the health risks associated with indicator organisms such as faecal coliforms in sewage are far higher than those in a leachate flow where significant fractions of the indicator organism may well come from vermin. Vermin-sourced indicators result in a much lower health risk than similar indicator numbers from raw sewage.

Health risks summary

Appropriate engineering design of the irrigation scheme will minimise the generation of small droplets or mists avoiding any off-site dispersion of leachate from the irrigation process.
Operators will be trained in the correct manner of operating the scheme to minimise contact with the leachate, and have appropriate PPE.
The health risks associated with leachate remains significant but are far smaller (in terms of orders of magnitude) to exposure to raw sewage by wastewater treatment plant operators and sewer maintenance gangs.

Legality aspects of leachate irrigation

The local environmental legislation is silent on these specifics. The requirements are generally generic in terms of do no environmental or health harm.
Irrigation of untreated leachate is common throughout both the developed and developing world

provided that it is operated under a suitable operations regime and also in accordance with the requisite Environmental Management and Monitoring Plans.