Initial Environmental Examination

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Pakistan: Developing Resilient Environments and Advancing Municipal Services in Punjab Project

Integrated Solid Waste Management System, Bahawalpur

Prepared by Project Management Unit of PRF PUDP, Government of Punjab, Pakistan for the Asian Development Bank (ADB).

ADB

Punjab Urban Development Projects (PUDP) DREAMS-I, Bahawalpur

Initial Environmental Examination (IEE)

Project:	**Integrated Solid Waste Management System (ISWMS), Bahawalpur (DREAMS-I)**
Client:	**Local Government & Community Development Department (LG&CDD) through the Program Management Unit (PMU)**
Consultant:	**Engineering Design and Construction Management (EDCM)**
Prepared By	**PMU - PUDP for the Asian Development Bank (ADB)**

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Table of Contents

List of Figures

List of Tables

List of Appendices

Abbreviations

ADB	Asian Development Bank
ADC	Alternate Daily Cover
AD	Anaerobic Digestion
AIP	Access to Information Policy
AMSL	Above Mean Sea Level
BDA	Bahawalpur Development Authority
BC	Before Construction
BOQ	Bill of Quantities
BWMC	Bahawalpur Waste Management Company
CIU	City Implementation Unit
CORDEX	Coordinated Regional Downscaling Experiment
CSC	Construction Supervision Consultant
DBO	Design Build Operate
DC	During Construction
DO	During Operation
EA	Executing Agency
EDCM	Engineering Design Construction Management
EGL	Existing Ground Level
EHS	Environmental, Health, and Safety
EIA	Environment Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
GFI	Ground Fault Interrupter
GoP	Government of Pakistan
GRM	Grievance Redress Mechanism
HDPE	High Density Polyethylene
IA	Implementing Agency
IBAT	Integrated Biodiversity Assessment Tool
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
ISWMS	Integrated Solid Waste Management System
LAA	Land Acquisition Act (of 1984)
LARP	Land Acquisition and Resettlement Plan
Leq	Equivalent continuous sound pressure level
LG&CDD	Local Government and Community Development Department
LHW	Lady Health Worker
LULC	Land use/Land cover

MBT	Mechanical & Biological treatment
MGD	Million Gallons per Day
MRF	Material Recycling Facility
MSF	Material Sorting Facility
MSWLF	Municipal Solid Waste Landfill
NCS	National Conservation Strategy
NEP	National Environmental Policy
NEQS	National Environmental Quality Standards
OHS	Occupational Health and Safety
O&M	Operation & Maintenance
PAP	Project Affected Persons
PC	Public consultation
PCC	Plain Cement Concrete
PICIIP	Punjab Intermediate Cities Improvement Investment Programme
PCOs	Public Call Offices
PDD	Planning & Development Department
PEPAct	Pakistan Environment Protection Act 1997
PEPC	Pakistan Environmental Protection Council
PEQS	Punjab Environmental Quality Standards
PGA	Peak Ground Acceleration
PMU	Project Management Unit
PPE	Personal Protective Equipment
PEPD	Punjab Environmental Protection Department
RCC	Reinforced Cement Concrete
RDF	Refuse Derived Fuel
REA	Rapid Environmental Assessment
RFP	Request for Proposal
RO	Reverse Osmosis
RP	Resettlement Plan
SOPs	Standard Operating Procedures
SS	Suspended Solids
SPS	Safeguard Policy Statement
SSEMP	Site Specific Environmental Management Plan
SWM	Solid Waste Management
TS	Transfer Station
TPD	Tonnes per day
TMA	Tehsil Municipal Administration
TMP	Traffic Management Plan
UC	Union Council

USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CURRENCY EQUIVALENTS

As of 5th September, 2023	Currency Unit – Pak Rupees (Pak Rs.)
Pak Rs 1.00 = $ 0.0033	US$1.00 = Pak Rs. 305

CONVERSIONS

1 meter = 3.28 feet

1 hectare = 2.47 acre

1 kanal = 0.125 acre

Definition of Terms

“Carbon Monoxide” (also CO): A colourless, odourless, poisonous gas produced by incomplete fossil fuel combustion.

“Carbon Dioxide” (also CO_2): A colourless, odourless, incombustible gas, CO2, formed during respiration, combustion, and organic decomposition and used in food refrigeration, carbonated beverages, inert atmospheres, fire extinguishers, and aerosols. Also called carbonic acid gas.

“Ground Water”: The supply of fresh water found beneath the Earth’s surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants or leaking underground storage tanks.

“Laws”: means state and local laws and all regulations, rules, orders, decrees, decisions, instructions, requirements, policies and guidance which are issued or made by any Relevant Authority and which are legally binding, as any of them may be amended from time to time.

‘’Leachate’’ Contaminated water that seeps out of landfills. Often contains high amounts of organic matter and toxic chemicals.

‘’Liner system’’ The technical term for the layers of materials (such as clay and geo synthetics) that protect landfills from erosion, and keep trash and leachate from escaping from landfills.

“**Methane”** (also CH_4): A colourless, non-poisonous, flammable gas created by anaerobic decomposition of organic compounds. A major component of natural gas used in the home.

“Municipal Solid Waste” (MSW) is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area. The term residual waste relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing.

“**Operator”** means the SLF operator employed or contracted by the EA to operate, maintain and manage the facility.

“Particulates” (also PM_{10}): 1. Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. 2. Very small solids suspended in water; they can vary in size, shape, density and electrical charge and can be gathered together by coagulation and flocculation.

“Personal Protective Equipment” (also PPE): Clothing and equipment worn by pesticide mixers, loaders and applicators and re-entry workers, hazmat emergency responders, which is worn to reduce their exposure to potentially hazardous chemicals and other pollutants.

“Peak Ground Acceleration” (PGA) is a measure of earthquake acceleration on the ground and an important input parameter for earthquake engineering.

“Recyclables” Any materials that will be used or reused, or prepared for use or reuse, as an ingredient in an industrial process to make a product, or as an effective substitute for a commercial product. This includes, but is not limited to, paper, glass, plastic and metal.

“Recycling” means the process by which recovered materials are transformed into new products or feedstock for new products.

“Residual Waste” means all municipal solid wastes that are not processed and/or recycled.

“Risk Assessment”: Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants.

"Solid Waste Management" means any activity involving the handling, treatment and disposal of Solid Waste. Also means any supervised handling of waste materials from their source through recovery processes to final disposal.

"Integrated Solid Waste Management System" The entire process of storage, collection, transportation, processing, and disposal of solid wastes by any entity engaging in such process as a business, or by any state agency, city, authority, county or any combination thereof.

"Sulfur Dioxide" (also SO_2): A pungent, colourless, gas formed primarily by the combustion of fossil fuels; becomes a pollutant when present in large amounts.

"Transfer Station" means the facility where solid wastes are temporarily stored and consolidated before being transported elsewhere for further treatment or disposal.

"Waste" means any movable articles or material for which their owner wishes to relinquish responsibility by Disposal or which must be removed from their holding place as waste to safeguard the common welfare and to protect the environment.

EXECUTIVE SUMMARY

Project Overview

1. This IEE covers the project development of improved municipal waste infrastructure in the intermediate city of Bahawalpur located in Pakistan. The project comprises of three component phases which will run concurrently.

2. The project is part of the Developing Resilient Environments and Advancing Municipal Services (DREAMS) multi-year Punjab Intermediate Cities Improvement Investment Programme (PICIIP) project portfolio. The DREAMS projects will build upon the achievements and lessons learned from previous urban sector projects supported by the ADB and other partners in Pakistan, including PICIIP, with the intention of improving urban services in cities of Punjab province.

   - **Component 1** will include the construction of a new engineered landfill along with construction of a new Composting Plant and Construction and Demolition Recycling Plant. The new landfill will have associated gas and leachate recovery infrastructure in place. A major portion of the solid waste generated in Bahawalpur will be diverted into the composting plant which is anticipated to prolong the lifespan of the engineered landfill.

   - **Component 2** will involve closing and rehabilitating the legacy landfill located at Kahnu Wali and the construction of a Material Recycling Facility (MRF) and Transfer Station (TS) on adjacent land to the north. The existing transfer station will be closed as part of Component 2. Component 2 will also include the development of an Anaerobic Digestion (AD) Plant and Plastics Recycling. The plant will be powered by solar energy. Investigations will also be undertaken to assess whether the legacy landfill is generating enough gas to facilitate a landfill gas – to - energy plant.

   - **Component 3** will comprise the establishment of primary and secondary municipal solid waste collection systems in the city and re-education of residents on sustainable waste management.

Project Need

3. Solid waste disposal is one of the basic indicators of environmental health. There is a deep relation between the improper disposal of solid waste and the incidence of vector-borne diseases.

4. Due to the open dumping of waste in the cities, the leachate and odour of waste is disturbing the people and polluting the environment. The Bahawalpur Waste Management Company (BWMC) aims to counter these practices, but the existing SWM system and BWMC is not fully equipped with modern technologies, essential equipment, a landfill or the required manpower.

5. DREAMS will equip the cities of Bahawalpur and Dera Ghazi Khan (SWM pilot cities) with: (i) collection equipment, parking, transfer, and sorting facilities; (ii) establishment of segregation and composting centres, with a minimum 10% of women workers; and (iii) construction of sanitary landfills and biogas recovery to reduce greenhouse gas emissions.

6. The legacy Khanu Wali landfill is characterised as an area where garbage is simply transported, unloaded and at times levelled by a bulldozer. The site operates without protection against soil and groundwater contamination. There is no liner system, leachate collection system and/or landfill gas recovery system. The legacy landfill is

in the middle of the agriculture zone and the leachate is contaminating both the groundwater and surface water in the area. Notably, the Sutlej River is located approximately 200m west of the legacy landfill.

7. The harmful air emissions are impacting the health of residents around the legacy landfill. The volume of waste presently dumped at the existing dump site is not accurately known at present, however based on satellite measurement, the main dumpsite covers an area of 214m x 235m x 5m depth. Estimating waste volume to be c.251,450m^3 once filled to ground level. The dumpsite is in the middle of an active farming area. According to the feasibility study of the site, the contamination situation will worsen from continued migration of leachate and this contamination will continue whilst the landfill is actively generating landfill gas and leachate. The estimated lifetime of a landfill is between 25-50 years depending on the wastes deposited. A key part of this project will be improvements to the current management of the site and closure and rehabilitation of the legacy landfill area once the new landfill is operational. This will significantly improve its long-term impact on the surrounding environment compared to taking a *passive do-nothing* approach.

Component 1 – Construction of a New Landfill.

8. The proposed landfill will be designed as an integrated facility and will comprise of 4 cells 150m x 200m, which will be developed sequentially. In year 2024, cell one will be developed and will be ready to receive waste by January 2025. The landfill will be integrated with a gas recovery system, gas flaring and conversion of methane component into CNG. The closure and post closure utilisation of site conceptual design will be included which may have to be modified as closure of cells progresses over the years. The engineered landfill site will consist of landfill cells to be developed over 44 acres of land over a total site area of 110 acres.

9. Projected total waste generation of Bahawalpur will be 524 tons per day (tpd) in 2028, which is considered for design of ISWMS in the project feasibility. Out of 524 tpd waste generation, scavengers will directly collect 20 tpd from the source, while the remaining waste of 504 tpd shall be collected by the BWMC. The BWMC will collect, process and dispose of 85% of remaining waste which will be comprised of source segregated 85 tpd domestic and commercial waste and mixed waste of 343 tpd through the proposed ISWMS.

10. An extensive environmental awareness and community interface programme will be designed and implemented as part of ISWMS of Bahawalpur. The public awareness program will start from primary schools and spread over the school system up to high schools. The environmental awareness program for higher education i.e. universities, will be custom designed for all students and faculty members. The special programmes will be developed for students undertaking environmental and engineering studies. Besides internal BWMC environmental awareness organisation, the education department and local government-designated representatives will become part of permanent environmental awareness organization for the city.

Baseline Conditions Component 1

11. **Physical Environment:** The project area has irregular topography. The sand dunes are deposited all over the project area, which comprises of mostly flat terrain with scattered vegetation consisting of bushes, grasses and some trees. In general, no fill material is present at the top. Silty Sand dominates up to 3-5 m depth and afterwards, Lean Clay and Sandy Strata is observed. The probabilistic seismic hazard assessment shows that the project area falls in Zone-2A with peak horizontal ground acceleration of 0.08g-0.16g i.e. negligible damage. As far as the project area is

concerned, there are no water bodies lying in proximity of the project. Ground water is found at depth of about 15-20 feet. As part of IEE baseline, a ground water sample were collected. The sample was collected from Basti Chachran (near the proposed landfill site) collected and analysed from at an EPA-certified lab.

12. Ambient noise levels being within the most stringent guidelines during the daytime, however, exceedances were observed at the night-time at two locations (Basti Chachran and Existing dumpsite).

13. Air quality monitoring was conducted for 24 hours at six locations near the project site. Results showed that all ambient air quality parameters of PM10, PM2.5, CO, NO, NO2, SO2 were compliant with the PEQS. However, exceedance was observed from stringent WHO guidelines at most of the monitored locations. The PM2.5 values have exceeded WHO guidelines at Basti Kareem Baksh, PM10 and NO and SO values exceeded stringent guidelines in all monitored locations.

14. **Biological Environment:** The proposed landfill falls outside environmental sensitive areas (Wildlife Park, Wildlife sanctuary, Game Reserve or Protected/Reserved Forests) and critical habitats. Floral species belonging to 18 families including 63 plant species from project site and adjacent areas were reported (Sadia et al, 2021, Ahmad et al, 2012). Similarly, faunal species were also observed during the survey. Among them, 16 tree species, 09 shrubs, 20 herbs and 18 grass species were found. Also, 17 bird species, 11 mammal species, 5 reptiles, 2 amphibians, 4 fish and 3 grazing mammal species were observed.

15. Species of special concern found in the vicinity of the project area were Hog Deer (Endangered) and Houbara Bustard (Vulnerable). These species do not exist near the landfill site as the location does not provide a habitat for such species due to urbanisation. An IBAT proximity report shows that there are no key biodiversity areas or protected areas falling within a 5 km radius of the site. The No Objection Certificate (NOC) from the Punjab wildlife department has been obtained for the project. Consultation with the Punjab wildlife department has been carried out and NOC for the project execution has been obtained and attached as **Appendix A.18.**

Analysis of Alternatives - Component 1

16. Three different sites for the development of landfill were as follows:

- **Yazman** - located at Marot Yazman Road Bahawalpur next to the Malot Machinery Store.
- **Khanu Wali** –The site is located at 0.5 km from the Sutlej River and the nearest human settlement is located within 350-400 metres radius from the project site. The proposed site area is adequate for 25 years of useable life.
- **Mari Sheikh Shijra Mouza Nouabad** - located near Basti Yar Muhammad, Bahawalpur. Total area of the site is 110 acres. The proposed site is mostly surrounded by agricultural fields and located at a safe distance from the nearby human settlements.

17. Yazman site was rejected because of some technical points related to the nearby locations of Bahawalpur airport in terms of a high chance of birds strikes with flying aircrafts. The site area of 56 acres is not adequate for the waste treatment for 25 years and more land acquisition will be required which will create a financial burden to the project. Another factor to not select this site was the much farther location, being more than three times the distance of the alternative site, which would entail a much higher logistical expense in terms of fuel costs and vehicular maintenance.

18. The site at Khanu Wali was immediately eliminated, primarily due to its proximity to the city. The location lies very much within the urban built-up area. One option which this site provides is the setting up of a Transfer Station (TS), a point of convergence for waste originating from various parts of the city, possibly coupled with a Material Recycling Facility (MRF) and/or a composting facility. Establishing facilities in such proximity to the city will separate the waste not meant to be disposed in the landfill, thereby making more efficient use of the heavy equipment, compactors and large arm-roll trucks, which will travel to the landfill site.

19. The site at Mari Sheikh Shijra Mouza Nouabad fulfilled most of the criteria required for landfill site selection. It is far enough away from the city, the population is sparse and although there are a few sensitive receptors, proper environmental assessments are being carried and resettlement plans are being prepared to minimise both environmental and socioeconomic impacts. Most of the surrounding area is barren and agricultural. Given the locations of other alternative sites, all were either agricultural or semi-urban areas, which places this site as the most ideal in comparison to the other sites.

20. No additional land acquisition is required as land area of 110 acres is already owned by Bahawalpur waste management company (BWMC) and cell locations meet the buffer zone requirements, which ensures that potential effects of the landfilling operation may not cause any unacceptable impacts outside the site. The social acceptability of the project is enhanced by educating the nearby population on the merits of a sanitary landfill. There is no private land acquisition involved in the project.

21. Different types of landfills were also considered as part of IEE process such as sanitary landfill, bioreactor landfill and secured landfill. Based on the comparison conducted, the project design consultant suggested to construct a sanitary landfill for Bahawalpur in order to maximise and control the landfill gas extraction and harvesting of the methane component together with converting the methane gas into CNG for beneficial utilisation.

22. Different landfill construction alternatives were also considered such as Lining, Leachate collection and treatment and Gas collection and treatment with flaring proposed for landfill gas management. After a few years of landfill operation, gas recovery will be carried out and methane gas will be converted into CNG for further dispensing.

23. Other types of alternatives that were considered were technological alternatives for Anaerobic Digestion (AD) Plant, technological alternatives for MRF, waste disposal alternatives along with a comparison of possible treatment options as well as an economic aspect analysis of the different types of landfilling technologies.

Component 2 Rehabilitation of the Legacy Landfill and construction of MRF.

24. The existing (legacy) landfill site located at Khanuwali will undergo rehabilitation and restoration and will be monitored for potential landfill gas emission and groundwater contamination. The MRF and associated facilities will be developed over approximately 4.5 acres of land of the available 10 acres of vacant land located adjacent to the existing legacy landfill. Hence, there is a low risk of potential interference between the closing of the legacy landfill and construction and operation of the MRF.

25. The operation phase impacts of Component 1 have been identified to be site-specific, largely reversible and for which mitigation measures can be designed more readily than for category A projects. An IEE with an EMP is required for projects classified as

environment Category ‘B’. This IEE report contains an EMP for all phases of the project.

Baseline Conditions - Component 2

26. **Physical Environment:** The topography of the legacy site is flat due to its location on the flood plain of the Sutlej River with a gentle slope towards the north and east of the legacy project site. The major land use of the project area being barren land followed by cropping of agricultural areas.

27. As part of IEE baseline, a ground water sample was collected and analysed from at an EPA-certified lab. The results of the tests are attached as **Appendix A.4**, which indicates that all parameters of the ground water samples taken are within the applicable limits. Surface water is at risk of flood impacts due to its close location to the Sutlej River, surrounding canals and soil type.

28. Ambient noise levels were within the most stringent guidelines during the daytime; however, exceedances were observed at night-time at the legacy landfill.

29. Air quality monitoring was conducted for 24 hours at the legacy landfill and all parameters were compliant with the stringent standards.

30. Two soil samples were collected, at the surface level and 3 feet below with analysis taking place at an EPA certified Integrated Environmental Lab.

31. **Biological Environment**: The legacy landfill falls outside environmentally sensitive areas and inhibits little wildlife outside of rodents and insects.

Analysis of Alternatives - Component 2

32. No alternatives other than closure were analysed for Component 2. Further investigation and evaluation work will be undertaken to optimise the closure plans.

Component 3 – Provision of Waste Collection Systems.

33. Component 3 includes the provision of improved waste collection systems, vehicles and resources and education of residents on the benefits and need for improved waste management.

Baseline Conditions - Component 3

34. Physical and biological baselines were not conducted for Component 3 as it is not anticipated to create significant repercussions on the surrounding natural environment and therefore, ecology. Improved waste collection systems are considered to have a signficant social benefit to the area.

Analysis of Alternatives - Component 3

35. The current waste disposal system is based on un-controlled dumpsites. These dumpsites are often characterised by an area where garbage is simply transported, unloaded and at times levelled by a bulldozer. Nearly all these sites operate without protection against soil and groundwater contamination.

36. The situation is further exacerbated by operators’ ineffective attempts to control pungent smoke, objectionable odour and vermin. Sorting is only achieved through scavenging which is undertaken with no health and safety controls. Such dumpsites are inexpensive to operate, but pose significant risks to the environment and the health of the surrounding population. These dumpsites are also difficult to rehabilitate

after they have been filled and abandoned. Failure to implement the project or a "No-Action alternative" will result in the allocation of land only for further uncontrolled tipping continuing and exacerbating the existing situation.

37. In this context, alternatives will include in the establishment of a Sanitary Landfill at an alternative site or the project not achieving its objectives. However, such alternatives will not negate the disadvantages of allocating land for disposal purposes only under the current practice of dumping.

38. On the other hand, if all components of the project are implemented, it will result in an improved SWM system and improved urban environment quality. Furthermore, project implementation will also create job opportunities during construction, thereby improving the socioeconomic conditions of the local people and help in improving their quality of life. Thus, the 'no project' option is not a viable option.

General Project Area (Components 1,2 & 3)

39. **Social Environment:** The study area falls in Bahawalpur city and Saddar tehsil. According to DCR Bahawalpur 2017, it has a population of 1,256,646 persons of which 681,696 population is of City tehsil while 574,950 population is from Saddar tehsil. The project area is primarily rural suburbs. The names of the major settlements falling in the project area are the villages of Mari Sheikh Shujra, Sangal Wali Pull, Khanu wala, Noabad and Dera Ramazan and stadium road. The average family size in the project area is five persons. No archaeological and cultural site was observed in close proximity of Bahawalpur landfill site or the existing dumpsite at Khanuwali (legacy landfill). The population of the district is predominantly Muslims i.e. 98.1 percent. The next higher percentage is of Hindu with 0.9 points followed by Christian 0.6 percent. While other minorities like Ahmadis, Schedule Castes etc. are very small in number. The main castes and groups of the Bahawalpur district are Arain, Jatt, Rajput, Pathan, Gujjar, Baloch, Qureshi and Syed. These casts have been further sub-divided in various sub- caste and sub-tribes. Major occupations in the project area are small businesses, shop keeping, government service, farming and manual labour. It was noted that facilities such as electricity, gas, water supply, telephone, sewerage drainage and schools are available in the settlement or in its vicinity.

Categorization of Project

40. The Rapid Environmental Assessment (REA) Checklist for the project categorisation from an environmental safeguards perspective for the proposed ISWMS has been prepared and its findings conclude that the proposed project falls under Category 'B' project as per ADB SPS, 2009.

41. The Project is therefore categorised as 'B' for environmental safeguards as the area for the new landfill site is located in a barren land with no nearby sensitive receptors within 500 meters. It complies with the IFC guidelines for site selection[1].

Study Methodology

42. Both secondary and primary data analysis on ambient noise levels and air quality, water resources, soil contamination, flora, fauna, existing facilities and information from the detailed design conducted for this and other projects of similar nature were collected, reviewed and analysed. Extensive field visits to the project area were

[1] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ifc.org/content/dam/ifc/doc/2000/2007-waste-management-facilities-ehs-guidelines-en.pdf

undertaken and key receptors and stakeholders within the project area were identified and consulted.

43. Further technical studies are required to determine the conceptual site model of the legacy landfill and determine the most suitable site closure method. These have been included in the EMP for the project and will be undertaken during the design phase.

44. The significance of impacts from the proposed project have been assessed and for those impacts requiring mitigation, suitable measures have been proposed to reduce impacts to within acceptable limits as per local and international applicable regulations. A detailed environmental management and monitoring plan has been developed and is included in this IEE to ensure compliance to the proposed measures during the project development.

45. Integrated Biodiversity Assessment Tool (IBAT) proximity analysis has been carried out in order to mark any protected areas, key biodiversity areas and habitats of key species in close proximity of the landfill site.

46. Potential leachate leakage impacts on ground water quality have been assessed and the findings have been presented and discussed. Also, air pollutant dispersion modelling has been carried out using Lakes Environmental Software, AERMOD and the results have been used for impact assessment of gas flaring.

Public Consultation Process

47. Three rounds of comprehensive stakeholders' consultations were organised with a total of over 160 different stakeholders. The first round of public consultations was conducted in the first week of November, 2022 while the second round of public consultation was completed in December, 2022 and the third round in October 2023. Information on positive and negative impacts associated with its construction and operational stage and proper mitigation of adverse impacts were shared at these consultations. A further Public Hearing was held in October 2023

Potential Major Impacts

48. The screening matrices for the pre-construction, construction and operation phases of the ISWMS are provided below as **Tables ES.1, ES.2** and **ES.3**.

Mitigation Measures

49. Mitigation measures associated with pre-construction, design, operation, closure and post closure phases are detailed in the IEE report. Necessary design considerations have been included for leachate collection and treatment, landfill gas management, odour and vector controls. Mitigation measures associated with the construction phase are detailed in the IEE report to avoid soil and ground/surface water contamination, OHS issues, social conflicts, vegetation loss and communicable diseases.

50. Mitigation measures for the operation phase are provided to ensure that leachate and landfill gas is managed properly; there would be no waste hauling impacts, traffic issues, wind-blown litter, vector spread and air quality problems. Daily cover will be applied to avoid odour and litter issues. Buffer zones through necessary plantation will be developed to improve aesthetic appeal of the area. Also, the proposed project will result in improved waste management services, improved public health and improved aesthetic appeal of the area.

Climate Change Sensitivity of Landfill Site

51. Bahawalpur lies at an elevation of 117m above mean sea level. The climate here is dry. During the year, there is virtually no rainfall in Bahawalpur. According to Köppen and Geiger, the project area falls in Zone 'B', which represents hot arid deserts and is classified as BWh. The city witnesses some of the extreme temperatures in the country. The summer season starts from the month of April and continues till October, while the weather is pleasant and cold from November to February. Dust storms are also common in the area.

52. Due to less than average annual rainfall (143 mm) the city features an arid climate with sweltering summers and cold winters. The wettest year observed was 2021, with an annual total rainfall of 166.2 mm. Minimum annual rainfall was 119 mm recorded in 2017.

53. Based on the past decade's data, the month with the maximum precipitation on average was July with 27.67 mm of precipitation. The month with the least precipitation on average was October with an average of 2.33 mm.

54. The average temperature for the past decade in Bahawalpur is 89.6°F (32°C). The warmest month, on average, was July with mean temperature of 104.36°F (40.2°C). The coolest month on average was January with a mean temperature of 66.56°F (19.2°C).

55. The wind experienced at any location is highly dependent on local topography and other factors and instantaneous wind speed and direction vary more widely than hourly averages. Wind speed usually blows from the north to south after the wind has arrived strongly and steadily from those quarters for a day or more. In the fall season, the rain clouds come mostly from west due to western depression/ disturbance.

56. Based on the past decade data, the maximum average wind speed of 16.70 kmph has been recorded in the month of July while average minimum wind speed of 7.71 kmph was observed in November.

57. The likelihood of climate change-related hazards including floods, flash rains and temperature variations are included in sensitivity assessment that could negatively affect the functioning of the landfill site including direct impacts (accessibility, physical damage, water damage) and indirect impacts (accidental fire, explosion or ecosystem damage). These direct and indirect impacts can affect the landfill site in terms of damage to liner or cover materials, washout of contaminated contents, leachate collection and removal, landfill gas management etc.

Cumulative Impacts

58. No other infrastructure works are planned to be conducted in the landfill project area while these project works shall be conducted till 2025. Thus, no cumulative impacts are expected.

Indirect and Induced Impacts

59. The potential effects of every stage of the proposed Bahawalpur SWM facility have been identified and evaluated using field data, secondary data, expert opinion, and research into earlier, comparable projects in Pakistan. These include effects on physical, biological and socio-economic environment. Impacts on the environment from air emissions, traffic and community noise have also been assessed and have found to be acceptable and within the carrying capacities of the environmental media.

60. Thus, negative indirect and induced impacts from the proposed ISWMS works are not expected.

Institutional Arrangements for EMP Implementation

61. During the construction phase, the overall responsibility for the implementation and monitoring of the EMP rests with the Project Director (PD), Project Management Unit (PMU) and Punjab Intermediate Cities Investment Program (PICIIP). The PD, through assistance from the Supervision Consultant's Environmental staff and the Environment team of PMU, will supervise the implementation of the proposed mitigation measures and monitor the implementation progress in the field. Monthly environmental monitoring data/reports will be incorporated in the project implementation progress reports to be shared with ADB and such monthly reports will be consolidated into bi-annual monitoring reports and submitted to ADB for review and clearance. Upon clearance, all such reports will be uploaded on the PMU and ADB websites.

Conclusion & Recommendations

62. An action plan with clear roles and responsibilities of stakeholders has been provided in the report. The PMU, Contractors and the Construction Supervision Consultant are the major stakeholders responsible for the action plan. The action plan must be implemented prior to commencement of construction work.

63. Mitigation measures will be assured by a program of environmental monitoring conducted during construction and operation to ensure that all measures in the EMP are implemented and to determine whether the environment is protected as intended. This will include observations on and off-site, document checks, and interviews with workers and beneficiaries, and any requirements for remedial action will be reported.

64. The majority of the environmental impacts are associated with the operation phase of the project and closure of the legacy landfill. Since these will be long term, such as generation of objectionable odors and impacts on air quality, attraction of vermin and disease vector generation, Leachate generation, possible contamination of soil and groundwater and generation of Landfill Gas. These will be mitigated through necessary measures provided in EMP.

65. The potential adverse impacts that are associated with design, construction, and operation can be mitigated to standard levels without difficulty through proper engineering design and the incorporation or application of recommended mitigation measures and procedures. It is concluded that the proposed project should proceed, with appropriate mitigation measures and monitoring programs identified in the IEE study.

66. The Punjab EPA has issued NOC for the same site back in 2018 which is attached as **Appendix A.14** which shows that project can be established at proposed site and EPA has already carried out site assessment and accorded approval following legal requirements. PMU PICIIP will maintain close coordination with Punjab EPA on the status of already issued NOC and upon direction of EPA will file application for its renewal or submit updated EIA along with review fee to obtain new NOC.

Tables of possible impacts through the Project phases

Table ES.1: Screening of possible Impacts during Design/Pre-Construction phase

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual (Significant, Medium, Low)
1	1	Landfill Site Selection	Likely	Moderate	Medium	Low
All	2	Lack of integration of IEE/EMP requirements in construction bid documents	Likely	Moderate	Medium	Low
All	3	EMP Implementation	x	x	x	x
1	3	Land acquisition and resettlement impacts	Likely	Moderate	Medium	Low
All	4	Impacts due to natural hazards	Likely	Moderate	Medium	Low
1&2	5	Site Characterisation and Baseline monitoring	Likely	Moderate	Medium	Low
1&2 (Legacy Landfill	6	Site Closure Planning	Likely	Major	Significant	Low

Critical Risk Level

Significant Risk Level

Medium Risk Level

Low Risk Level

Table ES.2: Screening of Possible Impacts during Construction Phase

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Significant, Medium, Low)
All	1	Water Contamination	Likely	Major	Medium	Low
All	2	Air Quality Degradation	Likely	Moderate	Medium	Low
1,2	3	Loss of Vegetation	Likely	Moderate	Medium	Low
1,2	4	Damage to Wildlife	Likely	Moderate	Medium	Low
All	5	Occupational and Community Health and Safety Hazard	Likely	Moderate	Medium	Low
1,2	6	Noise and Vibration	Likely	Moderate	Medium	Low

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Significant, Medium, Low)
All	7	Hazardous and Non-Hazardous Waste Disposal	Likely	Moderate	Medium	Low
1,2	8	Waste Effluent Disposal	Likely	Moderate	Medium	Low
1,2	9	Soil Erosion and Sedimentation	Likely	Moderate	Medium	Low
1,2,3	10	Soil Contamination	Likely	Moderate	Medium	Low
All	11	Employment Conflicts	Likely	Moderate	Medium	Low
All	12	Communicable diseases	Likely	Moderate	Medium	Low
All	13	Historical/Archaeological Sites	Unlikely	Moderate	Low	No Residual Impact
	14	Impacts associated with Construction of Administration and BWMC office Buildings and Other Infrastructure	Likely	Moderate	Medium	Low
1,2	15	Impacts associated with Construction/Widening of Access Road	Likely	Moderate	Medium	Low
2	16	Impacts associated with specific restoration of legacy landfill.	Certain	Major	Signficant	Low

Critical Risk Level

Significant Risk Level

Medium Risk Level

Low Risk Level

Table ES.3: Screening of Possible Impacts during Operation Phase

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact
1 & 2	1	Leachate Generation	Likely	Major	Significant	Low
1&2	2	Soil and Groundwater Contamination	Likely	Major	Significant	Low
1&2	3	Landfill Gas Generation	Likely	Major	Significant	Low
1	4	Air Strikes	Likely	Major	Significant	Low
1&2	4	Air Quality Deterioration	Likely	Major	Medium	Low
1&2	5	Disease Vector Generation and Vermin Attraction	Likely	Major	Medium	Low
All	6	Occupational Health and Safety	Likely	Major	Medium	Low
3	7	Waste Collection and Hauling Impacts	Likely	Major	Medium	Low
All	8	Wind Blown Litter	Likely	Major	Medium	Low
All	9	Solid waste & health and sanitation	Positive impacts expected			Medium positive

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact
						residual impact
All	10	Public Health	Positive impacts expected			Medium positive residual impact
All	11	Aesthetic aspects	Positive impacts expected			Medium positive residual impact
1	12	Construction and Demolition Waste Disposal	Positive impacts expected			Medium positive residual impact
2	13	Impacts associated with MRF operations	Likely	Major	Medium	Low
2	14	Impacts of operations of composting plant and AD plant	Likely	Medium	Medium	Low
2	15	Impacts associated with regeneration of legacy landfill.	Positive impacts expected			Medium positive residual impact
1,2	16	Lack of Site Closure Planning	Likely	Major	Significant	Low

Critical Risk Level

Significant Risk Level

Medium Risk Level

Low Risk Level

1 Introduction

1.1 Overview of DREAMS Project

67. The Government of the Punjab is implementing Punjab Intermediate Cities Improvement Project (PICIIP) in intermediate districts with financial assistance of The Asian Development Bank (ADB). PICIIP targets investments in urban management infrastructure and services across clusters of cities in Punjab. This Program represents seven cities in Punjab province, namely Sargodha, Rahim Yar Khan, Muzaffargarh, Bahawalpur, Dera Ghazi Khan, Multan, and Rawalpindi.

68. Developing Resilient Environments and Advancing Municipal Services (DREAMS) is part of a multiyear PICIP portfolio which will build upon the achievements and lessons learned from previous urban sector projects supported by the ADB and other partners in Pakistan including the PICIIP, with the intention of improving urban services in cities of Punjab.

69. The consultancy services for DREAMS have been awarded to the Engineering Design and Construction Management (EDCM) Consultant by the PMU to achieve the objectives of the project.

70. The wider DREAMS project will enhance climate-resilience and urban living standards for about 2.8 million people in four cities (Bahawalpur, Dera Ghazi Khan, Rawalpindi, and Sargodha) of Punjab Province, one of Pakistan's most urbanised regions and vulnerable to climate change. It will expand and modernise water supply and solid waste management systems to improve quality, coverage, efficiency, and reliability of basic urban services for residents and businesses, while contributing to decarbonisation and improved resilience of social and environmental systems.

71. ADB has approved a Project Readiness Finance (PRF) loan to enhance readiness for project implementation, thereby facilitating the timely and cost-effective achievement of project outcomes. Activities to be conducted under the PRF include spatial planning, feasibility studies, engineering design and construction management (EDCM) during the Design and Construction Phases, and operational design and business models (ODBM) during the Operation Phase.

72. DREAMS will equip the cities of Bahawalpur and Dera Ghazi Khan (SWM pilot cities) with: (i) collection equipment, parking, transfer, and sorting facilities; (ii) establishment segregation and composting centres, with a minimum 10% of women workers; and (iii) construction sanitary landfills and biogas recovery to reduce greenhouse gas emissions.

73. Due to a lack of systematic management, solid waste is also listed as a priority sector in all cities. While greater tools and abilities could improve collection, it is vital to establish sanitary landfills to reduce health hazards and enhance environmental conditions. Heaps of garbage are one of the greatest challenges that cause poor states of cleanliness in all cities. Furthermore, improved sanitation operations will also provide solid waste management services including collection, segregation, transportation and safe disposal of solid wastes in the cities. Collected garbage will be dumped in landfills and later these sites will be transformed into parks.

74. The Local Government and Community Development Department (LG&CDD) of the Government of Punjab will be the executing agency (EA) of the project and the Bahawalpur Waste Management Company (BWMC) will be the implementing agency. The LG&CDD has established a Project Management Unit (PMU) and city

implementation units (CIUs), which will support LG&CDD, with the implementation and capacity development component of the project.

75. Due to the open dumping of waste in the cities, the leachate and odor of waste is disturbing the people and polluting the environment. The BWMC aims to counter these practices but the existing solid waste management system and BWMC is not fully equipped with modern technologies, essential equipment, a landfill and manpower.

76. This IEE document focuses solely on the scope of works for the development of an improved Integrated Solid waste management system (ISWMS) in Bahawalpur Region, Punjab. and the project will be delivered in three phases as detailed in the table below and this document assesses any potentially significant impacts identified and proposes the required mitigation measures, which shall be implemented by the Contractor and monitored by the PMU/CIU, Local Government and LG&CDD, Punjab and ADB using the Environmental Management Plan (EMP).

77. For the remainder of the report, each section will include an evaluation of the individual risks and planned mitigation measures for each of the below components.

Table 1-1: Project Description

Project Description			
Reference	**Report Reference**	**Project Description**	**Timeline**
Component 1	New Landfill	This phase includes the construction of a new landfill site located south-west of Bahawalpur City.	Construction anticipated to commence Q1 – 2024 – completion Q4 - 2027
Component 2	Legacy Landfill Site Construction of new Transfer Station and Material Recycling Facility (MRF) Closure of existing Transfer Station	This phase includes construction of a new Transfer Station and Material Recycling Facility (MRF) and closure of an existing landfill site at Khanu Wali which will be rehabilitated to a solar farm. The existing Transfer Station will also be closed. NOTE: The legacy landfill site will continue to accept waste until 2027 when the new landfill becomes operational.	Construction of MRF anticipated Q1 2024 Continued operation of legacy landfill until 2027. Rehabilitation of legacy landfill – 2028 – 2029 Continued Legacy Landfill Monitoring -
Component 3	Improved Waste Infrastructure System	This phase involves the acquisition, placement and operation of new waste collection infrastructure – including bins and collection lorries.	To be in place by Q4 2024

1.2 Project Locations

78. **Component 1** will include the construction of a new landfill site located at Mari Sheikh Shijra, mouza Nouabad approximately 13km away from Bahawalpur city centre at an elevation of 392 ft (119 m) above mean sea level (AMSL). Additionally, a compost plant (5 tpd) and C&D waste processing plant (5tpd) is scheduled for installation at this location. The site is accessible through Basti Yar Muhammad road, however, the project will also include the construction of a new 2.5km road leading to the landfill site.

79. **Component 2** includes the construction of a Transfer Station (TS), Anaerobic Digestion (AD) Plant and Material Recovery Facility (MRF) located at land adjacent to an existing dump site (herein referred to as the legacy landfill) in Khanu wali. This site will be accessible via a new road which will also be constructed as part of this project. The Transfer Station and Material Recycling Facility will be constructed on 10 acres land adjacent to the north of the existing legacy landfill. The legacy landfill will continue to be operated by BWMC until the commencement of operation of the MRF in 2027. The MRF has a capacity of 60 tons per hour (tph). A solar farm will be installed on the buildings of the MRF. The capacity of the solar plant will be enough to power the MRF site operations.

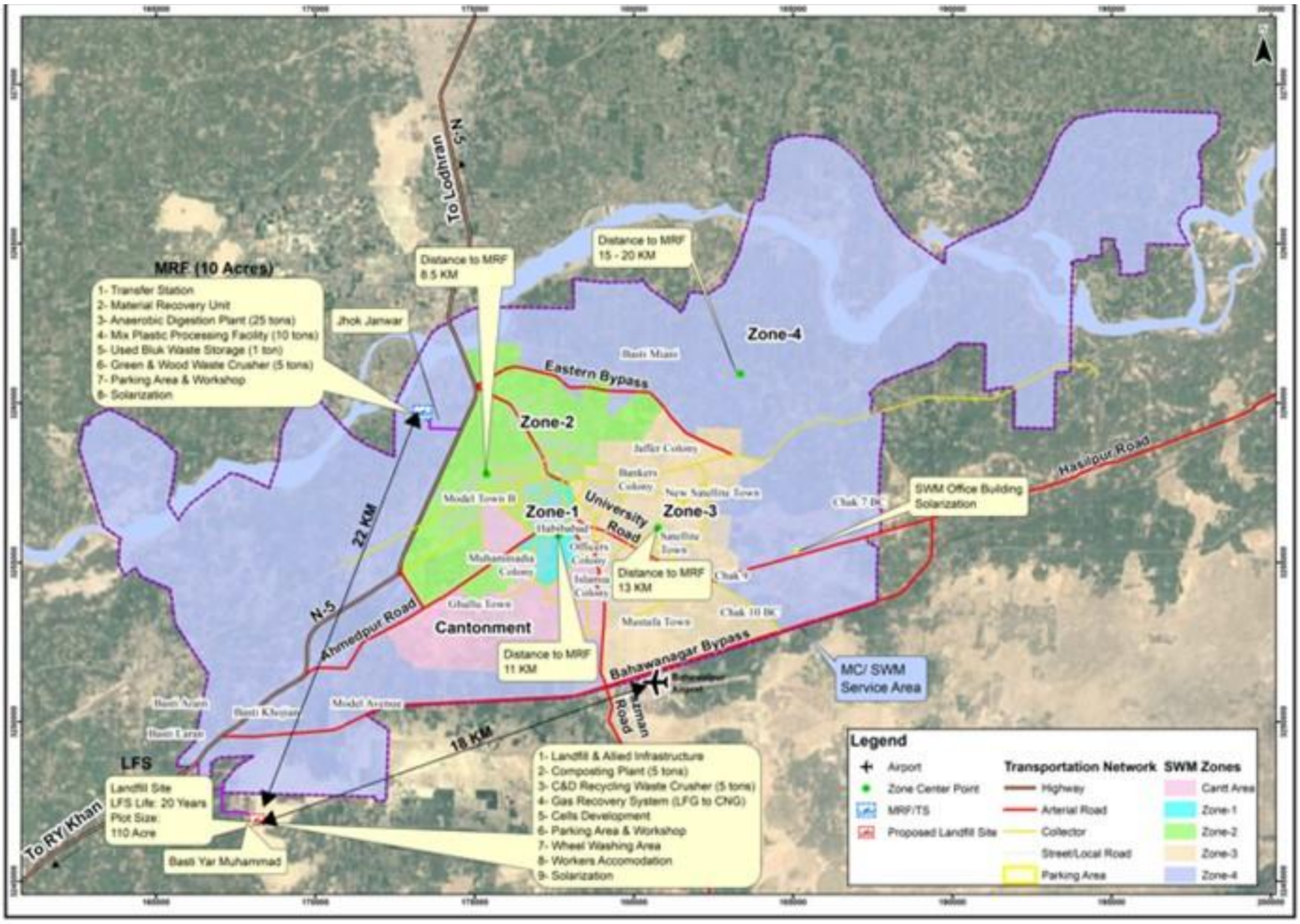
80. The Legacy Landfill at Khanu Wali will be properly restored and rehabilitated once the new landfill is operational. The method of rehabilitation will be confirmed, following further site investigation that is required to fully understand the conceptual site model and ensure the legacy landfill poses minimum long risk to the environment and human health. This investigation and site closure planning will be undertaken prior to its closure in 2027.

81. The current Transfer Station, situated on Stadium Road will be dismantled, while the upcoming BWMC office building, set to be erected on 1.125 acres of land, will be positioned along Hasilpur Road.

82. **Component 3** will encompass the Bahawalpur city limits that are included in the waste infrastructure system.

83. The key map for the proposed project locations provided in **Figure 1.1**.

Figure 1-1 Project Locations



1.3 Environment Safeguards Category of Project

84. According to ADB's Safeguard Policy Statement (SPS) 2009, a Rapid Environmental Assessment (REA) Checklist was prepared for the proposed landfill works (**Appendix A.1**).

85. As per Punjab Environmental Protection Act, 1997 (Amended 2017) and Review of IEE and EIA Regulations, 2022; the project is categorised as Schedule II, Category G-Waste Storage and Disposal (Rule 1) and requires that an EIA needs to be prepared and submitted to Punjab EPA for review and necessary approval.

86. Based on the initial findings, it was ascertained that certain adverse environmental impacts are expected, due to development of the proposed landfill, MRF and the compost plant and risks will be minimised and mitigated with implementation of Environmental Management Plan (EMP) and therefore the project is considered as category "B" for Environment safeguards as per ADB SPS, 2009. Therefore, an IEE has been conducted.

1.4 Objectives of the IEE

87. The objectives of this IEE study are to:

- Assess the existing environmental conditions of Bahawalpur landfill area and MRF area including the identification of environmental sensitive receptors to develop a baseline of its prevalent environmental and socioeconomic conditions;
- Identify and investigate all impacts of the proposed landfill pre-construction/design, construction, operation, closure and post closure on the physical, biological and socioeconomic environment of the project area;
- Propose mitigation measures that would help PMU PICIIP, LG&CDD, Punjab and the supervision consultant in conducting the proposed project activities in an environmentally sustainable manner;
- Uncover the planning and operational phase impacts up to microenvironment levels in which the project is proposed to be sited; and
- Develop an Environmental Management Plan (EMP) that would assist PMU PICIIP LG&CDD, Punjab and EDCM in the effective implementation of the recommendations of the IEE.

1.5 IEE Team

88. The team participated in the IEE study comprised of following experts:

Table 1-2: IEE Study Team Experts

Sr. No.	Name of Expert	Designation
Project Management Unit (PMU) PICCIP		
1	Saad Malik	ADB's Environmental Consultant Review of first draft of IEE study.
2	Aziz Karim	Individual Consultant (Environmental Consultant)

Sr. No.	Name of Expert	Designation
		Review of first draft of IEE study.
3	Waqas Afzal	Deputy Director (Environment and Social Safeguards) Project Management Unit (PMU) Review of first draft of IEE study.
4	Usama Faheem	Assistant Director (Environmental Safeguards) Project Management Unit (PMU) Review of first draft of IEE study.
3	Shahnaz Aslam	Assistant Director (Environmental Safeguards) Project Management Unit (PMU) She participated in review of the IEE.
EDCM Team (Environment Component)		
4	Engr. Ihtasham ul Haq	Landfill Design Engineer EDCM
5	Dr. Abdul Qayyum Aslam	Environment Expert (EDCM) Lead Environment Expert
6	Dr. Rashid Mehmood	Ecology Specialist
7	Dr. Gulnaz	Environment Specialist (EDCM)
8	Ehtasham Raza	Environment Specialist (EDCM)
9	Adnan Sharif	Environmentalist (EDCM)
10	Mehmood Amjad	Environmentalist (EDCM)
11	Ihsan Nadir	Social Expert-Environment Component (EDCM)

1.6 Methodology of IEE Study

89. The following methodology was employed for this IEE study:

1.6.1 Understanding of the Proposed Operation

90. This involved collecting information from the ADB, PMU Punjab, LG&CDD and Engineering Design and Construction Management technical team on the proposed

project activities and understanding the activities to identify potential impacts of implementing them.

1.6.2 Review of Legislation and Guidelines

91. National legislation, international agreements, environmental guidelines both of Punjab EPD, and ADB, and best industry practices have been reviewed to set environmental standards that Punjab LG&CDD as the executing Agency will adhere to during the implementation and operation phases of the project.

1.6.3 Secondary Data Collection

92. Available published and unpublished information related to the background environment was obtained and reviewed. All data sources have been carefully reviewed to collect the following information:

- Physical environment – topography, geology, seismology, geomorphology, soils, surface and groundwater resources and climate;
- Biological environment – habitat types, flora and fauna (particularly rare or endangered species), critical habitats, vegetation and communities within the area;
- Physical cultural resources – sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance; and
- Socio-economic environment – settlements, socio-economic conditions, infrastructure and land use.

1.6.4 Field Data Collection (Baseline Survey)

93. The principal field visits were undertaken in the month of October and November 2022 consisting of preliminary scoping through survey and assessment activities to establish the potential impacts and categorisation of activities and the Rapid Environmental Assessment (REA) Checklist was completed. The key receptors and stakeholders within the project area were identified. Some additional surveys and investigations were conducted in the first half of 2023 to gather further information in relation to specific issues, such as subsurface conditions.

94. Baseline surveys required to identify and establish physical and biological conditions and ecosystems in the project area were carried out by the IEE team and results have been incorporated in this report. The socio-economic environment in the project areas has been obtained through the socio-economic profiles and social impact assessment carried out by the social safeguards team. Climate risk and vulnerability assessment findings have also been presented and discussed.

95. Primary data collected was generally as follows:

- Component 1:
    - Geology and soils by boreholes and test pits, surface water collected from surrounding canals, ground water samples, air quality land use/land cover analysis.
    - Primary data collection in a two-kilometre area of influence, such as ambient noise levels, ambient air quality and ground water quality at the key receptor locations in the project area and particularly in close proximity to the project site were conducted.

- Component 2:
    - Collection of soil and groundwater samples.

96. Review of secondary information on the physical, biological and ecological aspects, physical cultural resources and infrastructure utilities in the project areas were also conducted.

1.6.5 Public Consultations

97. Public consultations (PC) were carried out with all key stakeholders, particularly local communities residing in the project area, local businesses and government and local government bodies in line with ADB's "Safeguard Policy Statement (SPS) – June 2009"/ Environmental Assessment Guidelines. Under ADB requirements, the environmental assessment process must also include meaningful public consultations during the completion of the study. In this IEE study, the public consultation process was carried out including verbal explanation of the project development with stakeholders to brief them about project and to seek their response/recommendation.

1.6.6 Impacts Identification and Assessment

98. Potential impacts arising from each phase of the proposed project have been identified and assessed based on field data, secondary data, expert opinions and examining previous similar projects in Pakistan. These include effects on physical, biological and socio-economic environment.

1.6.7 Recommendations for Mitigation Measures

99. Mitigation measures to minimise, eliminate or compensate for the potential environmental impacts have been recommended. The mitigation measures have been recommended based on past experiences, best industry practices, legislative requirements and professional judgement.

1.6.8 Development of Environmental Management Plan (EMP)

100. An Environmental Management Plan (EMP) has been developed for effective implementation of the recommended mitigation measures. The EMP includes controls to minimise the identified impacts and monitoring programme to monitor the effect of mitigation measures implemented and residual impacts, if any, during implementation. The EMP has identified roles and responsibilities for all concerned parties during the implementation of the project.

1.7 Proponent of Project

101. The LG&CDD, Govt. of Punjab is the Executing Agency (EA) for the ISWMS of Bahawalpur, while the project will be implemented through BWMC with support from PMU.

102. Contact details of the EA are provided as **Table 1-3** below.

Table 1-3: Executing Agency Contact Details

Executing Agency Details	Information
Name of EA	Project Management Unit (PMU), Local Government and Community Development Department (LG&CDD), Govt. of Punjab

Executing Agency Details	Information
Address	40-B-I, Gulberg-III, Lahore
Telephone	+92-42- 99268484
E-mail	info@piciip.gov.pk
Web	piciip.gov.pk

1.8 Structure of the Report

103. The IEE report contains twelve further sections as detailed in **Table 1-4** below. Given that Component 1 and Component 2 sites are located 22km apart, Sections 3 to 7 of the report describe the regional conditions that apply to both components as well as detailing the site specific details that are particular to the local conditions of each site.

Table 1-4: Report Structure

Section	Description
2	**Policy and Legal Framework** Briefly discusses the environmental policy of the ADB, existing national policy and resulting legislation for sustainable development and environmental protection, and then presents the legislative requirements of Punjab Pakhtunkhwa Environmental Protection Act (amended act).
3	**Description of the Project** Provides the description of the proposed projects, its layout plans and associated activities, utility requirement, technology used, current and proposed waste disposal practices, project layout plans, etc.
4	**Project Program and Design – Component 1** Provides details of the proposed construction of Component 1, including the new Landfill
5	**Project Program and Design – Component 2** Provides details of the proposed construction of Component 2, including the Legacy Landfill and MRF.
6	**Description of the Baseline Environment** Describes the project area's existing physical, biological, and socioeconomic conditions, including geomorphology and soils, water resources, water and air quality, flora and fauna, demography, etc.
7	**Analysis of Alternatives** Presents the project alternatives (site and technology alternatives, landfill types and construction alternatives, waste disposal alternatives) that were considered, and the reasons for their acceptance or rejection.
8	**Assessment of Environmental Impacts and Mitigation Measures** Presents an assessment of the project's impact and their required mitigation measures to the physical, biological, and socioeconomic environment.
9	**Institutional Requirements Environmental Management Plan** Contains comprehensive prescriptions regarding environmental impacts and their mitigation measures. This also includes institutional arrangements and Environmental Management & Monitoring Plan.
10	**Public Consultation** Record of consultation meetings, for obtaining the views of the affected people, local non-governmental organizations and regulatory agencies.
11	**Grievance Redressal Mechanism** This section provides GRM stages and its process of receive and facilitate resolution of the Displaced/Affected Persons concerns and grievances regarding the project's social and environment performance.
12	**Findings, Recommendations and Conclusions** Concludes the IEE report with some practical recommendations.
13	**References** Provides key references made in the IEE report.

1.9 Further Additions & Updating of IEE Study

104. This version of the report will be further updated once the final engineering detailed design and drawing are furnished by the Design-Build-Operate contractor and any other details of the proposed landfill become available over the coming weeks and months. These revisions shall be incorporated into any subsequent updated versions of this IEE report.

2 Policy and Legal Framework

2.1 General

105. This section provides an overview of the policy framework and national legislation that applies to both phases - the proposed Landfill development at Mari Sheikh Shijra mouza Nouabad and the legacy landfill and MRF development at Khanu Wali in the outskirts of Bahawalpur city, Punjab, Pakistan. The project will comply with all national legislation relating to the environment in Punjab and Pakistan and will obtain all the regulatory clearances required from the financing agency, ADB in compliance to ADB SPS, 2009.

2.2 National Policy and Legal Framework

106. The Pakistan National Conservation Strategy (NCS) that was approved by the federal cabinet in March 1992 is the principal policy document on environmental issues in the country (EUAD/IUCN, 1992). The NCS outlines the country's primary approach towards encouraging sustainable development, conserving natural resources, and improving efficiency in the use and management of resources. The NCS has 68 specific programs in 14 core areas in which policy intervention is considered crucial for the preservation of Pakistan's natural and physical environment. The core areas that are relevant in the context of the proposed landfill development are pollution prevention and abatement and increasing energy efficiency while conserving biodiversity.

107. Prior to the adoption of the 18th Constitutional Amendment, the Pakistan Environmental Protection Act (PEPA) 1997 was the governing law for environmental conservation in the country. Under PEPA 1997, the Pakistan Environmental Protection Council (PEPC) and Pak EPA were primarily responsible for administering PEPA 1997. Post the adoption of the 18th Constitutional Amendment in 2011, the subject of the environment was devolved, and the provinces have been empowered to address environmental protection and conservation.

108. Before the passage of 18th constitutional amendment by the parliament, Punjab Government had enforced The Punjab Environmental Protection Act, 1997 in the province which was originated and derived from the Pakistan Environmental Protection Act, 1997. After the passage of 18th amendment, Punjab provincial assembly passed an amendment in the act ‘The Punjab Environmental Protection (Amendment) Act 2012’. About 22 amendments were made in the original act.

2.3 Punjab Environmental Protection Act, 1997 and Amendments

109. According to the Section 12 of the Act ‘Initial Environmental Examination and Environmental Impact Assessment’ no proponent of a project shall commence construction or operation unless; a file been made with the Provincial Agency including the Initial Environmental Examination or where the project is likely to cause an adverse environmental effect or an Environmental Impact Assessment, and therefore the Provincial Agency has given approval.

110. The Act is quite comprehensive to provide for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution, and promotion of sustainable development in the province of Punjab. Punjab Environmental Quality Standards (PEQS) have also been promulgated in 2016 under PEPA 1997 (Amended 2017).

2.4 Review of IEE and EIA Regulations, c2022

111. The Punjab Environmental Protection Agency Review of IEE and EIA Regulations, 2022 (the 'Regulations'), prepared by the Pak-EPA under the powers conferred upon it by the PEPA, provide the necessary details on the preparation, submission and review of the initial environmental examination (IEE) and the environmental impact assessment (EIA).

112. The Regulation classifies projects based on the expected degree of adverse environmental impacts and lists them in two separate schedules. 'Schedule-I' lists projects that may not have significant environmental impacts and therefore require an IEE. Schedule-II lists projects of potentially significant environmental impacts requiring preparation of an EIA. The Regulations also require that all projects located in environmentally sensitive areas require preparation of an EIA.

113. As per the Punjab Environmental Protection Act, 1997 (Amended 2017) and Review of IEE and EIA Regulations, 2022; the IEE and EIA review fee has to be submitted to Punjab-EPA. Moreover, the review period for IEE and EIA has been also been predefined which is 45-90 days.

2.5 Regulatory Clearances, Punjab EPA

114. In accordance with provincial regulatory requirements, an IEE/EIA satisfying the requirements of the Punjab Environmental Protection Act (Amended 2017) is to be submitted to Punjab environmental protection agency (Punjab-EPA) for review and approval, and subsequent issuance of the NOC before the commencement of construction.

115. As per Punjab Environmental Protection Act, 1997 (Amended 2017) and Review of IEE and EIA Regulations, 2022; the project is falling in Schedule II, Category G-Waste Storage and Disposal (Rule 1) and requires that an EIA shall be prepared and submitted to Punjab EPA for review and necessary approval.

116. Punjab EPA has issued the NOC for same site back in 2018 which is attached as **Appendix A.14** and which shows that the project can be established at the proposed site and the EPA has already carried out site assessment and accorded approval following legal requirements. PMU PICIIP will maintain close coordination with Punjab EPA on the status of already issued NOC and upon direction of EPA will file application for its renewal or submit updated EIA along with review fee to obtain new NOC.

2.6 Punjab Environmental Quality Standards (PEQS), 2016

117. PEQS were promulgated in 2016 under the Punjab Environmental Protection Act, 2012 (Amendment 2017) by Punjab Environmental Protection Agency and approved by Punjab Environment Protection Council. PEQS are mainly adopted from NEQS after the enactment of Punjab Environmental Protection Act, 2012 as result of 18th amendment. The act specifies the imposition of a pollution charge in case of non-compliance with the PEQS. The project will strictly comply with environmental quality standards of both provincial domains.

118. Under Section 6 (I) (c) of PEPA Act 1997, the National Environmental Quality Standards (NEQS), now called the Punjab Environmental Quality Standards (PEQS) post-devolution, have also been set for liquid effluents, gaseous emissions, noise levels and drinking water quality such as:

119. The PEQS (2016) specifies the following standards for:

2.6.1 Liquid Effluents and Gaseous Emissions

- Maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea (three separate sets).

- Maximum allowable concentration of pollutants (16 parameters) in gaseous emissions from industrial sources.

- Maximum allowable concentration of pollutants (2 parameters) in gaseous emissions from vehicle exhaust.

- Maximum allowable noise levels from vehicles.

2.6.2 Drinking Water Quality

120. The PEQS notified documents provide standard values for following 37 parameters:

- Biological (6 parameters)
- Physical (7 parameters)
- Chemical (19 parameters)
    - Essential inorganic (9 parameters)
    - Toxic inorganic (10 parameters)
- Organic (3 parameters)
- Radioactive (2 parameters)

2.6.3 Motor Vehicle Exhaust and Noise

121. Under the PEQS (2016), different areas/zones have been categorised to specify PEQS (2016) limiting values depending on land use and exposure level of sensitive receptors in different environmental conditions. Four types of areas have been mentioned with specific values for the noise level during day and night times in this regard. These are:

- Residential area
- Commercial area
- Industrial area
- Silence Zone

2.6.4 Ambient Air Quality

122. Ambient quality parameters in the standard are provided below;

- Five ambient gaseous parameters of SO_2, NO_2, NO, O_3, and CO.
- Three numbers of ambient particulates parameters of SPM, PM, and PM 2.5
- One parameter of Pb (Lead)

2.7 National Environmental Quality Standards (NEQS) 2000

123. The National Environmental Quality Standards (NEQS), 2000, specify the following standards:

- Maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea (three separate sets of numbers);
- Maximum allowable concentration of pollutants (16 parameters) in gaseous emissions from industrial sources;
- Maximum allowable concentration of pollutants (two parameters) in gaseous emissions from vehicle exhaust and noise emission from vehicles;
- Maximum allowable noise levels from vehicles;
- Maximum allowable concentration of parameters in drinking water

124. PEQS guidelines are provided as **Appendix A.12** of this EIA report.

2.8 Other Environment Related Legislations

125. The national laws and regulations are provided in **Table 2-1** below.

Table 2-1: Environmental Guidelines and Regulations

Legislation/Guideline	Description
National Environmental Policy (2005) (NEP)	NEP is the primary policy of Government of Pakistan addressing environmental issues. The broad Goal of NEP is, "to protect, conserve and restore Pakistan's environment in order to improve the quality of life of the citizens through sustainable development". The NEP identifies a set of sectorial and cross-sectorial guidelines to achieve its goal of sustainable development. It also suggests various policy instruments to overcome the environmental problems throughout the country.
The Forest Act (1927)	The Forest Act 1927, was amended in 2016, promulgated after the approval of the Governor of Punjab on January 26, 2016. This act is applicable to all regions of Punjab. It includes procedures for constituting and managing various types of forests, such as reserved forests and protected forests. The act empowers the provincial forest departments to declare any forest area as reserved or protected and prohibits the breaking up or clearing of forest for cultivation, grazing, hunting, removing forest produce, quarrying and felling, lopping and topping of trees, branches in reserved and protected forests. The latest amendment bill grants provisions for the use of reserved or protected forest land, where inevitable, for national projects of strategic importance.
The Punjab Wildlife (Protection, Preservation, Conservation and Management) Act, 1974	This Act provides for the protection, preservation, conservation and management of wildlife by the formation and management of protected areas and prohibition of hunting of wildlife species declared protected under this Act. The Act also specifies three broad classifications of the protected areas; national parks, wildlife

Legislation/Guideline	Description
	sanctuaries and game reserves. Activities such as hunting and breaking of land for mining are prohibited in national parks, as are removing vegetation or polluting water flowing through the park. Wildlife sanctuaries are areas that have been set aside as undisturbed breeding grounds and cultivation and grazing is prohibited in the demarcated areas. Nobody is allowed to reside in a wildlife sanctuary and entrance for the public is by special dispensation. However, these restrictions may be relaxed for scientific purpose or betterment of the respective area on the discretion of the governing authority in exceptional circumstances. Game reserves are designated as areas where hunting or shooting is not allowed except under special permits. Based on available/published material, SOP maps and the list issued by the concerned authorities the project area for EIA is located outside of any Wildlife Sanctuary, National Park or Game Reserves and therefore the project will not contravene with any provisions of the Act.
The Canal and Drainage Act, 1873	The Canal and Drainage Act, 1873 prohibits corruption or fouling of water in canals (defined to include channels, tube wells, reservoirs and watercourses), or obstruction of drainage. This act has relevance to the study due to the presence of canals and irrigation network in the project area. All project activities near the irrigation network will have to be implemented in a way that no physical damage to the canal or alteration in water quality occurs. Any discharge of waste into the canal shall also be prohibited. Any abstraction of water from the canal or associated watercourses shall be subject to approval from the concerned irrigation department.
The Antiquities Act (1975)	The protection of cultural resources in Pakistan is ensured by the Antiquities Act of 1975. Antiquities have been defined in the Act as ancient products of human activity, historical sites or sites of anthropological or cultural interest, national monuments etc. The act is designed to protect antiquities from destruction, theft, negligence, unlawful excavation, trade and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area which may contain articles of archaeological significance. Under the Act, the project proponents are obligated to: ▪ Ensure that no activity is undertaken in the proximity of a protected antiquity; and ▪ If during the project an archaeological discovery is made, it should be reported to the Department of Archaeology, Government of Pakistan.
Pakistan Penal Code (1860)	It authorises fines, imprisonment or both for voluntary corruption or fouling of public springs or reservoirs so as to make them less fit for ordinary use.

Legislation/Guideline	Description
NATIONAL ENVIRONMENTAL AND CONSERVATION STRATEGIES	
National Conservation Strategy	Before the approval of NEP, the National Conservation Strategy (NCS) was considered as the Government's primary policy document on national environmental issues. Now, this strategy just exists as a national conservation program. The NCS identifies 14 core areas including conservation of biodiversity, pollution prevention and abatement, soil and water conservation and preservation of cultural heritage and recommends immediate attention to these core areas.
Biodiversity Action Plan	The plan recognises IEE/EIA as an effective tool for identifying and assessing the effects of a proposed operation on biodiversity.
INTERNATIONAL CONVENTIONS	
The Convention on Conservation of Migratory Species of Wild Animals (1981.21)	The Convention requires countries to take action to avoid endangering migratory species. The term "migratory species" refers to the species of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries. The parties are also required to promote or cooperate with other countries in matters of research on migratory species. There are no endangered species of plant life or animal life in the vicinity of the proposed project areas for the landfill works.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973)	The convention requires Pakistan to impose strict regulation (including penalisation, confiscation of the specimen) regarding trade of all species threatened with extinction or that may become so, in order not to endanger their survival further.
International Union for Conservation of Nature and Natural Resources Red List (2000)	Lists wildlife species experiencing various levels of threats internationally. Some of the species indicated in the IUCN red list are also present in the wetlands of Pakistan.
Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention) **(1971)**	The Ramsar Convention deals with the protection of water bodies of international importance and their associated biodiversity, as well as promoting wise use of allied resources. The Convention was adopted in 1971 at Ramsar, Iran and entered into force in 1975. Pakistan signed the Ramsar Convention in 1971 and ratified it in July 1976. There are 19 Ramsar sites in Pakistan.
Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal **(1992)**	The Basel Convention deals with the controlled trans-boundary movement of hazardous wastes and their disposal. The Convention was adopted on March 22, 1989 and entered into force on May 5, 1992; Pakistan signed the Convention in May 1992 and ratified it in October 1994.

Legislation/Guideline	Description
United Nations Framework Convention on Climate Change (UNFCCC) **(1994)**	This convention highlights broad guidelines for protecting the climate of the planet. It was adopted in 1992 and came into force in 1994. Pakistan signed the UNFCCC in 1992 and ratified it in June 1994.
Kyoto Protocol to UNFCCC **(2005)**	The Kyoto Protocol seeks to mitigate climate change and to reverse the pace of climate change using carbon sequestration and carbon credits known as Certified Emission Reduction trading. The Protocol was adopted in 1997 and came into force in 2005; Pakistan signed the Protocol in December 1997 and ratified it in January 2005.

2.9 Implications of national policies and regulations on proposed project

126. According to the Punjab-EPA ‘Review of IEE and EIA Rules and Regulations, 2022’, development projects are categorised under two Schedules- I and II. Projects are classified based on expected degree and magnitude of environmental impacts and the level of environmental assessment required is determined from the schedule under which the project is categorised.

127. The projects listed in Schedule-I include those where the range of environmental issues is comparatively narrow, and the issues can be understood and managed through less extensive analysis. Schedule-I projects require an IEE to be conducted, rather than a full-fledged EIA, provided that the project is not located in an environmentally sensitive area.

128. The projects listed in Schedule-II are generally major projects and have the potential to affect many people in addition to significant adverse environmental impacts. The impacts of projects included in Schedule-II may be irreversible and could lead to significant changes in land use and the social, physical and biological environments. The proposed Landfill development project has been categorised as Schedule II (G) and requires an EIA.

129. The PMU PICIIP LG&CDD, Govt. of Punjab, being the Executing Agency for the Project is responsible for management of project impacts and has to undertake the commitments and mitigation measures proposed in this environmental report and in the subsequent review.

130. According to the regulations, no construction, preliminary or otherwise, relating to the project shall be undertaken until and unless approval of the EIA report has been issued by the Punjab EPA.

131. The PMU LG & CDD will submit the EIA Report on a prescribed application along with the processing fee to Punjab EPA. After submission of the EIA report, a thirty (30) day period for public comments will be provided. The assessment will be completed within a period of ninety (90) days from receipt of the complete documents, and earlier than this wherever practicable. Following the completion of a public hearing, if required, and the provision of any further data from the proponent, the decision shall be made and conveyed after thirty days.

2.10 ADB's Safeguard Policy Statement (SPS), 2009

132. The ADB's SPS 2009 requires that environmental considerations be incorporated into ADB funded projects to ensure that the project will have minimal environmental impacts and be environmentally sound. Occupational health & safety of the local population should also be addressed as well as the project workers as stated in SPS. A Grievance Redress Mechanism (GRM) to receive applications and facilitate the resolution of affected peoples' concerns, complaints, and grievances about the project's environmental performance is also established.

133. All loans and investments are subject to categorisation to determine environmental assessment requirements. Categorisation is to be undertaken using Rapid Environmental Assessment (REA) checklists, consisting of questions relating to (i) the sensitivity and vulnerability of environmental resources in the project area, and (ii) the potential for the project to cause significant adverse environmental impacts. Projects are classified into one of the following environmental categories:

134. **Category A**: A proposed project is classified as category A if it is likely to have significant adverse environmental impacts that are irreversible, diverse or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment (EIA) is required.

135. **Category B**: A proposed project is classified as category B if its potential adverse environmental impacts are less adverse than those of category A projects. These impacts are site-specific, few if any of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects. An initial environmental examination (IEE) is required.

136. **Category C**: A proposed project is classified as category C if it is likely to have minimal or no adverse environmental impacts. No environmental assessment is required although environmental implications need to be reviewed.

137. **Category FI**: A proposed project is classified as category FI if it involves investment of ADB funds to or through a financial intermediary (FI).

2.11 ADB's Access to Information Policy (AIP) 2018

138. ADB's new Access to Information Policy (AIP), reflects the ADB's ongoing commitment to transparency, accountability, and participation by stakeholders. The policy contains principles and exceptions to information sharing with external stakeholders, led by a new overarching principle of "clear, timely, and appropriate disclosure."

2.12 ADB's Accountability Mechanism Policy 2012

139. The objectives of the Accountability Mechanism are providing an independent and effective forum for people adversely affected by ADB-assisted projects to voice their concerns and seek solutions to their problems, and to request compliance review of the alleged noncompliance by ADB with its operational policies and procedures that may have caused, or is likely to cause, them direct and material harm. The Accountability Mechanism is a "last resort" mechanism.

2.13 Implications of ADB's safeguard policies on proposed project

140. The objectives of ADB's safeguards are to:

- avoid adverse impacts of projects on the environment and affected people, where possible;
- minimise, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; and
- help borrowers/clients to strengthen their safeguard systems.

141. ADB's SPS sets out the policy objectives, scope and triggers, and principles for three key safeguard areas:

- environmental safeguards,
- involuntary resettlement safeguards, and
- Indigenous Peoples safeguards.

142. The objective of the environmental safeguards is to ensure the environmental soundness and sustainability of projects and to support the integration of environmental considerations into the project decision-making process. ADB's policy principles are summarised in **Table 2-2** below.

Table 2-2: ADB Policy Principles

No.	Policy principle	Summary
1	Screening and categorization	Screening process initiated early to determine the appropriate extent and type of environmental assessment.
2	Environmental assessment	Conduct an environmental assessment to identify potential impacts and risks in the context of the project's area of influence.
3	Alternatives	Examine alternatives to the project's location, design, technology, and components and their potential environmental and social impacts, including no project alternative.
4	Impact mitigation	Avoid, and where avoidance is not possible, minimise, mitigate, and/or offset adverse impacts and enhance positive impacts. Prepare an environmental management plan (EMP).
5	Public consultations	Carry out meaningful consultation with affected people and facilitate their informed participation. Involve stakeholders early in the project preparation process and ensure that their views and concerns are made known to and understood by decision makers and taken into account. Continue consultations with stakeholders throughout project implementation. Establish a grievance redress mechanism.
6	Disclosure of environmental assessment	Disclose a draft environmental assessment in a timely manner, in an accessible place and in a form and language(s) understandable to stakeholders. Disclose the final environmental assessment to stakeholders.
7	Environmental management plan	Implement the EMP and monitor its effectiveness. Document monitoring results and disclose monitoring reports.

No.	Policy principle	Summary
8	Biodiversity	Do not implement project activities in areas of critical habitats.
9	Pollution prevention	Apply pollution prevention and control technologies and practices consistent with international good practices. Adopt cleaner production processes and good energy efficiency practices. Avoid pollution, or, when avoidance is not possible, minimise or control the intensity or load of pollutant emissions and discharges. Avoid the use of hazardous materials subject to international bans or phase outs.
10	Occupational health and safety/Community safety.	Provide workers with safe and healthy working conditions and prevent accidents, injuries, and disease. Establish preventive and emergency preparedness and response measures to avoid, and where avoidance is not possible, to minimise, adverse impacts and risks to the health and safety of local communities
11	Physical cultural resources	Conserve physical cultural resources and avoid destroying or damaging them. Provide for the use of "chance find" procedures.

143. The basic environmental assessment requirements for Category 'B' projects are provided in **Table 2-3** below.

Table 2-3: ADB Environmental Assessment Requirements for Category 'B' projects

Aspect	**Environmental Assessment & Management Requirements**
Project processing	
Reporting	▪ Prepare initial environmental examination (IEE).
Public consultations	▪ Conduct consultations at the early stage of IEE field work and when the draft IEE report is available during project preparation, and before project appraisal by ADB.
Disclosure of environmental assessment report	▪ Disclose final version of IEE report before Board consideration.
Project implementation	
Reporting	▪ Submit semi-annual reports during project construction, and annual reports during project operation to ADB for disclosure.

2.14 IFC Sector Specific Guidelines on Solid Waste Management[2]

144. The IFC guidelines provide guidance for development and operation of SWM sites. In terms of site selection of the landfill site, these guidelines require the location

[2] https://www.ifc.org/wps/wcm/connect/5b05bf0e-1726-42b1-b7c9-33c7b46ddda8/Final%2B-%2BWaste%2BManagement%2BFacilities.pdf?MOD=AJPERES&CVID=jqeDbH3

of the landfill to consider potential impacts associated with releases of polluting substances, including the following:

- **Proximity to residential, recreation, agricultural, natural protected areas, or wildlife habitat and areas prone to scavenging wildlife, as well as other potentially incompatible land uses:**
    - Residential development should be typically further than 250 metres from the perimeter of the proposed landfill cell development to minimise the potential for migration of underground gaseous emissions;
    - Visual impacts should be minimised by evaluating locational alternatives;
    - Siting should be further than 3 km of a turbojet airport and 1.6 km of a piston-type airport or as permitted by the aviation authority fully considering potential threats to air safety due to attraction and presence of birds.
- **Proximity and use of groundwater and surface water resources:**
    - Private or public drinking, irrigation, or livestock water supply wells located down gradient of the landfill boundaries should be further than 500 metres from the site perimeter, unless alternative water supply sources are readily and economically available and their development is acceptable to regulatory authorities and local communities;
    - Areas within the landfill boundaries should be located outside of the 10-year groundwater recharge area for existing or pending water supply development;
    - Perennial streams should not be located within 300 metres down gradient of the proposed landfill cell development, unless diversion, culverting or channelling is economically and environmentally feasible to protect the stream from potential contamination.
- **Site geology and hydrogeology:**
    - Landfills should be located in gently sloped topography, amenable to development using the cell (bund) method), with slopes which minimise the need for earthmoving to obtain the correct leachate drainage slope of about 2%;
    - Groundwater's seasonally high table level (i.e. 10 year high) should be at least 1.5 meters below the proposed base of any excavation or site preparation to enable landfill cell development;
    - Suitable soil cover material should be available on-site to meet the needs for intermediate (minimum of 30 cm depth) and final cover (minimum of 60 cm depth), as well as bund construction (for the cell method of landfill operation). Preferably, the site would have adequate soil to also meet required cover needs (usually a minimum of 15 cm depth of soil)[3].
- **Potential threats to landfill site integrity from natural hazards such as floods, landslides, and earthquakes:**

[3] Daily cover needs can be alternatively met by using removable tarps, other relatively inert materials (i.e., compost residuals), or by removing the previously laid daily soil cover at the start of each day for reuse at the end of the same day.

- Landfills should be sited outside of a floodplain subject to 10-year floods and, if within areas subject to a 100- year flood, amenable to an economic design which would eliminate the potential for washout;

- There should be no significant seismic risk within the region of the landfill which could cause destruction of berms, drains or other civil works, or require unnecessarily costly engineering measures; otherwise, side slopes should be adjusted accordingly to prevent failure in the event of seismic activity;

- No fault lines or significantly fractured geologic structures should be present within 500 metres of the perimeter of the proposed landfill cell development which would allow unpredictable movement of gas or leachate;

- There should be no underlying limestone, carbonate, fissured or other porous rock formations which would be incompetent as barriers to leachate and gas migration, where the formations are more than 1.5 metres in thickness and present as the uppermost geologic unit above sensitive groundwater.

145. All the guidelines mentioned above with regards to site selection for the landfill site have been taken into consideration during finalisation of the site for the landfill development.

146. The IFC guidelines also provide guidance on the operational aspects of landfill sites, such as measures to prevent, minimise and control leachate generation, groundwater and leachate monitoring, measures for controlling of landfill gas emissions, controlling of dust and odour emissions from landfill site, measures for controlling dispersal of litter along with closure and post closure activities.

2.15 US EPA Subtitle 40 CFR

147. US EPA regulations subtitle 40 CFR provide a summary of the regulatory criteria for municipal solid waste landfills (MSWLFs). The regulations detail general requirements (Sub Part A) and local restrictions (Sub part B) that are applicable to landfill designer and operators. The regulations establish special siting restrictions and performance standards for six types of MSWLF site locations: airport surroundings, 100-year floodplains, wetlands, fault areas, seismic impact zones, and unstable areas (Part 258, Subpart B). These six types of locations are sensitive areas that warrant additional regulatory controls. While all six-location restrictions apply to new and laterally expanding MSWLF units, existing units are subject only to airport safety, floodplain, and unstable area controls.

148. Regulations sub part C details operating criteria are controls for the day-to-day management of a MSWLF. For example, owners and operators must have a program in place to exclude regulated quantities of hazardous waste and polychlorinated biphenyl (PCB) wastes. Additional requirements include daily cover material, controlling disease vector populations (such as rodents and mosquitoes), restricting public access, and maintaining appropriate records.

149. Regulations' sub part D deals with design criteria which requires a composite liner and leachate collection system to be installed. The lower component must be constructed of at least a 2-foot layer of compacted soil and must exhibit a hydraulic conductivity of no more than 1 x 10-7 cm/sec. EPA believes that the combination of an FML and a compacted soil layer ensures adequate protection by providing both a highly impermeable upper liner to maximise leachate collection and removal, and a lower soil layer to serve as a back-up in the event of FML failure (56 FR 51060;

October 9, 1991). The leachate collection system must be designed and constructed to maintain less than a 30-cm depth of leachate over the liner (Section 258.40(a)(2)).

150. Regulations' sub part E deals with ground water monitoring and corrective action. It establishes criteria for establishment of ground water monitoring wells, sampling and analysis program, detection monitoring program, assessment monitoring program and detection standards.

151. Regulations' sub part F details the closure and post closure requirements of landfill sites while sub part G deals with Financial Assurance criteria.

152. Bahawalpur landfill has been designed keeping in view the requirements of US EPA Subtitle 40 CFR.

2.16 Comparison of International and Local Environmental Legislations

153. The ADB SPS requires application of pollution prevention and control technologies and practices consistent with international good practice, as reflected in internationally recognised standards. The SPS states that when host country regulations differ from these standards, the EA will achieve whichever is more stringent.

154. To select the most stringent standards applicable, a mix of local Punjab Environmental Quality Standards (PEQS) and international (IFC) regulations have been selected. The IFC Environmental, Health, and Safety (EHS) Guidelines, General EHS Guidelines and Environmental standards are also applicable.

155. The **Table 2-4** presents IFC workplace noise standards that are applicable to the construction workers. It should also be noted that IFC EHS guidelines advise that where existing ambient noise levels already exceed thresholds, the project should not result in an increase of more than 3 dB over existing ambient noise levels at the nearest receptor location off-site.

156. A comparison of applicable local and international guidelines for ambient air quality has been provided in **Table 2-5** below. In the case of most pollutants, the Punjab Environmental Quality Standards (PEQS) for ambient air quality are more stringent in comparison to USEPA and WHO/IFC standards. The applicable and most stringent parameters for each respective pollutant are highlighted in green.

157. Similar to the standards for air quality, the comparison of noise standards provided in **Table 2-6** clearly shows that the PEQS standards for noise are more stringent in comparison to the IFC standards. The only exception is the daytime noise level standard for Industrial areas where the IFC standard is more stringent (70 dB(A)) in comparison to PEQS (75 dB(A)) and so for this parameter, the IFC standard will be used. Apart from this one exception, the PEQS standards have been used for the proposed landfill development project.

158. Comparison of local and international water quality standards is provided as **Table 2-7.**

159. As far as regulations regarding other environmental parameters are concerned such as acceptable effluent disposal parameters, the local regulations i.e. PEQS take precedence over any other international regulations such as IFC.

Table 2-4: IFC Work Environment Noise limits

Type of Work	IFC General EHS Guidelines
Heavy Industry (no demand for oral communication)	85 Equivalent level L_{eq},8h
Light industry (decreasing demand for oral communication)	50-65 Equivalent level L_{eq},8h

Table 2-5: Applicable Most Stringent Air Quality Standards*

Pollutants	WHO/IFC		PEQS	
	Avg. Time	Standard	Avg. Time	Standard
SO_2	24 hr	40 mg/m^3	Annual Mean	80 mg/m^3
CO	24 hr	4 mg/m^3	8 hrs 1 hr	5 mg/m^3 10 mg/m^3
NO_2	1 yr 24 hr	10 mg/m^3 25 mg/m^3	-	-
O_3	8 hrs	100 mg/m^3	1 hr	130 mg/m^3
TSP	-	-	Annual Mean 24 hrs	360 mg/m^3 500 mg/m^3
PM_{10}	1 yr 24 hr	15 mg/m^3 45 mg/m^3	-	-
$PM_{2.5}$	1 yr 24 hr	5 mg/m^3 15 mg/m^3	1 hr	15 mg/m^3

* In instances where the airshed is significantly degraded and the pollutant levels are already exceeding the ambient pollutant concentrations provided in the table above, it shall be ensured that the project activities cause as small an increase in pollution levels as feasible and amounts to a fraction of the applicable short term and annual average air quality guidelines or standards as established in the project specific environmental assessment.

Table 2-6: Applicable Most Stringent Noise Standards

Category of Area/Zone	Limit in dB(A) Leq			
	PEQS		WHO/IFC	
	Day Time 06:00 – 22:00	Night Time 22:00-06:00	Day Time 07:00 – 22:00	Night Time 22:00-07:00
Residential area (A)	55	45		
Commercial area (B)	65	55		
Industrial area (C)	75	65	70	
Silence zone (D)	50	45	55	45

* In instances where baseline noise levels are already exceeding the standards above, it will need to be ensured that the project activities do not cause an increment of more than 3 dB(A) from the baseline noise levels.

Table 2-7: Comparison of International and Local Water Quality Standards

Parameter	Unit	PEQS	WHO/IFC
Bacterial			
E-Coli	numbers/ml	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample
Total Coliform	numbers/ml	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample
Physical			
Color	TCU	≤ 15 TCU	-
Taste	No objectionable/Acceptable	-	-
Odor	No objectionable/Acceptable	-	-
Turbidity	NTU	< 5 NTU	
Total Hardness	mg/l	< 500 mg/l	
TDS	mg/l	< 1000	
pH		6.5-8.5	
Chemical			
Aluminum	mg/l	≤0.2	--
Antimony	mg/l	≤0.005 (P)	
Arsenic	mg/l	≤0.005 (P)	
Barium	mg/l		0.3
Boron	mg/l		0.3
Cadmium	mg/l		0.0003
Chloride	mg/l	<250	250
Chromium	mg/l	≤0.05	0.05
Copper	mg/l	2	2
Cyanide	mg/l	≤0.05	
Fluoride	mg/l	<1.5	1.5
Lead	mg/l		0.01
Manganese	mg/l		
Mercury	mg/l	≤0.0001	0.0001
Nickel	mg/l	≤0.02	0.02
Nitrate	mg/l	≤50	50
Nitrite	mg/l	≤3	-
Selenium	mg/l	0.01	0.01
Residual Chlorine	mg/l	0.2-0.5 at consumer end	-
Zinc	mg/l		3

Parameter	Unit	PEQS	WHO/IFC
Bacterial			

Parameter	Unit	PEQS	WHO/IFC
E-Coli	numbers/ml	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample
Total Coliform	numbers/ml	Must not be detectable in any 100 ml sample	Must not be detectable in any 100 ml sample
Physical			
Color	TCU	≤ 15 TCU	-
Taste	No objectionable/Acceptable	-	-
Odor	No objectionable/Acceptable	-	-
Turbidity	NTU	< 5 NTU	
Total Hardness	mg/l	< 500 mg/l	
TDS	mg/l	< 1000	
pH		6.5-8.5	
Chemical			
Aluminum	mg/l	≤0.2	--
Antimony	mg/l	≤0.005 (P)	
Arsenic	mg/l	≤0.005 (P)	
Barium	mg/l		0.3
Boron	mg/l		0.3
Cadmium	mg/l		0.0003
Chloride	mg/l	<250	250
Chromium	mg/l	≤0.05	0.05
Copper	mg/l	2	2
Cyanide	mg/l	≤0.05	
Fluoride	mg/l	<1.5	1.5
Lead	mg/l		0.01
Manganese	mg/l		
Mercury	mg/l	≤0.0001	0.0001
Nickel	mg/l	≤0.02	0.02
Nitrate	mg/l	≤50	50
Nitrite	mg/l	≤3	-
Selenium	mg/l	0.01	0.01
Residual Chlorine	mg/l	0.2-0.5 at consumer end	-
Zinc	mg/l		3

3 Project Description

3.1 Project Overview

160. The proposed Integrated Solid Waste Management System (ISWMS) project will be delivered via three components:

- **Component 1** - Construction of a new engineered landfill or solid waste management facility (SWMF) at Mari Sheikh Shijra, Mouza Nouabad. This is anticipated to be completed by Q4 – 2027. This component will also include the provision of a construction and demolition waste recycling and composting plant.
- **Component 2** – Closure of a legacy landfill and construction of a new material transfer station (MRF) on land to the north at Khanuwali. The MRF will be completed by Q4 2027, with the legacy landfill closed and rehabilitated between Q4 2028 and Q4 2030. The MRF will also include an anaerobic digestion plant and new transfer station. The existing transfer station will be closed as part of this component.
- **Component 3 –** Improvement of existing waste collection and transport system across Bahawalpur City to provide a fully functioning Integrated Solid Waste Management System (ISWMS). Improvement of the waste collection system will be delivered by Q4 2027.

161. All the proposed ISWMS components within Bahawalpur city are crucial for the successful operation of the SWMF. Together they provide a strategic approach to sustainable waste management covering all sources and all aspects, including generation, segregation, transfer, sorting, treatment, recovery, and disposal in an integrated manner, with an emphasis on maximising resource use efficiency.

162. The operational protocols and modalities of the ISWMS have been proposed to improve environmentally sound practices with respect to waste management and attempting to close existing bottlenecks in the system. They will enable the waste generated to be broadly categorised as industrial, agricultural, residential and medical waste types.

163. The development of a proposed new engineered landfill (or SWMF) is designed to support the BWMC and other involved agencies, so as to completely transform the solid waste management system in Bahawalpur city. Complete with institutional strengthening, recycling and other support initiatives, the project includes the installation of primary and secondary Municipal Solid Waste (MSW) collection systems and the development of an international standard MSW management facility that will accommodate Bahawalpur's residual MSW for at least 25 years.

164. Component 1 of the project comprises the development of a new engineered landfill (SWMF) within Bahawalpur and will comprise the central most important aspect of the project as its development will ensure that solid waste generated from Bahawalpur city is managed in future in accordance with international best practice and will reduce the current risks posed to the environment and human health from uncontrolled tipping. Given the sensitive nature of this development and given it will be the first component of the project to be commenced in 2024, significant technical studies have already been undertaken to understand and mitigate the environmental risks posed. Further technical studies will be undertaken for the other components to gather data and better understand the risks posed by eventual closure of the legacy landfill and development of the MRF which both comprise Component 2 of the project. It is not envisaged that the provision of improved waste collection infrastructure

(Lorries, Bins etc) comprising Component 3 of the project will pose significant environmental risks requiring mitigation.

165. The projected total waste generation of Bahwalpur is 524 tpd in 2028, which is considered for design of ISWMS in the project feasibility. Out of the 524 tpd of waste generated, scavengers will directly collect 20 tpd from the source, while the remaining 504 tonnes will be collected by the BWMC. BWMC will collect, process and dispose of 85% of remaining waste which will comprise of source segregated 85 tpd domestic and commercial waste and mixed waste disposal of 343 tpd through the proposed the new SWMF.

166. An overview of the activities and infrastructure to be developed under these components is summarised in the **Table 3-1** below.

Table 3-1: Activities & Infrastructure Development under Project Scope

Component	Activity Name	Activity Scope and Details
1	SWM Facility (New Landfill) Development	A new landfill site will be developed at Mari Sheikh Shijra, mouza Nouabad, located approximately 13km away from Bahawalpur city centre and 20.2 km from the legacy landfill site at Khanuwali. A total of four landfill cells will be developed over 44 acres of land over a total site area of 110 acres in a phased approach.
	Composting Plant Development	A 5 tons per day composting plant will be developed at SWM Facility (Landfill) location.
	Construction and Demolition (C&D) plant	A C&D plant with 5 tons per day capacity will be developed at SWM Facility (Landfill) location.
	Development of Administration buildings & associated structures incl. solar PV installation on building.	These buildings will be developed within the SWM facility site boundary.
	New Access Road	Development of a new access road and upgrading of existing road.
2	Remediation of legacy landfill site	The existing un-engineered and uncontrolled landfill site located at Khanuwali will be rehabilitated, capped and closed in-situ and be monitored for potential landfill gas emission and groundwater contamination. A full technical site closure plan will be undertaken during the commencement of Component 1 to confirm the best possible solution minimising environmental risk.
	Demolition of existing Transfer Station (TS)	The existing TS situated at Stadium Road will be dismantled.

	Development of New Transfer Station	A new TS will be established as an integral component of the MRF at Khanuwali.
	Material Recovery Facility (MRF) Development	The MRF of 343 tons per day capacity will be developed over approximately 4.5 acres of land located adjacent to the existing dump site.
	Mixed plastic processing facility	A 10 tons per day plastic recycling plant will be developed at MRF site location.
	Anaerobic Digestion (AD) Plant Development	An AD plant with 25 tons per day capacity will be developed at MRF site location.
	Development of Access Road	Approximately 5 kilometres of road improvements will be necessary for the access road.
3	Provision of collection vehicles and systems (bins etc.)	Waste management equipment and vehicles will be provided to improve the existing waste collection system.
	Capacity Building of BWMC	Capacity building of BWMC shall be conducted on integrated waste management system in the city.

3.2 Project Objectives

167. The following are the key objectives of the proposed project:

- Achieve about 95% generated waste volume collection daily in urban areas and alternate days from rural areas.
- Confinement of waste at point of waste generation.
- One hundred (100) percent door to door collection.
- The transfer of recovering recyclables from informal sector to the formal sector by establishing an MRF and reorganize primary waste collection system.
- Final disposal of the MSW with full environmental controls at an engineered sanitary landfill as per NEQS, IFC and USEPA Subtitle ‘’D’’ 40 CFR specifications.
- Limited composting from source segregated organic waste from commercial waste generators.
- The targeted resource recovery and diversion of the waste from the landfill is maximised.
- Stop harmful air emissions from the landfill by installing daily cover, landfill gas recovery system and capping the closed portion of the landfill as per IFC guidelines.
- Zero tolerance for offsite migration of contaminated surface water and leachate migration into underground water.

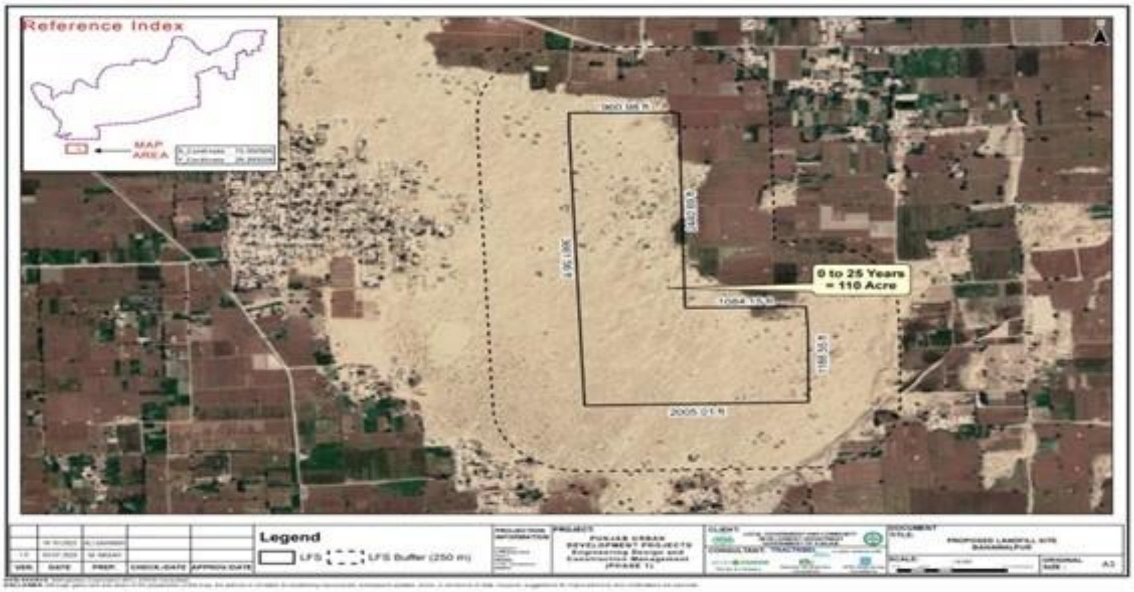
168. The resource recovery and recycling targets are:

- Recovery of 15% recyclables out of 22.6 percent present in the waste stream as per waste characterization study
- About 5% percent C&D recycling (100 percent)
- 5-10% percent of organic waste composting

3.3 Component 1 Details – Construction of new SWMF

169. A new SWMF is proposed to be constructed at Mari Sheikh Shijra mouza Nouabad on the location shown in **Figure 3-1**.

Figure 3-1: Key Plan of Bahawalpur Landfill



This section is divided into the following sections.

- Rationale for Site Selection
- Proposed Design Considerations

3.3.1 Rationale for Site Selection

170. The proposed landfill has been selected on the basis that it must comply with basic Punjab government regulations, IFC EHS guidelines and US EPA Subtitle D 40 CFR for waste management facilities and the ADB SPS, 2009. The various factors that have been kept in focus while selecting the proposed landfill site are provided in **Table 3-2** below.

Table 3-2: Criteria for Site Selection

Factors considered for site selection	Rational for Site Selection
Landfill area and capacity to meet requirement of landfill site	There is adequate land area (approx. 110 acres) available at Mari Sheikh Shijra mouza Nouabad which can be used for landfilling for next 25 years. There is adequate land (10 acres) available adjacent to existing dumpsite for TS, MRF and AD Plant.
Accessibility of landfill site	The landfill site can be accessed via Mari Sheikh Sijra and Basti Yar Muhammad road. The construction of a 2.5 km access road and improvement of 10km of the existing main road has been included in the project. The MRF is also accessible through Khanewal Bypass Road however

Factors considered for site selection	Rational for Site Selection
	approximately 5 kilometres of road improvements will be necessary for the access road.
Site Stability	The site is located outside areas susceptible to natural or human-induced events or forces capable of impairing the integrity of landfill components. Examples of unstable areas are those with poor foundation conditions, areas susceptible to mass movements (landslides, rock falls, etc.) and areas with karst terrains (sinkholes). A geotechnical investigation has been carried out for the site and the design is based on the findings of this report.
Land Use	The selected land is owned by BWMC therefore no or limited land acquisition conflicts are expected. The adjacent land use of the proposed Landfill Site is a mixed type, i.e. desert and agriculture.
Critical Habitat/Sensitive ecosystem	The site is not located in critical habitats of plants, wildlife and sensitive ecosystems.
Restricted Zone, Wildlife/Forest Protected areas	The site is outside of any restricted zone/wildlife/forest protected areas.
Wetlands Control	The site is located away from wetlands.
Site should be located outside of the 10-year groundwater recharge area for existing or pending water supply development	The site is located outside of the 10-year groundwater recharge area for existing or pending water supply development. However, the area naturally causes the subsoil water recharge during the rainy seasons.
Perennial stream	No perennial stream is available within 300 meters of the proposed landfill cell development. Further bottom lining of each landfill cell and leachate collection system ensures that no contamination is entering into perennial streams. The surface water drainage network will avoid risk of surface runoff and contamination.
Topography	The topography comprises arid dunes with an undulating topography. The site topography generally slopes up towards the southwest raising from 115m in the north and eastern edges to 124m in the south and western site area. The geotechnical study shows that topography is suitable for development of landfill site.
Ground Water Table	The depth of groundwater at the location of the proposed landfill site is between 15-20 m below the ground surface.
Flood plain & other climate risks	The landfill is not located within a 100-year flood plain and will not reduce the temporary water storage capacity of the floodplain or result in washout of solid waste.

Factors considered for site selection	Rational for Site Selection
	Due to climate change considerations with chances of unprecedented flooding, proper monitoring and maintenance of the leachate collection system will be required, along with the appropriate lining of the earth. A surface water drainage network has been provided in the detailed design of the landfill site to avoid risk of surface runoff and contamination. The site will have a run on and run off control system.
Seismic Risk/Fault lines	Probabilistic seismic hazard assessment shows that the project area falls in Zone-2A with peak horizontal ground acceleration of 0.08g-0.16g i.e. negligible damage (ground motion with a return period of about 500 years) for soft rock foundation condition. Based on the project location, Seismicity influencing the project area, area geology, field and laboratory investigation data and proposed structures, design parameters are in accordance with guidelines of Pakistan Building Code (PBC-2007).
Private/ Public water supply wells	No public water supply exists downstream of 500 m from the site. Similarly, no other irrigation or livestock water supply wells located down gradient of the landfill boundaries around a perimeter of 500 metres.
Airport Safety Control	The Airport is located 5 miles radius (US EPA Criteria), at about 8 miles from the site to limit potential issues resulting from scavenging birds on flight operations.
Sensitive Receptors	The nearest sensitive receptors are located at a safe distance from the proposed site. The boundary of the LFS was taken as a measuring point. However, design of the landfill site will be adjusted with 250m buffer area away from any sensitive receptor as per IFC guidelines. Furthermore, no LARP is required for site as land has already been acquired in 2018.

3.3.2 Consideration of Bird Strike Hazards

171. Landfill sites at this distance (c12-13km from an aerodrome) occur across the world, hence, due to the distance of the landfill site from the airport, development should be feasible without increasing risks to aircrafts. Different interpretations of the elimination of waste management sites in the vicinity of aerodromes have been used globally. In some countries, such as the USA for example, landfill sites (that have the potential to attract thousands of birds that are hazardous to aircraft), are precluded from being built within 5km of an airfield but may be built elsewhere within the vicinity. In the UK, no developments are precluded but any that fall within 13km of an aerodrome are subject to local planning regulations that require consultation to preserve flight safety.

172. The new landfill development is located 13km WSW of the Bahawalpur Airport ARP and approximately 12km from the end of the 08-runway centreline. The site will replace the existing landfill site located approximately 11km NW of the runway. Due

to the proximity of the landfill to the western approach corridor to 08-runway it is possible that if hazardous species were attracted, some may thermal overhead or cross critical airspace which could then result in risks to aircrafts.

173. To determine whether this is likely to occur and how bird hazard management techniques could be implemented to reduce any potential risks, information on the species and numbers of birds that are likely to use the landfill site should be gathered. As the site does not currently exist, gathering information on the species, abundance and movements of birds that present a hazard to aircraft that use the existing landfill site would be recommended. Information could then be reviewed to develop a plan to minimise the presence of hazardous species using the new landfill and ensure the site does not increase the risks to aircraft operating out of Bahawalpur Airport.

174. Species that have been recorded in the area and may be attracted to landfill sites therefore include, but are not limited to, members of the Pigeon (*Columbiformes*), Gull (Laridae), Stork (*Ciconiformes*), Egret and Ibis (*Pelecaniformes*), Birds of prey (*Accipitriformes*) Corvids and Myna (Passeriformes) families. Indeed, records from the site of the new landfill site confirm that several of the above are present although no records from the existing landfill site were available.

175. As the new landfill is located slightly further from the airport to the existing site but is situated closer to the approach alignment of the 08-runway, caution will be required to ensure any potential risks are appropriately assessed. The presence of each hazardous species at the existing site and the numbers of birds currently attracted should be recorded along with their existing movements between feeding (the landfill site) and roosting / breeding sites. The likely attractions and potential impacts these may have when transmitted to the new landfill site on aircraft operating into and out from the airport can then be reviewed.

176. The airport itself serves the local community with small national flights and is not being used for international flights. Inter-city flights are operated twice a day hence the movement rate is very low. No strike information has been reported from the airport.

3.3.3 Proposed Design Considerations for Landfill

177. The design selection has a major influence on the construction, operation and restoration of the facility. To incorporate advancement in technology and changes, a periodic review of the design shall be carried out, as the lifespan of a disposal site from commencement to completion is long compared to other construction projects. Aspects that have been considered in the design are briefly discussed below.

Nature and Quantity of the Waste

178. Nature of waste that will be landfilled at Bahawalpur will be only municipal solid waste (MSW). It is regarded as waste generated by households and waste of similar nature generated by commercial and industrial premises, institutions such as schools, hospitals and other facilities inhabited by people, construction and demolition of buildings, and from public spaces such as streets, markets, slaughterhouses, public toilets, bus stops, parks and gardens.

179. Project design has proposed a set of mechanical & biological treatment (MBT) options after detailed techno-economic assessment:

- It is estimated that all the waste streams except the bulk waste will be diverted to the MRF which will be in Khanu Wali.

- For the first five-years, The MRF will be able to recover five (05) percent of valuable material from the waste while all the rest of the waste (organic, inert) will be sent into the landfill. This waste will then be used for gas recovery starting from 3rd year until the post closure of the land fill until 10 years.

- The recovery percentage will gradually increase up to 15% to 20% of waste in future. The quantities of the waste diverted to material recovery facility and the mass balance is presented in the **Table 3-3.**

Table 3-3: Year wise Waste Generation

Year	Generation (t/d)
2028	524
2029	540
2030	557
2031	573
2032	591
2033	609
2034	628
2035	647
2036	666
2037	685
2038	706
2039	727
2040	748
2041	770
2042	792
2043	815
2044	840
2045	864
2046	889
2047	914
2048	941
2049	967
2050	995

Source: EDCM Updated FS Report, 2023

180. The major chunk of the organic waste along with the bulk waste and the MRF residual will be delivered to the sanitary engineered landfill for final disposal shown in table below:

Table 3-4: Waste Disposal to Landfill

Year	Landfill Input (t/d)
2028	369
2029	382
2030	423

Year	Landfill Input (t/d)
2031	440
2032	433
2033	448
2034	494
2035	512
2036	529
2037	529
2038	548
2039	568
2040	587
2041	607
2042	618
2043	639
2044	661
2045	683
2046	707
2047	705
2048	730
2049	754
2050	780

Source: EDCM FS Report, 2023

181. This would reduce the waste reaching the LFS and hence ensure the optimum land utilisation.

Protection of Soil and Water

182. A bottom and cap lining system for each landfill cell has been designed for the protection of soil, groundwater and surface runoff. The liner system may consist of a natural or artificially established mineral layer combined with a geo-synthetic liner that must meet prescribed permeability and thickness requirements. Single composite liner system in compliance to US EPA Subtitle 40 CFR requirements is proposed by the EDCM.

Leachate Control and Management

183. An efficient leachate collection and removal system (LCRS) has been provided to ensure leachate accumulation at the base of the landfill and keep it to a minimum. The leachate system will consist of a leachate collection layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) with pipe network to convey the leachate to a treatment facility. A three-stage open leachate treatment pond including potable anaerobic treatment system will be adopted for leachate treatment.

Gas Recovery and Reuse

184. The accumulation and migration of gases from the landfill facility must be controlled. Landfill gas will be collected through installation of perforated pipes within the cells. This gas transferred to gas recovery unit where it receives subsequent treatment and utilisation, or disposal in a safe manner through flaring. Initially 1000m^3 flaring system is provided in the conceptual design to manage landfill gas.

185. For the first five-years, the MRF will be able to recover five (05) percent of valuable materials from the waste while all the rest of the waste (organic, inert) will be dumped into the landfill. This waste will then be used for gas recovery starting from the third year until the post closure of the land fill until 10 years.

186. The recovery percentage will gradually increase up to 15% to 20% of waste in future.

Odour/Litter/Vector Control

187. Daily covers will be provided at end of each day to avoid risk of fire, wind littering, odour, vector breeding and dust hazards in the landfill. The working surface of waste will be covered with a soil layer called "daily cover" at the end of each working day. Amount of soil to be used in daily cover will be about 10% of the waste volume. Suitable quality of excavated material can be used as daily cover material.

Stability

188. Consideration has been given to the stability of the sub-grade, the base liner system, the waste mass and the capping system. The sub-grade and the base liner will be sufficiently stable to prevent excessive settlement or slippage.

Visual Appearance and Landscape

189. Consideration has been given to the visual appearance of the landfill site during operation and at the termination of the landfill site. Necessary plantation will be carried out, which will act as a buffer zone from the surrounding environment. A reasonable area has been allocated for plantation within and at the boundary of the proposed facility to improve landscape of the area.

Operational and Restoration Requirements

190. The Landfill will be operationalised in a phased manner. Site infrastructure has been included for the provision of; administration building, lookout tower, weighbridge, waste inspection area, wheel wash area, site services and security fencing to meet operational and restoration requirement.

Monitoring Requirements

191. A series of gas and groundwater monitoring wells will be installed around the perimeter of the landfill to monitor for landfill gas and leachate migration offsite. The wells will be installed as permanent features and will be monitored on a biannual basis during construction to ascertain the baseline and then quarterly throughout the operation of the landfill.

192. Gas monitoring wells should be installed such that they are perforated from 1m bgl until the base of the filled materials. Nested wells may be necessary depending on the geological conditions. Each well should be monitored for Methane, Carbon Dioxide, Volatile Organic Compounds, Hydrogen Sulphide, Ammonia, Oxygen, Temperature, Flow Rates, Atmospheric and Borehole Pressure. Consideration should be given to installing automatic monitoring sensors in regions nearest to receptors such as GasClam ®. The frequency of monitoring should be at least monthly with

consideration of daily monitoring near active cells. An action plan should be developed in the event that cross-boundary migration of landfill gas is detected

193. Groundwater monitoring should be undertaken quarterly and as a minimum for pH, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) Heavy Metals and Trace Elements, Nutrients (Nitrogen and Phosphorus), Total Suspended Solids (TSS), Volatile Organic Compounds (VOCs) plus any other determinants required by the local operating permit. A full suite should be undertaken annually, with reduced suites undertaken at other times after the first years monitoring and only if non-detectable concentrations measured. The limit of detection of the laboratory analysis should be below the screening criteria used.

194. Dust monitoring should be undertaken via automatic sensors positioned strategically through the site by operations and should be undertaken continuously throughout operating hours.

195. The results of all environmental monitoring will be collated into an annual report to be shared with ADB and necessary stakeholders. Monitoring methodology and frequency should be reviewed and amended if necessary, depending on the results and only if agreed with ADB.

3.3.4 Detailed Process Description

196. The following are the major operations that will be performed at the Bahawalpur Landfill site:

- Reception of the incoming waste stream;
- Placement and volume reduction of the waste through mobile compactors such as bulldozers;
- Installation of the landfill and environment control facilities.

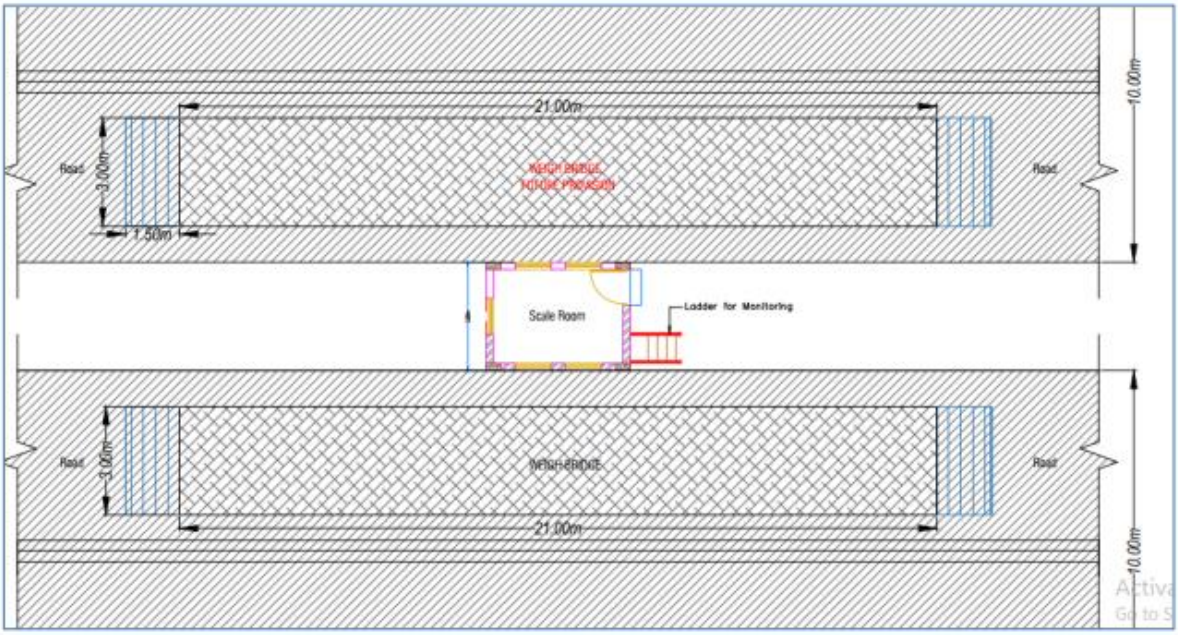
197. In a landfill, waste is spread in thin layers, compacted to the smallest practical volume and covered with the soil or other suitable material at the end of each day. When the disposal site reaches its ultimate capacity, a final layer of cover material is applied.

198. The detailed process description for disposal of MSW at the proposed site is presented in the following sections.

Weigh Bridge and Unloading Bay

199. Prior to unloading, the trucks will pass over a weight bridge to determine the exact amount of collected garbage from the city every day. In order to minimise the solid waste collection vehicle's circulation inside the landfill boundary and to reduce emissions and odours, an unloading bay has been incorporated in the design. To reduce the possibility of littering, incoming collection vehicles will empty the waste on the tipping floor outside the building to reduce the circulation at the site. Weighbridge of 100 tons' capacity will be installed at the entrance gate for Bahawalpur landfill site. A pit type weigh bridge of size 20X5 m having modular cubical bolting assembly will be installed on steel platform which will be fixed on RCC raft. A schematic diagram of the weighbridge is shown in **Figure 3-2** below**.**

Figure 3-2: Schematic Diagram of Weigh Bridge



Sorting Facility

200. The most suitable technological option for handling 524 tpd combination of mechanical and biological treatment options enabling around 95% of the organics, recyclables and combustibles from the landfill and saving landfill airspace for longer time, recovering the economic potential of the waste and improving the environment through reducing the methane emission from the landfill. Organic waste generated from sorting facility will be diverted to the compositing plant and bio-digester.

Composting

201. Limited composting (5 tpd) will be carried out at the new landfill site from source segregated waste from commercial waste generators that is animal dropping (dung), green waste and wood waste from nurseries, vegetable and fruit market and restaurants. The remaining organic waste will be utilised in the landfill in order to produce gas for recovery and revenue generation.

202. During the design phase, the feasibility of different organic waste treatment has been considered in detail, nonetheless, an area for biological treatment of organic waste has been set aside at the MRF location. All the waste collected from the city will first reach the MRF for sorting and segregation. From there, organic waste and residual waste will be transported to the compositing area for final treatment and disposal. The compost plant is located at new landfill site in Mari Sehikh Shijra.

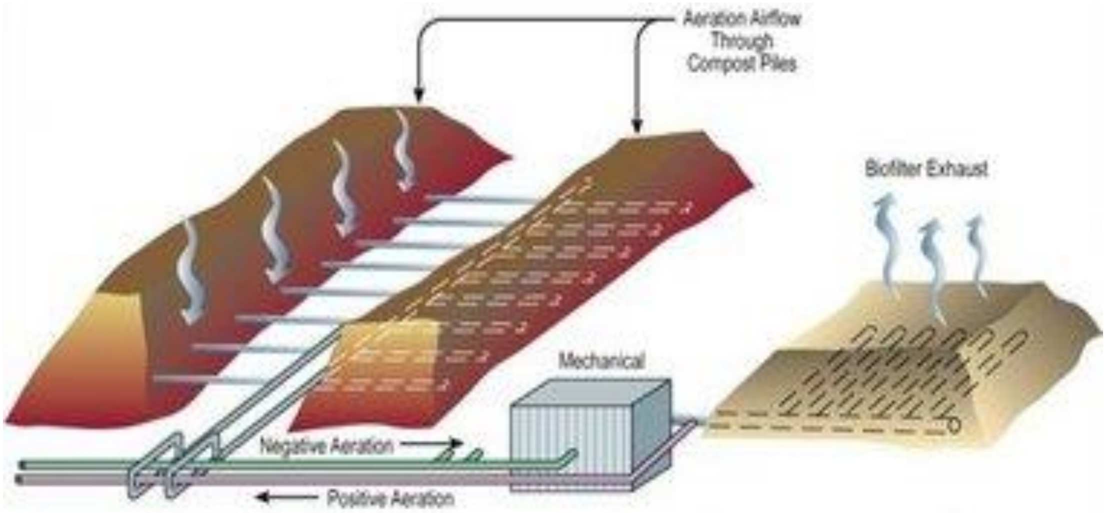
203. The methodology will be aerated static pile (ASP) composting with a capacity of 05 tons/day. In ASP composting, perforated pipes are placed on the ground that are connected to a blower to push (positive) or pull (negative) air through the compost to promote biodegradation. Static piles offer process control for rapid biodegradation, and work well for facilities processing wet materials and large volumes of feedstocks.

204. Advantages of this composting method include the ability to maintain the proper moisture and oxygen levels for the microbial populations to operate at peak efficiency to reduce pathogens, while preventing excess heat, which can crash the system. Aerated systems also facilitate the use of bio filters to treat process air to

remove particulates and mitigate doors prior to venting. However, aerated systems can dry out quickly and must be monitored closely to maintain desired moisture levels.

205. One composting building measuring 20X60m with a capacity of 5 tons per day is proposed. One for active composting process and a second for curing, screening and packaging. About 2400 square meters' open area is required for receiving raw material and processing. The total area requirement for compost plant is 3 Acres.

Figure 3-3: Aerated Static Pile Composting for Bahawalpur Landfill



Construction and Demolition (C&D) Waste Recycling

206. Construction and Demolition (C&D) waste recycling will be carried out through a dedicated unit. The construction and demolition waste recycling are simple, and 100 percent can be recycled, reused and diverted from the landfill. The Construction & Demolition facility will be constructed at the new landfill site to process 5 tpd. The machinery capacity can be enhanced to process a maximum of 30 tons per day through C&D plant extension for which area is available at the site. The construction and demolition waste recycling will promote sustainability by achieving diversion goals from the landfill.

207. The Waste Amount Characterisation Survey (WACS) study estimated C&D waste as 10% of total waste generated. Assuming fifty percent out of this estimation is C&D waste, a minimum of 30 tons per day of construction and demolition waste is generated in Bahawalpur City. C&D waste will be collected via dedicated C&D contractors and all components of waste will be processed, recycled and reused.

208. Construction & Demolition waste is collected right from its point of generation and is subsequently transported directly to the dedicated Processing facility situated at the Landfill Site (LFS) through a designated C&D contractor.

209. The treated Construction & Demolition waste will serve a dual purpose: it will be utilized for wet weather roads within the landfill area, as well as used as a daily cover material for the landfill cells. Designated 41ompl cover storage area is provided in the landfill design which will be utilised for storage of C&D processed waste. Below are the interventions planned for C&D waste recycling:

- Recovered Asphalt Concrete can be mixed in Recycled concrete or reused by mixing with fresh Asphalt concrete and will be used as wet weather roads.
- All metal can be recovered and recycled.
- Wood component can be processed and used as mulch or raw materials for compost.
- Processed waste can be used as Cover material for landfills.

210. The volume of construction and demolition waste is low. A locally made custom designed concrete crusher with screen and conveyor system would be adequate equipment. A dust control system would be installed. One medium size shovel and one bob cat would be required for feeding and maintenance of stockpiles. Since the project will be developed under a Design Build Operate (DBO) Contract, the exact equipment specifications are not available at present. However, a 'Typical' view of a C&D recycling plant is provided in below **Figure 3-4.**

Figure 3-4: C&D recycling plant at proposed landfill site

3.4 Component 2 – Legacy Landfill Restoration & Construction of MRF

211. The Legacy Landfill and proposed MRF facility are located in Khanu Wali at 29°25'37.63N 71°38'01.53E c.3.8km to the northwest of Bahawalpur City centre. The legacy landfill occupies an approximately square c.12acre plot of land and the proposed MRF facility is located to the north of this site also on a square c.12acre plot.

212. Ground levels in the vicinity undulate between 112 and 116m above sea level (m.asl). The nearest natural surface water is the River Sutlej located 0.5km east with the river channel at 112m m.asl. Man-made irrigation channels cross-sect the region fed from the Sutlej River; the closest channel is located adjacent east of the MRF site.

213. The nearest residential dwellings are located adjacent to the south, 0.1km east and 0.1km north.

214. This section includes project details for the:

- Construction of a new MRF facility (including the anaerobic digestion (AD) plant, transfer station (TS), plastics recycling facility (PRF). Due to be completed Q1 2028.
- Construction of a new access road and improvements to existing access roads. Due Q1 2028.
- Closure of an existing transfer station at Q1 2028; and
- Closure and Restoration of the Legacy Landfill by Q4 2030.

3.4.1 Material Recovery Facility (MRF)

215. A state-of-the-art MRF facility of 60 tph capacity will be created to recover the recoverable recycles from mixed MSW. Initially the recovery will be less, but it will increase gradually as primary waste collection incorporates confining of waste at the point of waste generation and the door to door waste collection system is implemented.

216. The site is located on a 5ha parcel of land adjacent to the current legacy landfill. No part of the legacy landfill site will be utilised for the MRF facility.

217. The proposed layout of the MRF is presented in the **Figure 3-5, Figure 3-6** and **Figure 3-7.**

Figure 3-5: MRF & Legacy Landfill Location

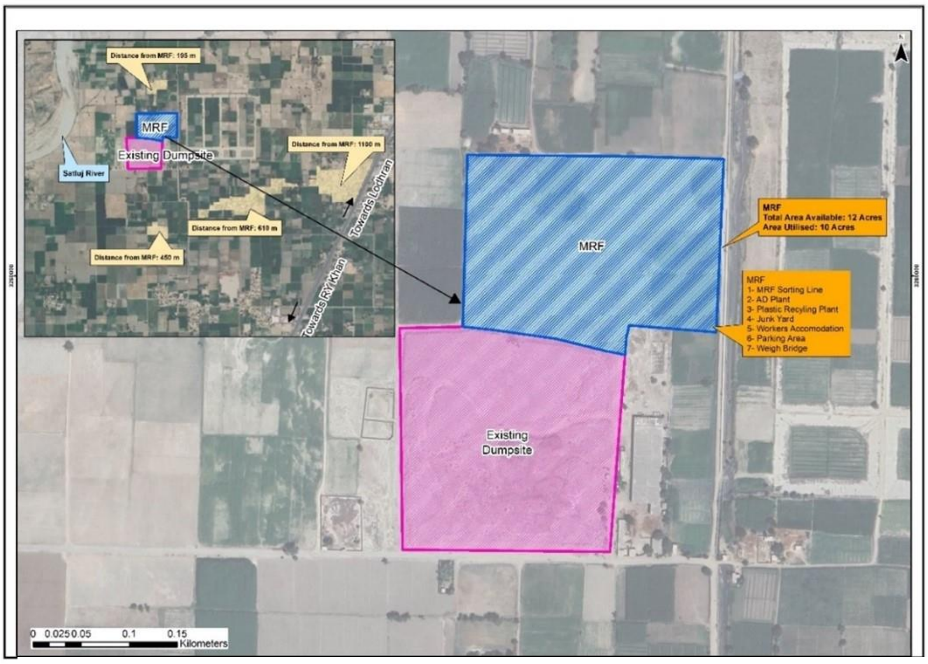


Figure 3-6: MRF Site Layout

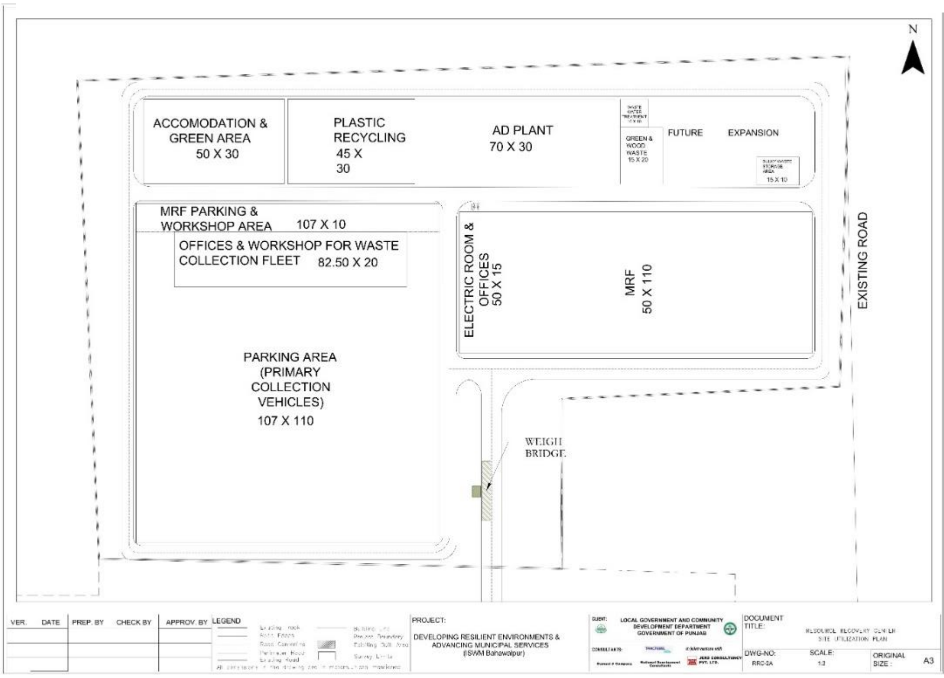
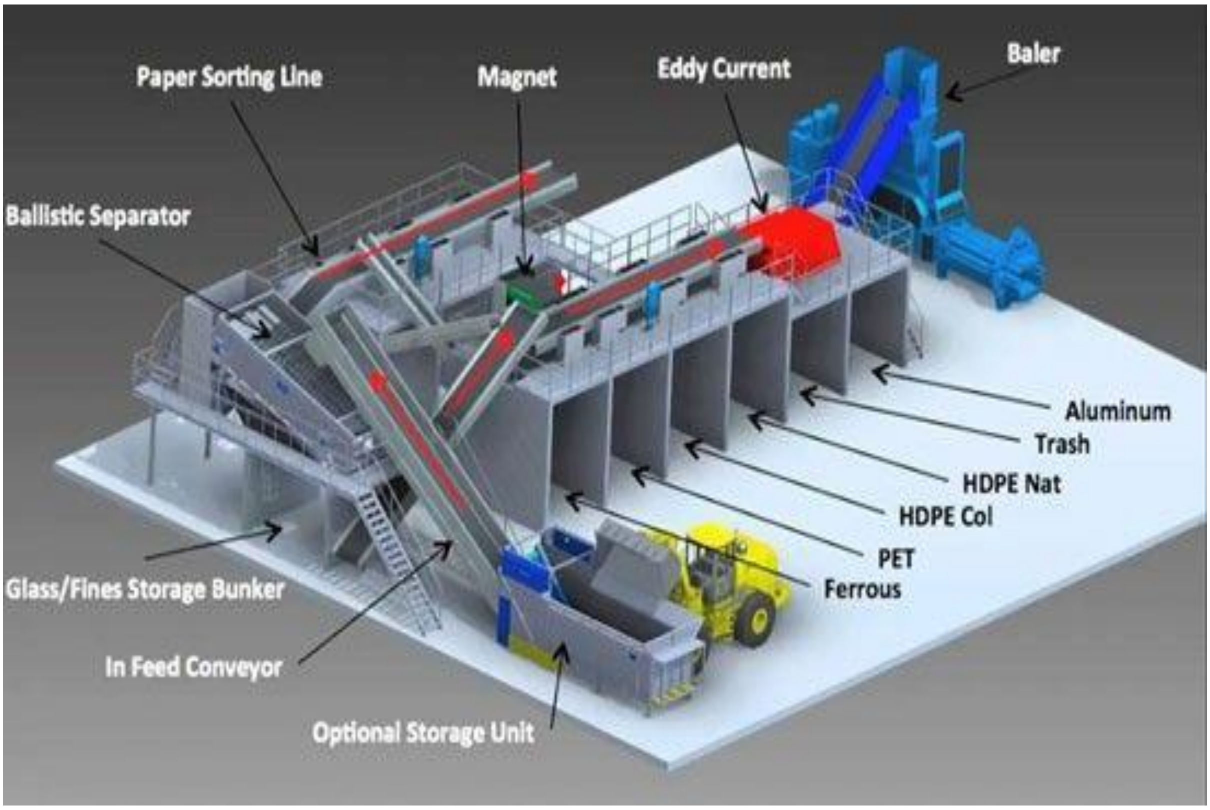


Figure 3-7: 3D view of a "Typical" MRF Facility.



Source:https://www.wastetodaymagazine.com/news/future-proofing-a-material-recovery-facility-sponsored-content/

218. The sorting area will be constructed with steel structures for the roof with a ceiling height reaching approximately two stories' high.

219. The project will be developed under a Design Build Operate (DBO) Contract, thus the exact equipment specifications are not available at present. However, at this stage, the process flow description and 3D view of a 'typical' MRF are provided as **Figure 3-7**: 3D view of a "Typical" MRF Facility. above.

220. The operations involved in the MRF are described below:

- Waste will be off-loaded on a tipping floor at the MRF. The floor is divided into three chambers to ease the operations on a first-in, first-out basis. The overall area can cater for 'two days' offloads, keeping a safety cushion for routine maintenance shutdowns. From the tipping floor a front-end loader will carry waste in batches and load it into a hopper. A bag opener is installed at the beginning of the segregation process. It will be used to open the closed bags. It will also work as a metering input device to control the throughput.

- After passing the bag opener, the waste will pass through a small horizontal conveyor belt, where larger components of the waste will be removed manually before entering other sorting equipment. The removal of large items from the sorting line will not only safeguard the facility against unnecessary loading of bulk waste, but it will also save the mechanical equipment from avoidable wear and tear. At the end of pre-sorting conveyor belt, a magnet will be installed to recover ferrous metals.

- Waste will then pass through a trommel screen with two distinct opening sizes of <90 mm and <6 mm. Material below 90 mm is mostly organic, which will be dropped into trolleys placed right underneath the trommel. Once filled, the trolleys will be transported by tractors for further processing.
- The material < 6 mm which is primarily inert or fines, will also be collected in a trolley and taken to the new landfill. This reject from MRF can be used as cover soil in waste cells.
- After the trommel screen, waste will pass from a Ballistic Separator and will be separated into two main streams:

  a) 3D or rolling fraction where all PET, HDPE, PP and other heavy fractions tend to jump towards the lower end of the system; and

  b) 2D or flat fraction where all film and flat material tends to move upwards.
- During this process, material is continuously shaken and consequently the dust and 'fines' are screened by the perforated surface of the blades. Dust and fines will be collected at the end of MRF daily operation.
- To prevent the suspension of dust in the air, the following design considerations will be incorporated in the MRF facility:
  - Incorporation of general ventilation throughout the MRF
  - Implementation of Local Exhaust Ventilation (LEV) systems
  - Utilisation of respiratory protective equipment for staff.
- Another chamber then separates non-ferrous metals with the help of Eddy-Current technique of aluminium sorting.
- The material is then fed onto a manual sorting conveyor belt located inside the picking station where plastics, glass, paper, cloth and other materials are picked before non-ferrous metals. Manual waste sorting will be collected in containers placed beneath the chutes, which will be emptied into their designated areas within the sorting facility. These materials can then be consolidated with the help of balers for ease of transportation.
- Recyclables and refuse derived fuel materials are fed onto a baler automatically to be packed in the shape of blocks. These are then stored for transportation to market. A storage facility will be erected within the MRF, featuring a temporary storage capacity for approximately 1 to 2 days.
- An industrial size shredder is proposed for reducing the size of larger waste components. The whole facility will have ventilation installed for creating a comfortable environment for the waste picking team.

221. The processing capacity of the MRF will be 60tpd with the recycling and diversion target from mixed waste streams provided below.

Table 3-5: Recycling and Diversion Targets

Recyclables Recovery Targets-Addition in Capacity after 05 years		
Sr No	**Description**	**Target**
1	AD plant	5 tpd
2	Mixed Waste Recycling Plant	10 tpd
3	C&D Plant	5 tpd

4	Bulk Waste	1 tpd

Plastic Recycling Plant

222. A plastic recycling plant of 10 tpd capacity has been proposed at MRF to process plastic waste and convert it into flakes and granular materials. 10 tons/day of plastic waste will be processed using this facility. Out of 50 tpd plastic obtained from MRF, about 10 tpd plastic will be recycled while remaining will be landfilled.

The process of a plastic recycling plant involves the following steps:

- **Collection and Sorting:** Plastic waste is collected from the city, such as households, & businesses. The collected plastic is then sorted based on its type and composition. Common plastic types include PET (polyethylene terephthalate), HDPE (high-density polyethylene), PVC (polyvinyl chloride), LDPE (low-density polyethylene), and PP (polypropylene).
- **Shredding and Washing:** The sorted plastic waste is shredded into smaller pieces to increase surface area and facilitate the subsequent processing steps. The shredded plastic is then washed to remove impurities, such as dirt, labels, and residual contents.
- **Melting and Extrusion:** Only PET will be converted into flakes and remaining are melted down using heat. The melted plastic is then forced through an extruder, which is a machine that shapes the molten plastic into a continuous forms, such strands or pallets.
- **Granulation:** The extruded plastic is further processed through a granulator, which cuts the plastic strands or pellets into small, uniform-sized granules. This step improves the quality and consistency of the recycled plastic.
- **Further Processing:** The recycled plastic granules or pellets can be used in various applications, depending on the quality and type of plastic. They are used as raw material in the manufacturing of new plastic products, such as bottles, containers, pipes, packaging materials, and even clothing.
- The capacity of the plant will be 1 ton/hr running for 10 hours, 10 tons per day of processing.
- The components of plastic recycling include: (i) Feed conveyor (ii) Grinder – Shredder (iii) Washing Line (iv) Agglomerate (v) Granulator (vi) Extruder (vii) Bagging plant (viii) Building size 15m x 30.

3.4.2 Residual Waste Transfer from MRF to LFS

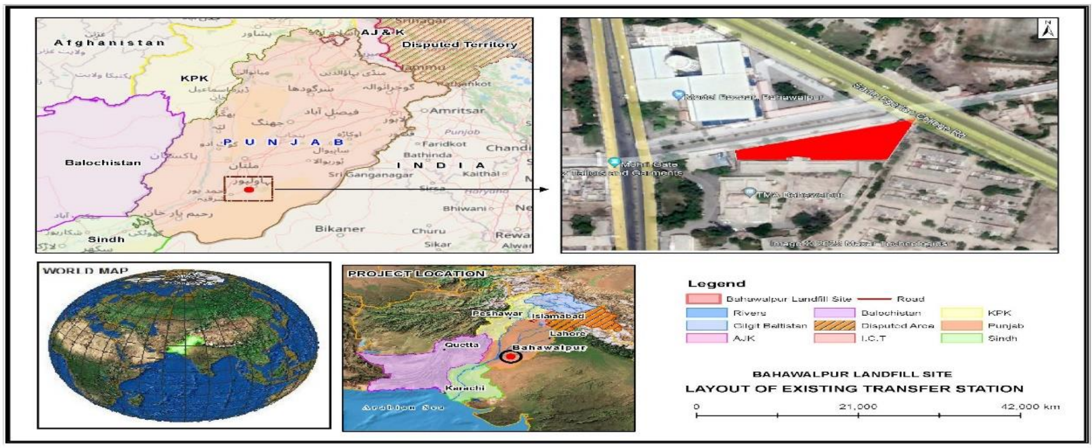
223. The residual waste after the removal of all the recoverable recycles at MRF will be baled. Two X 50 tons/hour, high-speed high-volume balers will be used for baling the residual waste. The baled waste will be transported to the LFS utilising 30–35-ton transfer-trailers. The use of transfer trailers will reduce the number of trips to the LFS and minimize the emissions for secondary transport by 60-70% compared to utilizing open-top trailers with a capacity of 18-20 tons/trip.

3.4.3 Transfer Station

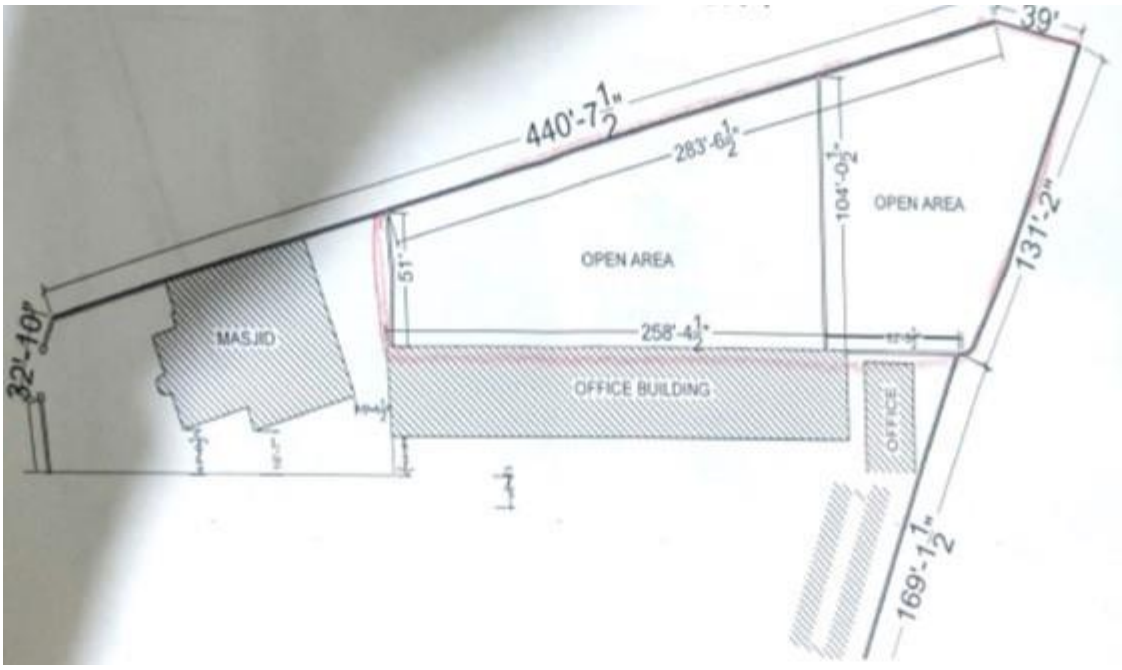
224. Currently, most waste collected by collection vehicles is taken to the TS at stadium road, TMA, Bahawalpur. This site has an area of 3.63 acres. The coordinates of the existing TS are 29.399457 N and 71.684874 E.

Figure 3-8: Location and Layout of Existing transfer station of Bahawalpur

a) Location of Existing Transfer Station



b) Layout of Existing Transfer Station



225. The existing TS will be dismantled, and a new TS will be established as an integral component of the MRF at Khanu Wali.

226. The following types of TS are proposed as part of this project but will be confirmed during detailed design:

- **Mini Transfer Station** – Arm Roll vehicles containers of 15-20 m^3 size, placed along a ramp in enclosures
- **Mobile Transfer Station** for vehicle-to-vehicle transfer – where space is constrained, large vehicles, like compactor trucks, could be used for emptying small collection vehicles.

- **Main Transfer Station** These TSs could be coupled with segregation or MRFs, reducing load on the actual landfill site. TSs will serve for transfer of waste from small capacity to large capacity vehicles to haul waste at SWMF.

3.4.4 Anaerobic Digestion Plant (AD Plant)

227. An AD Plant of 25 tpd will be installed at the MRF. AD is a process in which organic matter, such as food waste, animal waste and sewage sludge, is broken down by microorganisms in the absence of oxygen. This process produces biogas. The remaining digested material, called digestate, can be used as a fertilizer which is rich in nutrients.

228. Some of the generated gas is consumed by the AD plant while the remaining will be converted into electricity providing renewable energy to fuel the MRF operations. This will ultimately decrease the operational expense of each facility at the MRF.

229. The design and operation of this anaerobic digestion plant depends on factors such as organic waste being processed, the desired biogas production, and the intended use of the biogas and digestate. The plant would typically consist of the following components:

- **Feedstock receiving and pre-processing:** The organic waste is delivered, sorted, and prepared for the digestion process.

- **Digesters:** The feedstock is then transferred to anaerobic digesters, which are sealed containers where the digestion process occurs. The anaerobic process generates enough heat require to maintain the required temperature within the digesters[4] to support the growth of anaerobic bacteria responsible for breaking down the organic matter.

- **Biogas collection:** The biogas generated is stored in biogas bags. This gas will be used as a fuel for generating electricity.

- **Liquid fertilizer:** The liquid fertilizer is rich in nutrients and is used as a fertilizer in agriculture or horticulture.

- **Gas treatment and utilization:** Biogas produced will be purified to remove impurities, such as hydrogen sulphide and moisture. The purified biogas is used directly in gas engines to generate electricity.

230. The project is designed to treat 12.5 tons per day of fresh cow manure and 12.5 tons per day of segregated food waste.

231. **Parameters:** Biogas production: Total volume of biogas digester: 1400m3 (14*210M3) (for a 210m3 model assembly digester, the fermentation capacity 100m3, gas storage capacity 90m3) • Biogas storage capacity: 900m3

232. **The structure and scale of the project**: The project is composed mainly of 14 nos. of 210m3 assembly membrane digesters, a pre-treatment tank, a biogas digestate storage tank, a 1,400m3/d gas purify system.

233. The biogas digestate in the storage tank is dehydrated to separate the liquid and solid to make solid organic fertilizer, the liquid is pumped into the aerobic treatment plant to treat it clean to be discharged. Since the project will be developed

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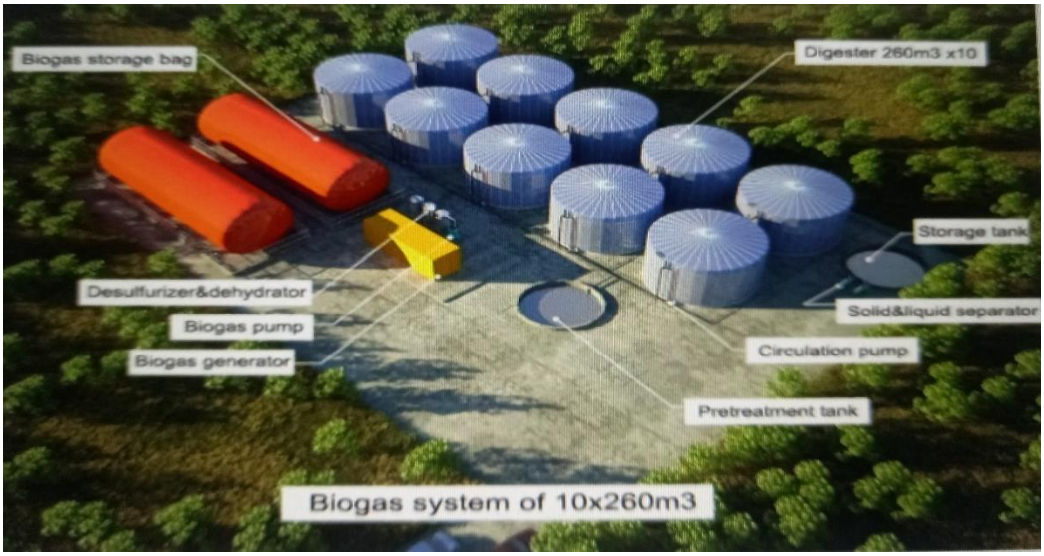
[4] PUDP EDCM Phase 1 Pakistan P.730409 May 2023

under a Design Build Operate (DBO) Contract, thus the exact equipment specifications are not available at present. However, a 'Typical' AD plant is shown in the **Figure 3-9** below.

Figure 3-9: Typical Layout of AD Plant



Source:Shenzen Puxin Technology, 2023

3.4.5 Legacy Landfill Site at Khanu Wali.

234. A detailed feasibility study of the site including assessment of current Khanuwali dumpsite and regeneration, and site closure plan will be carried out.

235. Waste generated in Bahawalpur is currently dumped at a site located at 29.425817 N, 71.633416 E. It is estimated by BWMC that 80% of the waste generated is being collected and disposed of in an un-engineered landfill site.

236. This site is square, comprising of 12 Acres of Land and is located adjacent to the south of the land proposed for the MRF.

237. The legacy landfill will continue to accept waste until the new landfill is operational in 2027, and at which point it will be closed and rehabilitated. A site closure plan has not been finalised for this site but will be created and agreed prior to its closure in 2027.

238. Images of the landfill site are shown below:

Figure 3-10: Bahawalpur Landfill Images

239. Satellite imagery indicates the site was agricultural land until it was excavated in 2010 during the construction of the adjacent (east) but is now an abandoned wastewater treatment plant. The excavation was c.3m depth with surrounding land at 115m asl and the base of the excavation at 113m asl.

Figure 3-11: Construction of the Legacy Landfill Void

240. The site lay dormant until 2016 when the first evidence of landfill is notable. As illustrated in **Figure 3-11**, filling commenced in the northwest corner and progressed southwest across the void. On at least one occasion, it appears that a soil covering has been placed over the waste, presumably to manage odour, pests and blown litter issues. The placement of the covering also facilitated additional waste disposal over

the existing fill. As shown in **Figure 3-12** waste disposal has continued at the site to the present day and appears to now be spreading onto the adjacent proposed MRF project area.

Figure 3-12 Evolution of the Legacy Landfill

Legacy Landfill and MRF area Prior to Waste Disposal (February 2016)

Early Stages of Waste Disposal (October 2016)

Intermediate Stage of Waste Disposal (April 2018)

Possible Soil Covering of Waste (December 2018)

Legacy Landfill Condition May 2023 with waste disposal evident on the adjacent MRF project area.

241. The current depth of waste deposited is estimated to be c.3m, however it has a further 4 years of waste deposition prior to the commissioning of the new regional landfill (Component 1 of this project) so the ultimate volume is likely to be substantially greater than currently. Assuming that waste disposal can be limited to the existing landfill area, and it is likely that the final fill level will be significantly above the surrounding ground level. To achieve this, it is likely that additional soil covering would be needed to provide a working surface for the ongoing fill operation. Clearly, there is a risk that waste disposal could continue to spread across adjacent areas, including the proposed MRF site.

242. A full site characterisation and site closure plan including monitoring regime will be agreed prior to its closure in 2027. It is anticipated that rehabilitation will involve capping of the landfill surface and the installation of a landfill gas recovery system to minimize and eventually stop harmful air emissions.

243. Given the limited rainfall in Khanu Wali, leachate generation is considered likely to be minimal. However, further investigation and monitoring will be undertaken to understand the leachate potential and establish the baseline conditions. The contamination situation of the site is likely to worsen from continued migration of leachate and this contamination will continue for next 60 years or more. A full site investigation of the surrounding geology, hydrology and hydrogeology will be undertaken to ensure that migration pathways are characterise and any risk mitigation measures can be appropriately designed.

244. The site mitigation and remediation specification are very stringent and require a closure cap together with LFG recovery system and flaring of landfill gas. The current plan for the rehabilitation of the legacy landfill is provided in the **Table 3-6** below.

Table 3-6: Rehabilitation Plan of Existing Dumpsite

Sr. No.	Activities to be conducted for site clean up	Timeline
1	• Site Characterization and Conceptual Site Model o A detailed site investigation will be undertaken around the perimeter of the landfill site comprising 8-10 permanent boreholes. The boreholes will be drilled to c.15m depth below ground level with detailed logging undertaken to BS5930. Records should be taken of any perched water layers and wells should be designed such that they do not create preferential pathways between perched, shallow and deeper groundwater. Wells will be installed with nested wells capable of monitoring gas and groundwater and different horizons down to 15m and should be installed as permanent wells protected from damage with metal, lockable covers. o The site characterization plan will fully address risks posed by the landfill to ecology, surface water, groundwater, human health of local residents and staff working at or near to the landfill and explosion risks posed by the migration of landfill gas.	2024-2025
2	• A series of gas and groundwater monitoring wells will be installed around the perimeter of the landfill to monitor for landfill gas and leachate migration offsite. The wells will be installed as permanent features and will be monitored on a biannual basis during construction to ascertain the baseline and then quarterly throughout the operation of the landfill. • Gas monitoring wells should be installed such that they are perforated from 1m bgl until the base of the filled materials. Nested wells may be necessary depending on the geological conditions. Each well should be monitored for Methane, Carbon Dioxide, Volatile Organic Compounds, Hydrogen Sulfide, Ammonia, Oxygen, Temperature, Flow Rates, Atmospheric and Borehole Pressure. The frequency of monitoring should be at least monthly for the first 24 months and depending on findings should be reduced or increased. An action plan and risk assessment should be developed in the event that cross-boundary migration of landfill gas is detected. • Groundwater monitoring should be undertaken quarterly and as a minimum for pH, Chemical Oxygen	2025-2027

	Demand (COD), Biological Oxygen Demand (BOD) Heavy Metals and Trace Elements, Nutrients (Nitrogen and Phosphorus), Total Suspended Solids (TSS), Volatile Organic Compounds (VOCs) plus any other determinants required by the local operating permit. A full suite should be undertaken for the first year of monitoring, with reduced determinants undertaken after the first years monitoring and only if non-detectable concentrations have been recorded. The limit of detection of the laboratory analysis should be below the screening criteria used. • Dust monitoring should be undertaken via automatic sensors positioned strategically through the site during rehabilitation. • The results of all environmental monitoring will be collated into an annual report to be shared with ADB and necessary stakeholders. Monitoring methodology and frequency should be reviewed and amended if necessary, depending on the results and only if agreed with ADB or their advisors.	
3	• Based on the information gathered during the conceptual site model, a **site closure plan** for the landfill will be prepared, detailing how landfill gas and leachate risks will be managed throughout the lifetime of the landfill. Active gas and leachate generation should be anticipated for c.30-50 years. • The site closure plan will include: o Details of how the site will be capped and restored (e.g. grassland/shrubs). o Details of how surface water will be managed to prevent infiltration into the waste. o Details of how landfill gas will be monitored on and offsite, and what actions will be taken to reduce risks to local receptors if elevated gas readings are detected. o Details of how leachate will be managed and treated and what offsite monitoring will be undertaken. o Modelling to ascertain whether landfill gas generation will be sufficient to use for energy production. o Details of the long-term monitoring plan for gas, groundwater and surface water at the site. o Details of how the site will be secured and maintained for c.30 years and how this will be funded.	2027

4	Interim measures to improve operations at the legacy landfill will be discussed with BMWC. As a minimum, whilst still operational, daily cover will be added to the tipping areas and gas and groundwater wells will be installed around the perimeter with monthly monitoring undertaken. A risk assessment will be undertaken if offsite migration of landfill gas is detected, and passive gas venting measures will be installed to control risks to off-site residents or site users.	2024-2027
5	Once the site closure plan is agreed and the new landfill from Component 1 is open, the site will be remediating and regenerated in accordance with the site closure plan.	2027-2028
6	Continuous monitoring will be undertaken both onsite and of the perimeter monitoring wells. Frequency should be monthly until conditions have stabilised, at which point the frequency will be agreed with the PMU. More frequent monitoring may be necessary if off-site migration of landfill gas is occurring depending on the findings of a detailed risk assessment. Consideration will be given to installation of continuous monitoring and telemetry for landfill gas monitoring particularly on any boundaries with nearby residential or commercial land uses.	2024-2050
7	Conversion of the remediated site into the solar park to generate electricity for the TS and MRF.	2028

3.5 Component 3: Waste Collection & Transport

245. This section provides a review of the existing waste collection system in Bahawalpur and the proposed changes because of this project to provide an integrated waste collection and disposal solution. Section 3.5.1 describes the existing waste collection system and Section 3.5.2 describes the proposed adaptation measures to be undertaken as part of this project.

3.5.1 Existing waste collection system in Bahawalpur

246. The existing solid waste management system of Bahawalpur is being managed by the BWMC. The existing solid waste collection in general is divided into primary and secondary collection systems. However, there is no proper solid waste disposal system in the town and no sanitary landfill site exists. The existing collection system is shown as **Figure 3-13.**

The key issues are identified as:

- Waste is only collected from a limited number of households
- Unauthorised dumping of household waste
- Unpaved roads generate dirt
- Poor areas have narrow access
- Sweepers depend on private work
- Inadequate equipment
- The BWMC lacks strategic direction, an under-developed workforce and poor management systems
- Inadequate planning capacity, poor information and weak financial management
- The administration is typically absorbed by its own internal procedures and processes, and largely deaf to the needs of citizens and communities
- Information is still managed using a manual, paper-based system with a high level of inconsistencies, long outdated records and difficult access and retrieval. This makes for ad hoc, arbitrary decision-making with neither transparency nor accountability
- The equipment and machinery of the SWM department is also constantly being used for removing encroachment and debris from roads
- Similarly, management complains that due to the negligence and inefficiency of line departments, their workload also increases such as whenever there is construction of new roads, streets or laying of new sewerage line or water supply etc.
- Existing institutional arrangements for SWM suffer from fragmentation, lack of clear division of responsibilities, and inadequate planning, management and enforcement capacity
- The legal and regulatory framework for SWM has shortcoming that limits its effectiveness. The main weaknesses are fragmentation and lack of clear allocation of duties and responsibilities. Existing solid waste management system is shown in **Figure 3-13** and describe in Table 3-6**.**

247. BWMC have currently deployed 89 vehicles of different types and capacities to collect and dispose the 283 tpd waste generated on daily basis. Most of this fleet is quite old and may not be used in future waste collection operations. The Table 3-7

below demonstrates the life and lifting capacity of current SWM collection fleet for Bahawalpur city.

Table 3-7: Existing solid waste collection fleet for Bahawalpur city

Sr. No.	Machinery	Quantity
1	Arm Roll Truck	4
2	Dumper Truck (5m^3)	10
3	Compactors (7m^3)	12
4	Compactors (13m^3)	2
5	Loaders	8
6	Tractor Trolleys	11
7	Mechanical Sweepers	2
8	Minitippers 1m^3	25
9	Minitippers 2.5 m^3	15
Total		89

Source: EDCM FS, 2023

248. The services of SWM are currently managed by the BWMC. The system deploys sanitary workers, handcarts and mini dumpers to collect waste from households and sweep related waste. The waste is then stored in containers of different capacities (5 M and 0.8 cu. m). Transportation of waste is done through arm-roll vehicles, dumpers, tractor trolley and compactors. However, there is a TS where waste is being dumped and transferred to dumpsite by loading it on dumpers and trolleys. No proper covering of vehicles is done while transporting waste from city/ TS to the dumpsite and littering is observed by the conveying vehicles on their way to the dumpsite. Current waste collection system of Bahawalpur is shown in **Figure 3-13** below. Photographs depicting existing management of solid waste by BWMC shown in **Figure 3-14.**

Figure 3-13: Current waste collection system in Bahawalpur

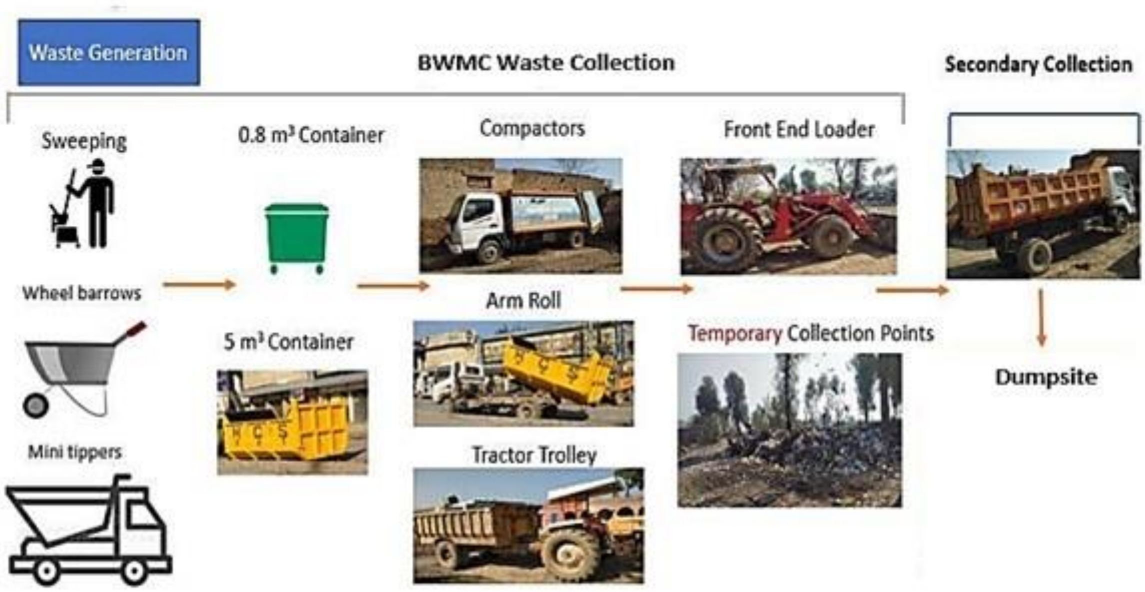


Figure 3-14: Modes of waste collection in Bahawalpur

Waste Collection through loaders and dumpers

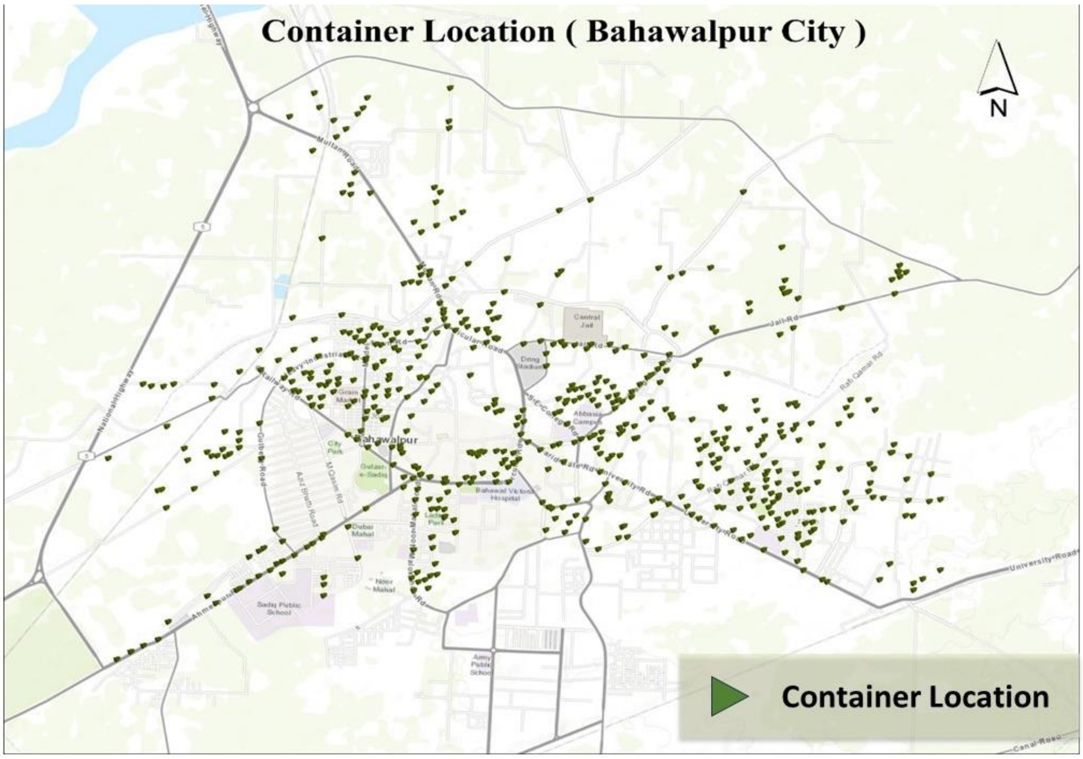
Minidumpers used for waste for waste collection in streets

Waste collection through handcarts in congested streets

View of waste collection and transfer through Arm Roll Truck

For primary waste collection, BWMC will place containers in different zones of the city. Containers of 5 M capacity (140) and 0.8 cu.m capacity (1075) will be strategically placed in the city to collect waste. Location of containers in the city is provided in the figure below.

Figure 3-15: Location of Containers for Waste Collection in Bahawalpur



249. The **Table 3-8** below provides the audit findings that was conducted to assess the existing activities being conducted from an environmental and social safeguards perspective and the required corrective measures that will be implemented.

Table 3-8: Audit of Existing Waste Collection System, Dump Site and Transfer Station and Required Corrective Actions

S/No.	Component	Audit Findings	Required Corrective Action
1	**Storage of waste at source in Bahawalpur**	▪ Lack of public awareness, motivation, and education ▪ Lack of civic sense and bad habits of people to litter ▪ Lack of cooperation from households, trade, and commerce ▪ Lack of litter bins in the city ▪ Long distance between community bins ▪ Resistance to change the public attitude	▪ Door to Door collection system shall be developed to reduce littering in the streets ▪ Strong behaviour change communication programs would improve citizen's behaviour. Communication program is included in project FS. ▪ Consider relocation of communal bins to attract more households ▪ Communal bins within city shall be selected in line with street requirements. ▪
2	**Segregation of recyclables in Bahawalpur**	▪ Lack of segregation of recyclables observed ▪ Lack of wide publicity through electronic and print media on waste segregation ▪ Lack of citizens' understanding how to use separate bins for storage of recyclables ▪ Lack of sufficient knowledge of benefits of segregation ▪ Lack of cooperation and negative attitude of people ▪ Lack of finances to create awareness ▪ Difficulty of educating scavengers ▪ Absence of by-laws	▪ Segregation and materials recovery facilities would be developed on land adjacent to existing dump site at Khanu Wali; ▪ Refuse Derived Fuel (RDF), facility would be made part of the MRF; ▪ Organic component of waste would be converted to organic compost and will be used in landfill for gas generation; ▪ In the medium term (3rd year onwards), efforts would be made to encourage segregation at source, with a 2-bin system. ▪ Environmental awareness and community interface program to increase awareness on segregation of recyclables is included in the project feasibility.
3	**Waste Collection System in Bahawalpur**	▪ Primary waste collection is carried out utilizing wheelbarrows ▪ Secondary waste collection is carried out through 7 & 13 cubic meter compactors ▪ Citizens throw waste on streets instead of communal bins. ▪ Workers need to collect all scattered waste manually. ▪ Multiple transactions of waste till disposal site ▪ Lack of awareness and motivation	▪ Citizen's behaviour will be improved through environmental awareness and community interface program ▪ Procurement of primary collection vehicles like mini tippers handcarts is included in the project feasibility. ▪ All collection staff would have PPEs, in order to safeguard their health and safety; ▪ Citizens shall hold the key to accountability, to ensure that the daily door to door collection is performed.

S/No.	Component	Audit Findings	Required Corrective Action
		▪ Unavailability of adequate primary collection vehicles like mini tippers, handcarts etc. ▪ Insufficient response from citizens	▪ Multiple transactions of waste shall be avoided. The waste shall go either directly to TS and MRF at land adjacent to the existing dumpsite in Khanuwali.
4	**Daily sweeping of streets**	▪ 100% manual sweeping system makes difficult for the sanitary workers to cover jurisdiction each day. ▪ Manual attendance management system is inefficient and leads to inefficiencies. ▪ Unavailability of workers on Sundays and public holidays	▪ With full Door to Door collection, the need for daily sweeping of all streets would be minimized to max twice a week; ▪ Focus would be on outcome-based indicators and not running after the worker's attendance. ▪ No need to sweep on Sundays.
5	**Communal Storage**	▪ Shortage of containers ▪ Lack of financial resources leading to broken and ill maintained bins; ▪ Lack of planning for waste storage depots or temporary storage locations; ▪ Inaccessible areas and narrow lanes that do not allow sufficient space for container	▪ Procurement of containers is included in the project feasibility ▪ There is need to remove broken and ill maintained bin however after repair these can be reused. ▪ All unnecessary communal storage points in residential areas shall be removed. ▪ No containers, no throwing by households into the streets; ▪ Only commercial areas and institutions would have communal bins; ▪ User charges would be levied to induce financial sustainability.
6	**Transportation & Transfer Station at Stadium Road**	▪ TS is located at Stadium Road at distance of 20 Km from proposed landfill site ▪ It is located at a distance of 12 km from the legacy landfill and MRF. ▪ Total area of TS is about 29 Kanal and 08 Marlas. ▪ Haphazard waste spread in nearby lands ▪ Odour problems due to long storage at TS ▪ Risk of vector spread and Risk of fire from TS ▪ Absence of waste segregation facility and resources at TS ▪ Economic loss due to disposal of recyclable materials ▪ Increased scavenging activity in the Bahawalpur ▪ Many open vehicles for transport ▪ Old vehicles that are difficult to replace ▪ No route planning	▪ SOPs of smooth TS operations shall be developed ▪ Delayed storage at TS shall be avoided to reduce risk of vector spread ▪ There is need to develop policy that no waste touches the ground ▪ Segregation of recyclables shall be carried out at MRF to cater for economic losses ▪ Dust and odour control mechanism shall be developed for upgraded TS ▪ Waste would be carried in fully covered vehicles, in order to avoid any littering and pollution. ▪ Number of vehicles would be minimized, with TSs and larger hauling containers.

S/No.	Component	Audit Findings	Required Corrective Action
		▪ No scheduling for lifting of containers	▪ Detailed site analysis including soil, air and ground water sampling and monitoring at TS and surrounding communities shall be carried out.
6	**Waste Treatment**	▪ Hardly any waste treatment in the formal sector ⁻ Lack of technical know-how for a scaled-up treatment facility ▪ Lack of institutional capacity	▪ MRF would be an integral component of the treatment and disposal system. ▪ Options for Private sector participation would be explored in operations of the MRF centres. ▪ Specialized skilled workers would be operating the TSs, and MRF.
7	**Disposal of Waste at Legacy Landfill**	▪ Located at 20.2 km from new proposed landfill site ▪ Located at 10 km from primary waste collection area ▪ Located 5.8 km from nearest population and 15 km from farthest population. ▪ The volume of waste already dumped at the existing dump site is not accurately known at present. ▪ No bottom lining, leachate and gas collection system available ▪ Waste is not deposited with daily cover ▪ The migration of leachate has contaminated soil and ground water. ▪ Haphazard waste spread in nearby lands ▪ Odor problems due to waste degradation ▪ Risk of vector spread and Risk of fire ▪ Economic loss due to disposal of recyclable materials ▪ Increased birds scavenging observed ▪ Lack of financial resources for a scientifically designed land fill site; ▪ Lack of technical personnel for LFS management; ▪ Lack of technical know-how for scientific disposal of waste ▪ Unavailability of appropriate land ⁻ Lack of institutional capacity	▪ Proposed new landfill development will stop open dumping at Khanuwali and will fix further environmental degradation of the area ▪ Existing dumpsite will be rehabilitated through compaction, gas network, leachate collection system and application of daily cover ▪ Site closure plan for existing dumping including trenching, gas well network and necessary compactions will be developed and implemented once dumping will be stopped. ▪ New Landfill will be properly engineered/ designed, constructed and operated. ▪ Segregation, MRF and Composting facilities would enhance the useful life of Landfill. ▪ New LFs will have proper facilities like reception areas, weigh bridge, worker’s accommodation access road, daily soil cover, workshops, wet weather area, security, lighting for 24 /7 usage and professionally trained workers to operate and supervise. ▪ Capacity building of BWMC shall be increased with respect to integrated waste management system in the city ▪ Adequate financial resources shall be arranged and allocated for rehabilitation of the existing dump site ▪ Application of daily cover shall be increased on existing dumpsite to reduce birds scavenging

S/No.	Component	Audit Findings	Required Corrective Action
			▪ Detailed site analysis including soil, air and ground water sampling and monitoring at dump site and surrounding communities shall be carried out. ▪ The site mitigation, remediation and rehabilitation will be done by capping the site with final cover and install LFG system.

Note: Suggested corrective actions are part of the proposed integrated waste management system of Bahawalpur. Corrective actions will be updated once project is implemented, and resources are provided to BWMC.

3.5.2 Proposed Integrated Waste Collection System for Solid Waste Streams in Bahawalpur

250. Total waste generation in Bahawalpur is broadly categorised in three types i.e. residential, commercial and bulk waste. Percentages of waste streams are established after careful review of the waste generation trends in the city and after analysing the primary and secondary data. **Table 3-9** particularly defines the quantification of different waste kinds to help establish the suitable machinery resource for collection and disposal of each waste stream. The tonnage figure for calculation purposes was taken for the year 2028, which means a little higher tonnage to keep the system balanced and sustainable until the project completion and to avoid another procurement in the middle of project life. The current and future waste generation quantities are shown in the figure below.

Table 3-9: Quantification of waste streams in Bahawalpur

Areas	Bahawalpur City
Total Daily Tonnage	524
Scavanger Take	20
Remaining Waste	504
BWMC Collection @ 85%	428
Total Waste	477

Source: Feasibility Report, 2023

Waste Storage & Collection Proposed in Residential Areas of Bahawalpur

251. The new operations model for solid waste storage and collection is purely based on one hundred percent door to door collection for residential waste, however for the commercial areas, waste storage containers are also proposed to store, collect and later transfer the waste to the LFS. There is a need to emphasise and execute a very comprehensive awareness campaign in all work zones. A specific schedule of waste collection in different areas on fixed timings and the same shall be followed by the citizens.

252. For the future system design, the EDCM has proposed a model to take citizens on board, make them aware and also accountable for successful execution of effective waste collection. The waste shall be collected from the doorstep of each household, and they will not be allowed to throw waste out of their property except handing it over to the collection crew at the defined collection timings. Preferably the citizens shall be provided with garbage baskets for storage of waste inside their premises until the collection vehicle arrives to pick the waste up.

Primary Waste Collection

253. The sizing of waste containers involves determining their capacity based on the expected waste generation rates from the assigned sources. The containers should be sized appropriately to accommodate the volume of waste generated between collection cycles without overflowing. Factors such as the number of waste generators, waste composition, collection frequency, and available space for container placement are considered. 1075 X 0.8 Cu.m containers have a total capacity of 283 tons and 140 X5 Cu.m arm-roll containers have a capacity 231 tons are recommended. This gives the operator a lift capacity of 514 tons based on single shift lifting of all containers.

254. The sizing of collection vehicles involves determining the appropriate capacity of the vehicles to handle the expected waste volumes within the designated collection

routes. The size and capacity of collection vehicles depends on factors such as the number of waste sources, waste generation rates, collection frequency, and distances between collection points and TSs. The vehicles should be able to accommodate the projected waste volume while considering payload limits and operational efficiency. The vehicles should be able to accommodate the projected waste volumes while considering payload limits and operational efficiency.

255. The primary waste generation sources include residential and commercial waste generators. The residential waste generation volume is 70% of the total waste collection, projected to amount 346 tons/day in 2028.

Secondary Waste Collection

256. The source segregation of waste from commercial waste generators will utilise two bin systems to separately collect organic waste, kitchen, vegetable and fruit market waste and wood waste and green waste to be directly utilised by AD plant & composting facility. The Placement of 0.8 cubic meter bins at street corners and outside commercial units and the placement of 5 cubic metre arm roll containers with easy access will be used for commercial waste generators; the containers will be picked by arm-roll trucks and 7-cu.m compactors.

3.5.3 Procurement of SWM Equipment, Machinery and Vehicles

257. The project design consultant, Engineering Design and Construction Management (EDCM), have analysed the future waste generation of the city and identified SWM equipment, machinery and vehicle requirements for year 2028 and for the project life span. The procurement plan has been established based on the review of existing waste collection fleet of BWMC and taking into consideration of future waste generation rates. Proposed procurement of SWM fleet for solid waste carrying machinery is shown in **Table 3-10** below**.**

Table 3-10: Proposed Equipment for Primary Waste Collection

Sr. No.	Equipment	Quantity
1	Compactor 7 M	13
2	Mini Tipper 1 M (four Wheel, Open Top)	97
3	Mini Tipper 1 M (Electric Tricycle)	5
4	Arm Rool Truck 5 M- Hook Lift	33
5	Container 5 M	140
6	Container 0.8 cum	1075
7	Pedestrain Fixed Bins	500
8	Multicolored Wheeled Bins	500
9	Hand Carts	498
10	Mechanical Washer	1
11	Mechanical Sweeper (Imported)	4
12	Tractor with Multiple attachments	5
13	Commercial Leaf/Inert Collector (Imported)	10
14	Mobile Workshop Small	1
15	Mobile Workshop (Large)	1

Sr. No.	Equipment	Quantity
16	Bobcat with Multiple attachments	1
17	Excavators	1
18	Staff Vans	2
19	Official staff vehicle replacement	8

Source: EDCM FS Report, 2023

4 Project Program and Design - Component 1

4.1 Construction Details for SWM Facility

258. Comprehensive site preparation activities for the landfill site are elaborated and illustrated in **Figure 4-1**. This section provides details of the following activities involved in construction of sanitary landfill:

- Landfill Cell Development
- Landfill Gas Management
- Leachate collection and treatment system
- Associated Infrastructure and Buildings

4.1.1 Landfill Cell Development

Landfill Design

259. The useable life of the landfill is 25 years. Four cells for depositing of the waste will be developed sequentially. The Cell 01 will receive waste for three years and will be filled up to the natural ground level (NGL). The landfill gas recovery wells are being installed as landfilling progresses. The landfill gas recovery system will be connected to ring main and flaring system. The beneficial utilisation of landfill gas will start in year 4 with the commencement of depositing the waste in cell 01. The second cell construction will start after two years of the start of receiving waste in cell 01. From the fourth year the depositing of waste will commence in cell 02. The process of this leap frogging will continue till all four cells are filled up to NGL and gas recovery system becomes operational. The recommended depth of the landfill cells will be 9 metres with a reverse fill of 18 metres.

260. Once all four cells are filled up to NGL, the reverse filling of the waste will start at cell 01 and continue through all cells to achieve the final lines and grades.

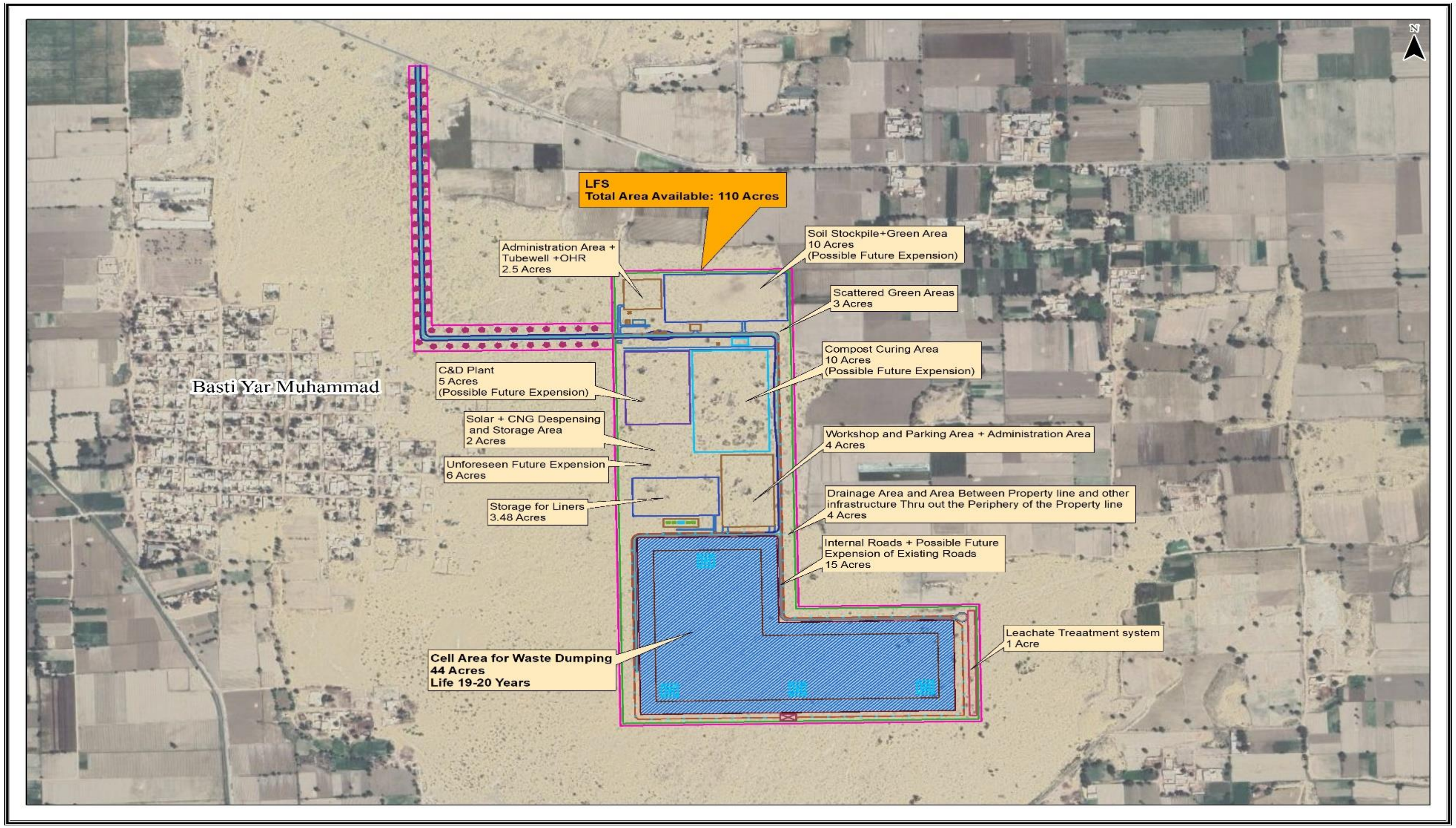
261. The gas recovery system will be extended to final lines and grades and final gas recovery system will be installed including final cover.

262. Location of waste cells and leachate collection and treatment is shown **Figure 4-1.** The simple composite liner specifies a three feet clay liner will be used. The design specification allows use of alternate clay liner which is geo synthetic clay liner (GCL) with a permeability of 1 x 10 raise to power – 11. This alternate clay liner is utilized for Bahawalpur. The components of the liner system are:

- Preparation of subgrade and side walls as per lines and grades and drawings.
- The compactor of the subgrade to 90-92 percent dry density.
- Installation of GCL liner as per the drawings.
- Installation of 2mm thick HDPE liner smooth on both sides as specified in the installation manuals to be supplied to contractors.

- Installation of geotextile 500 GSM. The heat welding of geotextile is not allowed; it will be double stitched using special stitching equipment (the field stitching machines are rapidly available in Pakistan).
- All three liners will be anchored into an anchored trench as per the design drawings.
- Installation of a drainage layer 30cm thick utilizing low ground pressure equipment not to exceed 6 psi.
- Installation of geotextile 500 GSM. The heat welding of geotextile is not allowed; it will be double stitched using special stitching equipment (the field stitching machines are readily available in Pakistan).
- This layer of geotextile will not be anchored in the trench and a portion of 2-meter length rolled and held at the top of the trench by loose soil.
- Installation of 50-60cm soil cover. The soil cover will be placed using low ground pressure equipment and procedure developed by site engineer and contractor.
- The Leachate collection and removal system (LCRS) will be installed as per design drawings.

Figure 4-1: Land Utilization Plan of Bahawalpur Landfill



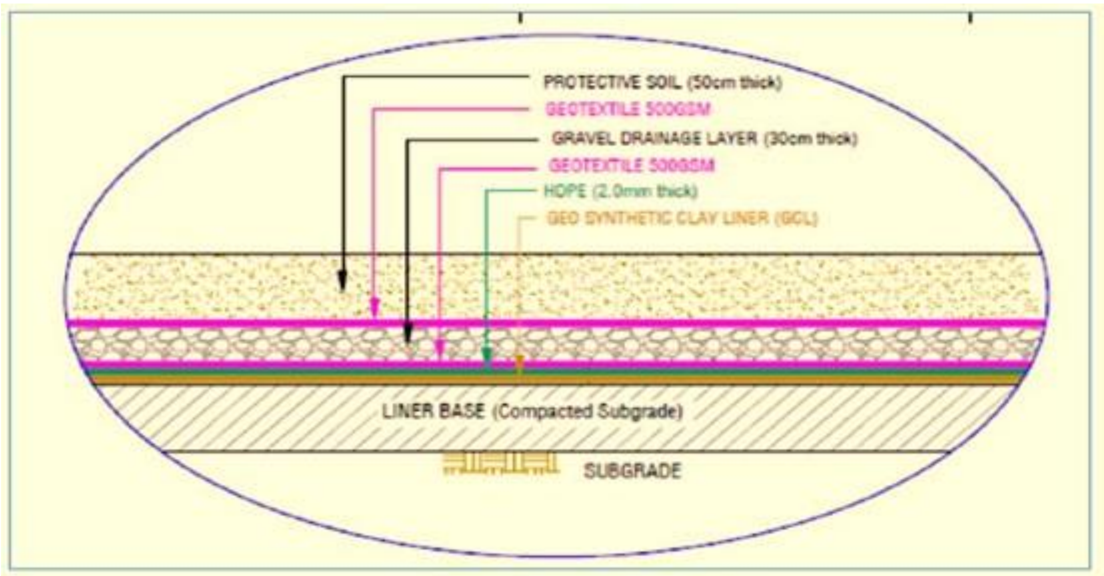
Bottom Lining of Landfill Cells

263. The liner system at the base of waste cells is aimed at protecting the surrounding environment. It includes soil, groundwater and surface water protection through containment of leachate, controlling ingress of groundwater, and assisting in the control of the migration of landfill gas. The liner system must achieve consistent performance and must be compatible with the expected leachate for the useful life of the landfill.

264. Bottom lining of the landfill cells will be carried out through the provision of lining of subsoil comprising of plastic and clay material as per international standards for sanitary landfills. Bottom lining will be comprised of compacted sub-grade base, geo-synthetic clay liner (GCL) topped by 2 mm HDPE layer. Silty sand or geotextile (500 GSM) will be covered for the protection of the HDPE on the side slopes. Above geotextile gravel layer (30 cm thick) will be placed which will be topped up with sand layer (50 cm thick). Single composite liner system conforms to US subtitle 40 CFR and illustrated below.

265. The composite liner system consists of an upper component, which is a flexible membrane liner (FML) that satisfies specific thickness standards. The lower component must be constructed of at least a 2-foot layer of compacted soil and must exhibit a hydraulic conductivity of no more than 1 x 10-7 cm/sec. The combination of an FML and a compacted soil layer ensures adequate protection by providing both a highly impermeable upper liner to maximize leachate collection and removal, and a lower soil layer to serve as a back-up in the event of FML failure (56 FR 51060; October 9, 1991). The leachate collection system must be designed and constructed to maintain less than a 30-cm depth of leachate over the liner. Structure of composite liner system selected for Bahawalpur site is shown in **Figure 4-2**

Figure 4-2:Structure of Composite Liner System



Final Capping Layer of Landfill Cell

266. Final capping of landfill cells will be carried out to limit and control the amount of precipitation that enter the waste and to limit wind and water erosion and burrowing

animals' activity. Main objectives of the capping system are: minimising infiltration into landfill, maximise surface drainage and run-off and gas control migration.

267. The top cover system will consist of the following arrangements:

- Thick topsoil layer (6 inches) capable of supporting vegetation in order to protect the landfill surface from wind and water erosion.
- Drain Layer (18 inches) of at the bottom to maximise runoff of precipitation while minimising infiltration and preventing ponding of water on the landfill.
- Compacted soil layer or barrier of low permeability ($1x10^{-5}$ cm/sec) to limit and control the amount of precipitation that enters the waste.
- Vent layer of reasonable thickness comprised of sand and gravel.

Daily Cover

268. A daily cover is placed on working surface of waste in order to reduce the risk of fire, wind littering, odour, vector breeding and dust hazards in the landfill. It is a soil layer and is placed on each working day. Generally, the amount of soil to be used in daily cover will be about 10% of the waste volume. A suitable amount of daily cover is usually stocked at the landfill sites during landfill cell excavation. However, any suitable excavated material from construction works can be used as daily cover.

4.2 Landfill Gas Management for New Landfill

269. Landfill gas is produced through decomposition of organic fraction present in the MSW deposited to the landfill site by microbial activity. Landfill gas is composed of roughly 50 percent methane (the primary component of natural gas), 50 percent carbon dioxide (CO_2) and a small amount of non-methane organic compounds. Methane is a potent greenhouse gas 28 to 36 times more effective than CO_2 at trapping heat in the atmosphere over a 100-year period, as per the latest Intergovernmental Panel on Climate Change (IPCC) assessment report (AR5)[5.] Methane possesses the combustible and explosive properties and also a Green House Gas responsible for global warming. In order to limit landfill gas entrance into environment and to avoid fire and explosive hazards land fill gas collection system has been designed.

270. An AD plant of 25 tpd capacity will be located at MRF site and a compost plant of 5tpd capacity will be established at new landfill site. Remaining source segregated organic waste and mixed organic waste will be directly landfilled. Organic waste designated for utilisation in the AD plant and for composting will undergo source segregation before it reaches the respective destinations. Other mixed organic waste will be transported directly to the landfill.

271. The gas recovery system is constructed with horizontal and vertical grid gas wells. The gas wells are connected to a ring main and flaring system combined with segregation of Methane gas and utilization of Methane in garbage trucks or is its conversion into CNG. This is the highest revenue generating component. Out of 524 tons/day of waste generation in year 2028, 264 tons/day of organic waste component will be deposited in sanitary. Following segregation at the MRF, all mixed waste is subsequently transferred to the landfill site. However, source-segregated commercial waste and green waste will be directly transported for processing without being sent

[5] https://www.epa.gov/lmop/basic-information-about-landfill-gas

to the landfill. The landfill gas will be available even 10 years after the final cover is installed in the year 2050.

272. Both Horizontal and Vertical gas collection systems will be implemented in the landfill. The gabion of the gas collection wells will be filled with gravel, and these will be constructed with iron mesh. There will be a perforated HDPE pipe with pressure class in the centre of the gas collection wells. The gap between the iron mesh and the perforated pipe will be filled with pebble stone.

273. Estimated gas production in 4^{th} year will be about 220 Nm^3/hr out of which 165 Nm^3/hr will be extracted which will continue to increase over years of landfill operation.

274. Collected gas will be then transferred to gas flaring system. Initially 1000m^3 gas flaring system is proposed, and the area has been allocated at the site. After a few years of landfill operation, landfill gas will be converted to CNG for further dispensing. The landfill gas will be collected from the landfill cells and will be diverted to CNG conversion plant where it will be treated, compressed and sent to dispensing unit. Since landfill gas production process is slow therefore initially it will be flared. After a few years of landfill operations, when the commercial gas volume is complete, it will be collected and converted to CNG and therefore no risk of fire explosion from methane gas is anticipated. Further, once one landfill cell is filled, top cover will be installed hence limiting the entrance of water and limited production of methane. Through flaring, 99% methane will be destroyed hence limiting the chances of fire explosion. Further, through conversion of Methane to CNG after few years of landfill completion, the project will harness methane for power generation and as LNG/CNG, thereby minimising any gas migration from the landfill operations.

275. Proposed gas collection system for Bahawalpur LFS is shown in **Figure.4-3 and Figure 4-4**. The combined implementation of the liner system, daily cover, gas capture system, and controlled flaring of excess gas significantly reduces the likelihood of any explosion occurring at this landfill site, making the potential for such an event negligible. Further after few years of landfill operation, landfill gas will be collected and converted to CNG plant.

276. The plan to deal with any fire hazards during construction phase is provided as **Appendix A-6**. Emergency plan to cope release of fire during landfill operations is provided as **Appendix A-21**.

Figure.4-3: Horizontal Gas Collection Pipes

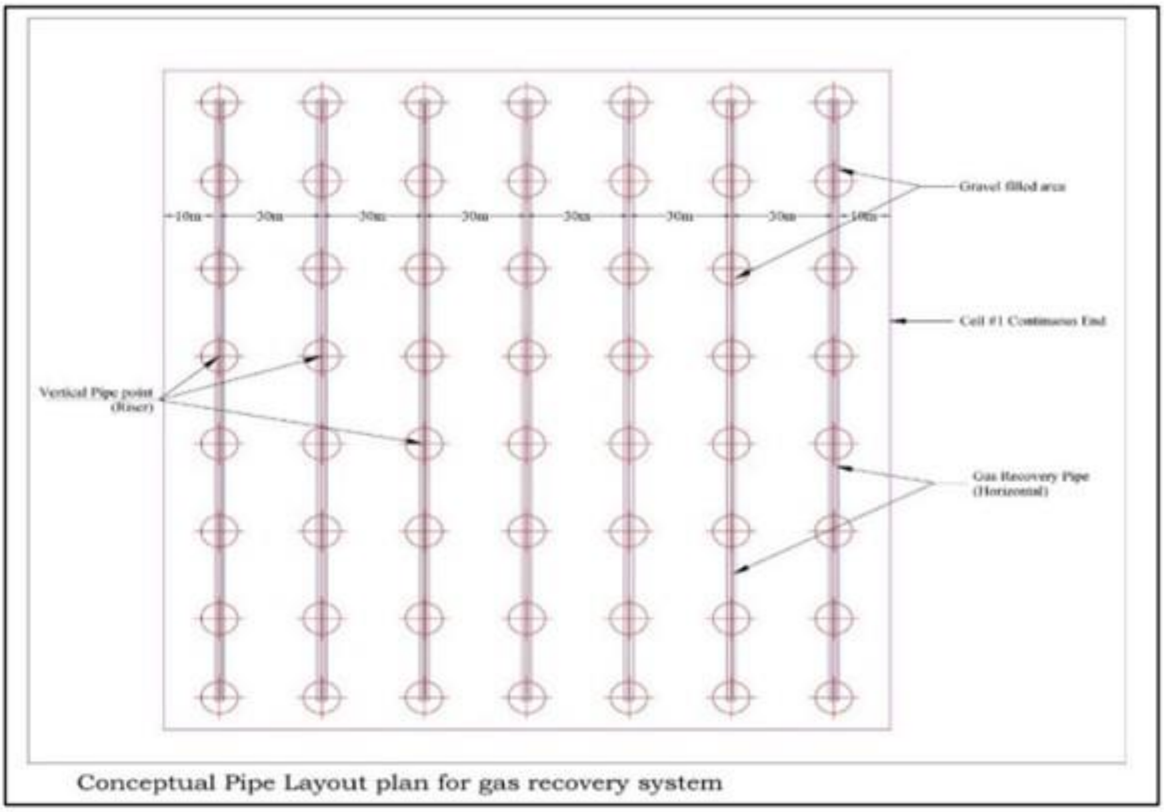
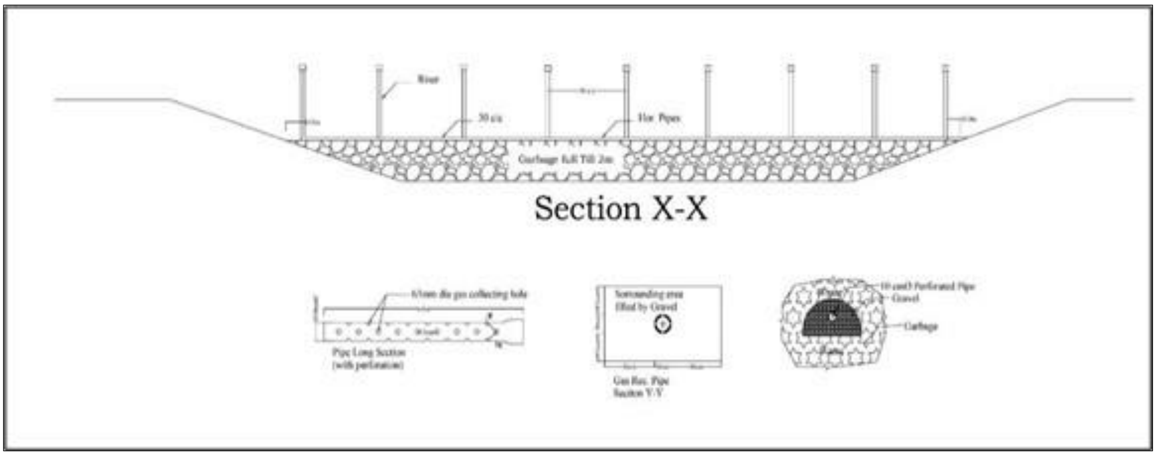


Figure 4-4: Vertical Gas Collection Pipes



277. EDCM has developed GASSIM 2 model for Bahawalpur Landfill site. GASSiIM is a computer software tool to carry out a Tier 1 screening assessment to ‘screen’ emissions from the former landfill and to identify the significance of risk associated with the former landfill on nearby receptors. The model input data is based on Site-specific data where possible. Appropriate assumptions and published data including GASSIM2 default values has been used where Site-specific data not available. GASSIM 2 model results are shown in the figure below.

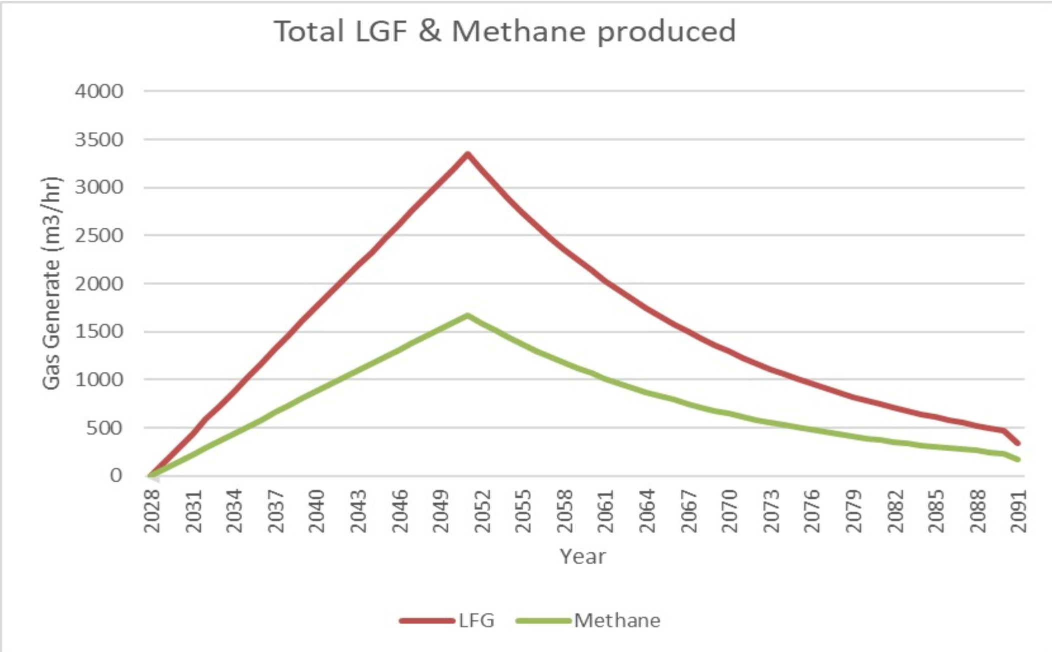
4.2.1 Methane Gas to CNG Conversion Plant

278. The beneficial utilisation of organic waste recommended in FS is an out of the box design of the landfill as a sanitary and processing the organic waste to generate revenue. The organic waste will be used as a resource in sanitary landfill to maximise and regulate the landfill gas recovery system and conversion of methane component of the gas into CNG. The conversion of organic waste into LFG and Methane component conversion will generate a high revenue and contribute to the substantially of the project.

279. The organic waste will be beneficially utilised when it is deposited in the bio reactor landfill where it will generate regular and increased quantity of landfill gas which will contain 55-60 percent of Methane. The methane can be converted into electricity or CNG. The CNG option is a much better option as the electricity tariff for green energy is very low in Pakistan and the CNG rates are quite high.

280. The qualitative landfill gas hazard assessment has been carried out using *EPD/TR8/97 Landfill Gas Hazard Assessment Guidance Note*. Assessment is based on the "Source (location, nature and likely quantities/ concentrations of LFG)– Pathway Baseline Conditions – Target" (Sensitive Receptors) model. Based on project feasibility report the Methane production will be 222 m3/hr for 2028 which gradually increase over the years of landfill operations and reaches maximum production in year 2052 upto 1600 m3/hr. After 2052 due to reduced moisture content and application of final cover decomposition rate of landfilled waste will significantly decrease which will result in low LFG and Methane production.

Figure 4-5: Gas Production Model Outputs



Source: EDCM GASSIM 2 Model Results

281. All the produced gas will be collected though landfill gas recovery system and will be processed without release to environment. Horizontal and vertical gas collection pipes are shown as **Figure.4-3**and **Figure 4-4**. The design of the landfill cells adheres to the guidelines outlined in the US Environmental Protection Agency's Subtitle 48 CFR. The landfill gas recovery will be designed from bottom up to avoid emission during landfill operation and drilling through the garbage when the cell is

filled with waste. When two meters of waste layer will deposit in the first cell, a 30m x 30m or 50m x 50m grid of perforated gas recovery pipes will be installed over a 15cm layer of gravel under the pipe and another layer of 15cm gravel will be placed on top of the gas grid. The 30m length of the pipe will be joined with the second pipe with a ''T'' joint and vertical gas well is installed. When desired height 20-30m of the fill achieved the ring main will be installed and connected to final LFG to CNG conversion arrangements. Periodic gas monitoring will be carried out during landfill operation to track any release and to assess if further mitigation measure or design changes are required.

282. Summary of Qualitative Source-Pathway-Target Analysis is provided below.

Table 4-1: Qualitative Source Pathway - Target Analysis

Source	Pathway	Target	Risk
Proposed waste disposal at landfill site will be produce LFG and Methane. Refer to GASSIM 2 output volume of LFG and Methane will continue to increase over years till 2050 and then will reduce. LFG will reach concentration of about 3400 m^3/hr while methane will reach volume of 1600 m^3/hr. LFG and Methane may be source of hazards if not collected and processed through engineered means.	In ward Migration into ground Outward Migration from landfill cells Accidental Release LFG Leakage	Nearest Communities such as Basti Rama, Basti Yar Muhammad, Basti Kareem Baksh, Basti Chachran, Bati Rasheed Abad	Medium

4.3 Leachate Collection and Removal System (LCRS)

283. Leachate produced in a landfill is a liquid which percolates through the waste carrying suspended and soluble materials that originate from or are products of the degradation of the waste. This liquid needs to be managed on site to avoid any seepages into the ground, any spill-over into ditches and drains, influence on gas collection system or effect on the stability of waste fill. For Bahawalpur landfill site, leachate collection and removal system is being designed which is explained below.

4.3.1 Leachate Collection System

284. Leachate is a waste product produced because of decomposition of organic fraction of waste by microorganisms in the landfill site. The mass balance in the leachate generally depends on the biological decomposition in the garbage body, amount of precipitation, temperature changes, and treatment of the leachate and/or transfer rate of the leachate to the treatment facility. This balance will be controlled

and arranged according to the conditions during the operation phase. The leachate is collected via main and auxiliary leachate pipes.

285. A leachate collection system comprising of a drainage layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) will be considered. Synthetic drainage material may be used on sidewalls of the landfill cells, where the construction and operation of granular material may be difficult. Perforated leachate collection pipes and filter layer will complete the piping network for the waste cell.

4.3.2 Leachate Treatment

286. The Leachate treatment system will comprise of a three-stage clarifier with aeration with diffusers or enclosed leachate treatment system utilising AD Plant. In Bahawalpur, the AD Plant will be used for leachate treatment. The reason to select AD is as follows:

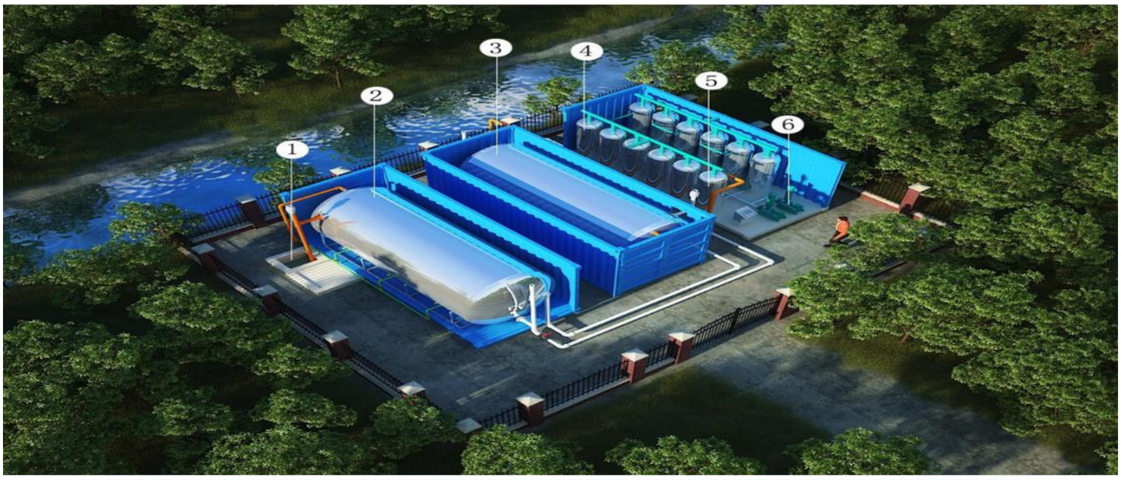
- The three-stage clarifier with diffusers and aeration system requires a large area of 3000 square meters plus another 500 meters for installation of two high volume compressors and electrical equipment. The air compressors must run continuously over 24 hours. Since the ponds are open an order control system must be installed. The water after treatment has to be dispose of in a wastewater treatment plant. There is no wastewater treatment plant functional in Bahawalpur. The treated water can only be used for landfill dust control only.

- An AD leachate treatment plant is completely enclosed produces electricity to offset the operations costs and the water quality is usable for landscaping. The sludge produces an excellent quality compost.

4.3.3 AD Leachate Treatment System

287. Three Stage Open Pond Leachate Treatment System or AD Plant will be utilised. AD is fully enclosed and most suitable option incorporated in the design. Overall, AD is a proven technique and at present applied in a variety of waste streams. Promotion and application of utilizing sewage sludge using this technique is one of the solutions to various environmental problems and a breakthrough in the field of waste recycling. The process flow diagram of series proposed for Bahawalpur facility are shown in **Figure 4-6** and **Figure 4-7** below.

Figure 4-6: Process Flow of 3 Stage Anaerobic Digestion



1. Leachate water collecting tank, 2. anaerobic treatment system, 3. aerobic treatment system,
4-5 deep aerobic treatment systems, 6. Blower.

Source: https://applbiolchem.springeropen.com/articles/10.1186/s13765-021-00652-z

Figure 4-7: View of Three Stage Leachate Treatment System

Source: https://applbiolchem.springeropen.com/articles/10.1186/s13765-021-00652-z

288. The system will be composed mainly of an AD Plant, an AD Plant and a deep aerobic treatment system. The anaerobic treatment system will be composed of anaerobic tanks; the aerobic treatment system and deep aerobic treatment system will be composed of aerobic tanks and a blower. The leachate will be first treated by the anaerobic treatment system, and then treated by the aerobic treatment system and deep aerobic treatment system. During the anaerobic treatment process the biogas produced can be collected, purified and stored as a fuel for use.

289. Treated leachate will be stored for application like landscaping and sprinkling or it can be discharged to nearby municipal drains after compliance with PEQS. Some major advantages of this treatment technology are as follows:

- High quality of the treated water: The treated water is colourless and without odour, can be used for gardening.

- Easy to install and maintain. It can be installed in several days and operates automatically.
- No smell is produced due to the treatment because all the gas (biogas) produced is collected and used as fuel.

4.4 Other Features of the Development

4.4.1 Solarization

290. Solar system will be installed at MRF, Landfill and Office building. As per the capacity of the solar plant, required power will be utilized in the internal system/operations of facilities.

4.4.2 Infrastructure / Buildings

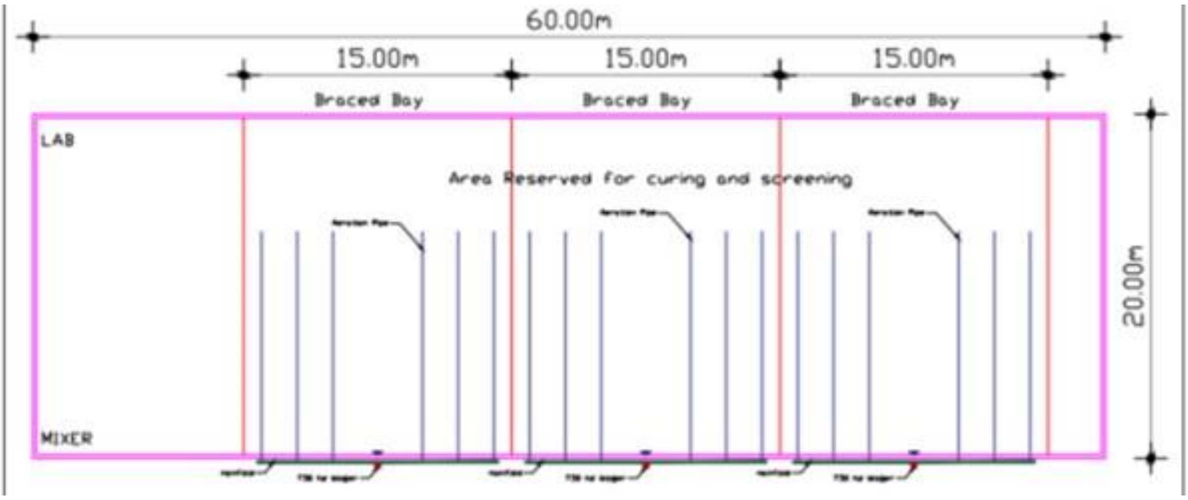
291. The proposed landfill will have proper facilities such as administration building, waste reception areas, weigh bridge, access roads, daily soil cover, security, the worker's accommodation, maintenance and washing area, CNG dispensing unit, LFG to CNG plant, flaring system, leachate treatment plant and uploading pad for vehicles.

292. The following building infrastructure is proposed:

4.4.3 Compositing Building

One compost building will be constructed. Since the project will be developed under a Design Build Operate (DBO) Contract, thus the exact equipment specifications are not

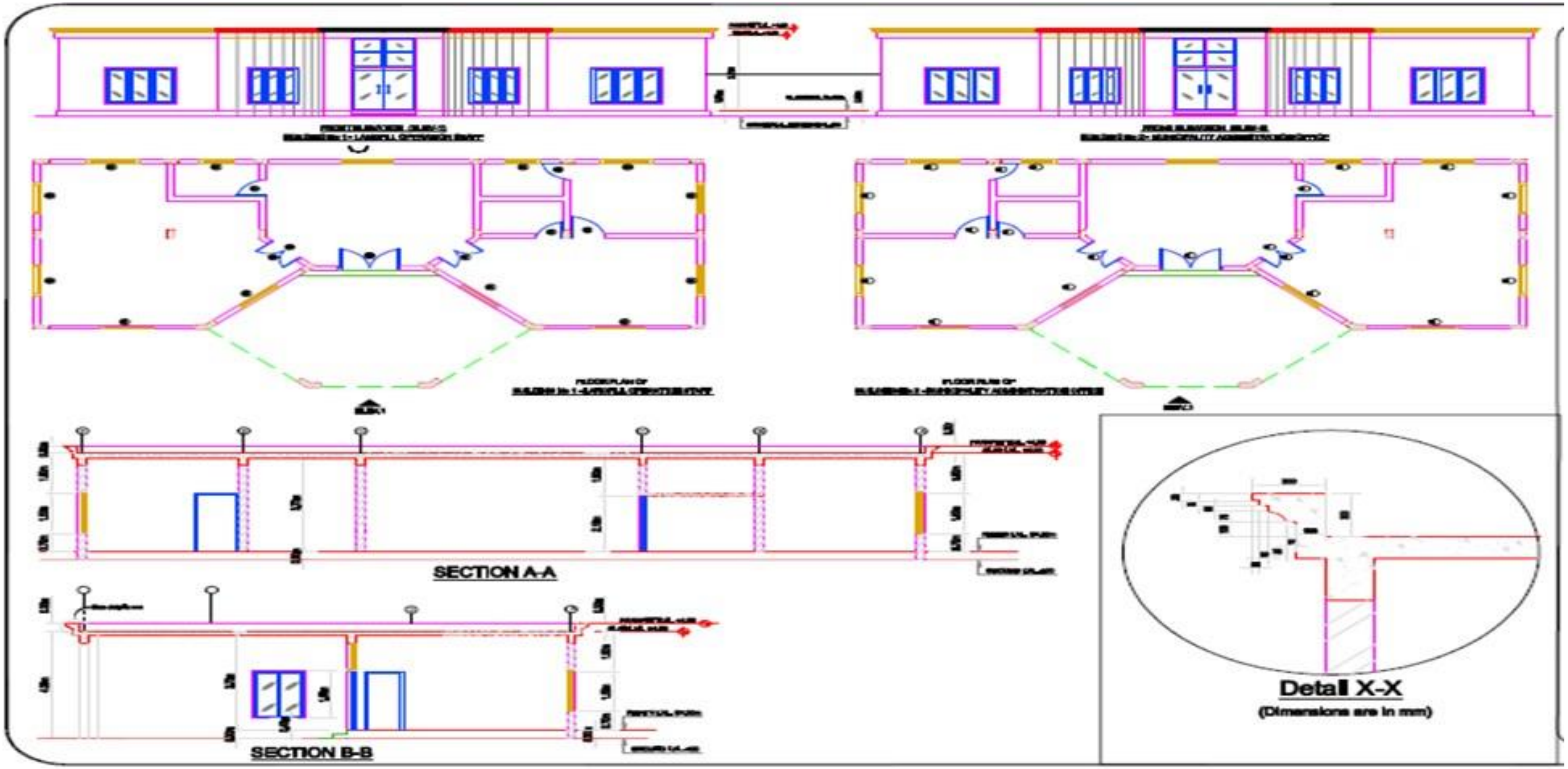
Figure 4-8: Typical Layout of Composite Building



4.4.4 Administration building

293. Administration building is designed within the landfill premises. It is planned such that it will accommodate landfill operations team, has a laboratory for quality control and MIS monitoring room for data acquisition and transfer to head office. The building also contains a conference room for meetings at landfill, an inventory room for storing supplies for repair and maintenance of landfill machinery and vehicles. There are showers, prayer area, rest rooms and a kitchen in the building. A car park outside the building is also designed for personnel's' vehicles. The area of the administrative building is surrounded by landscaping and greenery. The layout of admin building, including lookout tower, is presented in **Figure 4-9** below**.**

Figure 4-9: Layout of administration building at Bahawalpur Landfill

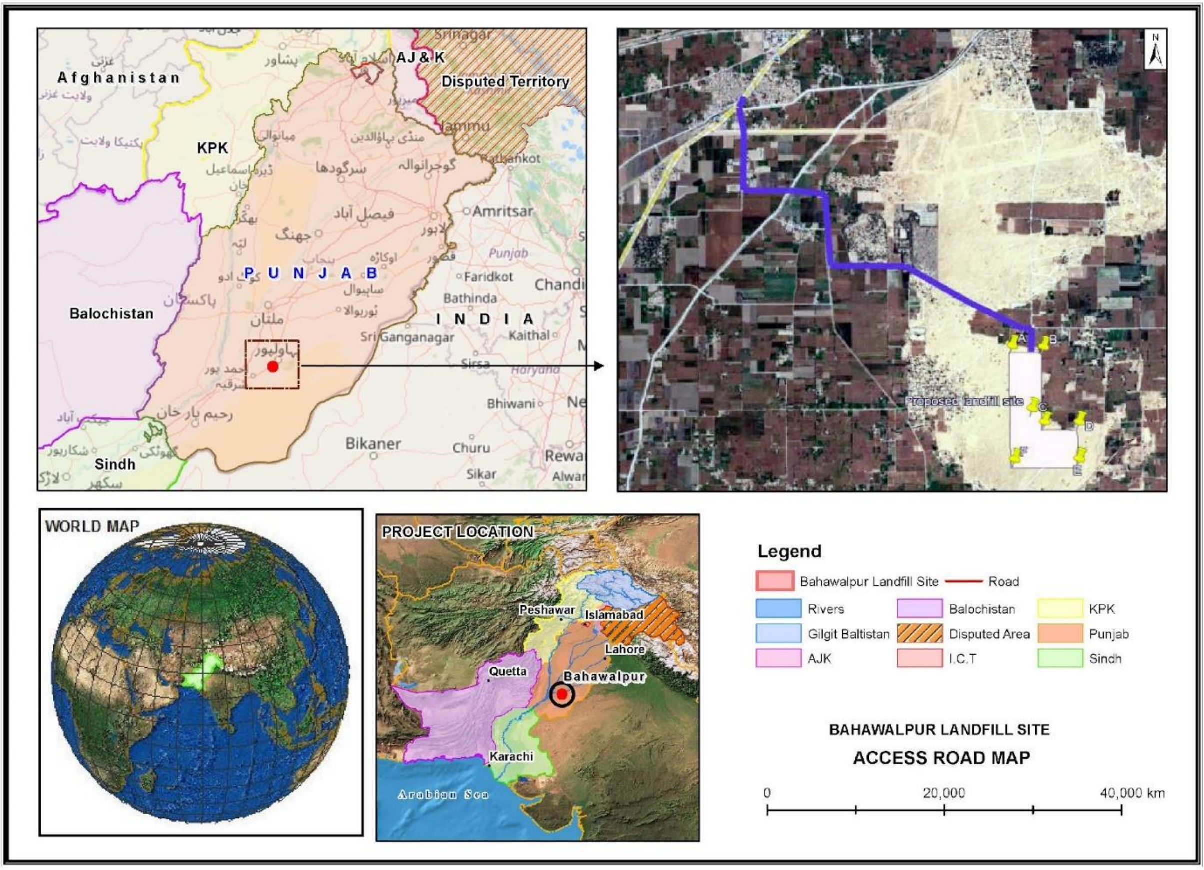


4.4.5 Construction of roads

294. The Following approach roads will be constructed as part of Bahawalpur ISWMS.

- The access road to new landfill site will require 2.5km of new road from the main access road and improvement of the main access road for about 10km. Location of access road to new landfill site is shown in below **Figure 4-10.**

Figure 4-10: Access Road to New Landfill Site



295. Roads inside the premises will cover all periphery. Ideally road width will be 10m wide with two lanes each 4 m for two-way traffic of waste carrying vehicles.

4.4.6 Surface Drainage Network

296. The runoff at landfill will be managed through the provision of surface water diversion channels and collection systems. Drainage for surface runoff along periphery is proposed through a network of RCC drainage channels. A surge pond is included in the project design to manage the surface drainage.

4.4.7 Wet Weather Area

297. A wet weather area is allocated to manage waste during monsoon.

4.4.8 Storage area for Soil Cover

298. Soil or similar inert material shall be used for the lifetime of the landfill site, to cover the waste on a regular basis. Extra thickness of “final cover” material will also

be required once the site has reached completion. The simple spreading of daily cover is a highly effective way to reduce the attraction of waste to birds, suppress odour, prevent fly infestations, discourage rats and other animals and to reduce exposure to atmospheric conditions and to reduce wind-blown litter.

299. Ideally, cover material will be taken from within the site, increasing the available space for waste disposal and reducing the need to bring material from elsewhere. The material excavated from the site is estimated to be adequate for use as temporary and final cover material. Final confirmation will be made on remoulded permeability of the representative samples taken from the borrow source, if adopted. At this time, it is expected that the soil removed during excavation will be used.

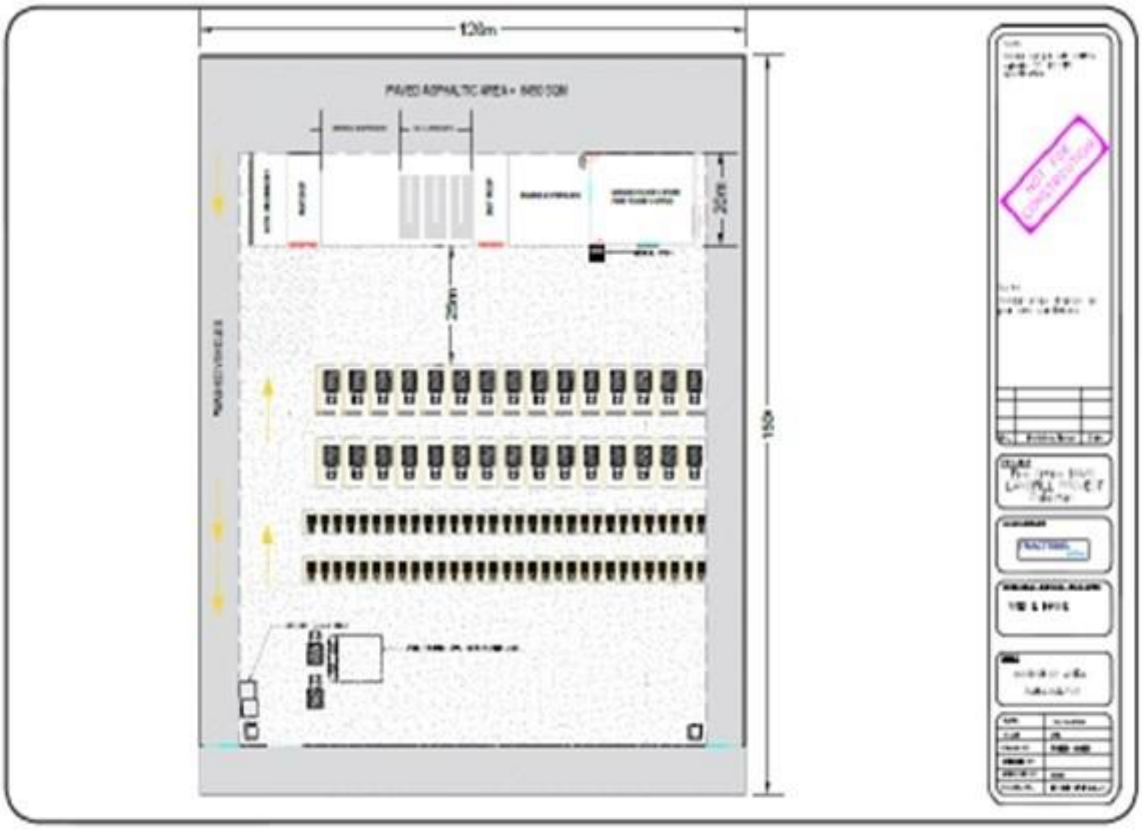
4.4.9 Wheel Washing and Vehicle Parking

300. A vehicle parking shed for landfill vehicles and occasional parking of waste carrying vehicles has been designed along with a workshop for routine repair and maintenance work. There will be pumps and nozzles that spray pressurized water to clean the wheels. The wheel washing unit will comprise of a sedimentation tank. The dirt on the wheels of vehicles will settle and the water in the pool will be transferred to wastewater sedimentation tank while the stale water can be used for washing the vehicles.

4.4.10 Workshops

301. Two workshops one for Category B vehicles (tired) and one for Category C vehicles (Truck) are included in project design to facilitate fleet maintenance works. Maintenance workshop layout is provided in below **Figure 4-11.**

Figure 4-11: Maintenance Workshop Layout



4.4.11 Tree Plantation/Buffer *Zone*

302. Inside the boundary wall, tree plantation will be conducted to create an environmental barrier between the external and internal environment. Indigenous tree plantation will be carried out which will serve as the buffer zone. For the landfill to present a clean and aesthetically pleasing view, a buffer zone with tree plantation and landscaped berms will be done. Plantation will start as one of the earliest activities of site development. Once the design of landfill is approved and necessary funds mobilized, plantation activity can be started by BWMC.

4.4.12 Boundary Wall

303. The boundary around the landfill will be a wall constructed of brickwork of 9'' thickness all around the premises.

4.5 Construction Phase Details for Landfill

4.5.1 Construction Schedule

304. The project construction phase is expected to last for a total of 2 years.

4.5.2 Construction phase activities

305. The activities to be conducted during construction phase of the project are provided below:

4.5.3 Development of Construction and Labor Camps

306. One of the first activities to be completed by the Contractor shall be the establishment of the construction and labour camp. The Contractor will also establish construction yards and sites (including storage and batching plant), offices and a workshop. No construction camp will be established at the existing dump site. However, a construction camp will be set up at the new landfill site specifically during the construction phase. Same camp will be used for construction of MRF.

307. The construction of the proposed landfill will be divided into construction work packages and these packages will be awarded to the selected project Contractors.

308. The construction activity must span over approximately twenty-four months. There shall be several contracts for a variety of works. The selected Contractors shall have the option to select suitable site(s) located near the project sites to establish his labour camps. If private land is selected, the contractor shall enter a contract with the private owner. No night-time construction activities will be conducted during the construction phase.

309. There will be no construction activities carried out on the complete dumpsite. The construction camp will be established at a new landfill site and the same will be utilised for construction of MRF. One HSE officer will be assigned for each civil work construction LOT. During construction phase, an estimated 150-200 persons consisting of both semi-skilled and skilled human resource will be required.

310. Essential for the work bases is easy approach, availability of a suitable place for temporary storage of material and availability of water for construction in the vicinity. Presence of shade from trees close to the work bases can add to the comfort for the labour while taking rest during the hot season.

311. The location of storage materials and camps will be critical. Since the project contractor(s) will be responsible for identifying the suitable locations for storage and

labour camps from the private sector, there will need to be clear guidelines for this process, which will need to be closely monitored by the implementing agency. As far as possible, the project design team shall be assigned the task to identify the suitable location(s) for storage of materials since inappropriate storage of materials may result disruption of the traffic movement.

312. The location of the batching and asphalt plants will be 300m away from any residential dwellings or sensitive receptors.

313. The proposed site for the Contractor's camp shall include the following facilities:

- Labour camp site
    - Accommodation
    - Kitchen
    - Dining area
    - Sanitation facilities
    - Septic tank
    - Liquid and solid waste disposal facilities
    - Generator(s), for operation when the power supply from the grid station was not available
- Construction camp site
    - Uncovered material storage
    - Covered material storage
    - Parking for vehicles and plant
    - Batching plant
    - Generator(s)
    - Site offices

  Workshop site: The current dumpsite will not serve as a worksite. Instead, a distinct 10-acre plot of land situated adjacent to the existing dumpsite will be designated as the worksite. The primary workshop will be established at the MRF, while a smaller workshop will also be set up at the Landfill site.

- Workshop for primary vehicles at landfill site will be paved asphaltic area of 5400 sq.m. with dimension of 126 m x 150 m. It will consist of a washing bay, paint shop, tool store, carpeting area and parking sheds. Workshop for MRF will be paved asphaltic area of 4200 sq.m consisting of washing area, tool store and parking sheds:
    - Workshop
    - Storage area

- Generator(s)

- Sites preparation

314. There may be a need to carry out cutting and filling of the land to attain the designed ground elevation. The effects of earth movement and excavation on site preparation are elaborated for the landfill facility and BWMC office building.

315. During the process, areas above the design elevation shall be cut and spoils shall be used to fill areas below the designed elevation. The area is to be clean of any obstructions in areas where the general design elevation is already attained. Cut and fill activities will be carried out using mostly heavy mechanical equipment. Manual labour will be negligible.

316. The ground will be compacted until the desired ground bearing capacity is attained. This is to ensure that all structures, particularly the foundations to be erected are stable and will not be subject to subsidence, settlements and other earth pressures.

4.5.4 Development of Access Roads & Internal Roads, drainage facilities and other horizontal earth works

317. Haul roads from the reception area to the entrance to each phase shall be designed to a standard adequate to allow trafficking of heavy vehicles. Haul roads may need to accommodate the passage of heavy construction vehicles e.g. steel wheel compactors and tracked bulldozers. Service roads to other facilities on site e.g. leachate treatment plant, gas extraction system, should be to an adequate standard to allow access by service vehicles.[6]

318. Particular attention should be given to the access point to each cell. It is important that the access routes chosen do not put the liner at risk. Typical access ramps will be up to 6m in width and have slopes up to 10%.

4.5.5 Construction of Admin building infrastructure within Landfill site

319. Site building infrastructure must be designed, constructed and maintained to a high standard and should include the following facilities:

- Administration building consisting of an administration office, first aid area and general reception area;
- Sanitary facilities: showers and toilets;
- Staff facilities: lockers and mess room;
- Waste reception area;
- Equipment maintenance and fuel storage; and
- Parking area.

320. Purpose built buildings will be constructed with on-site laboratory facilities provided as necessary. The administration building would include a working telephone, a facsimile machine and would be suitable for the storage of records.

[6] https://www.epa.ie/pubs/advice/waste/waste/EPA_landfill_site_design_guide.pdf

4.5.6 Construction of the weighbridge system and Unloading Bay and its components

321. The weighbridge should be located adjacent to the waste reception area and sufficiently far enough away from the public road to avoid queuing onto the road. Weighing facilities should be adequate to accommodate the weighing of both incoming and outgoing traffic if necessary.

4.6 Operation Phase Details for Landfill

4.6.1 Scope of Activities

322. The activities to be conducted during the operational phase of proposed project are provided in **Table 4-2** below.

Table 4-2: Operation Phase Activities

Landfill Development	Operation activities involved
Waste hauling to LFS	The compactor truck will transfer waste from Bahawalpur city to the landfill site.
Weigh Bridge and Unloading Bay	▪ Weighing operation ▪ Maintenance of mechanical and electrical equipment
Landfill site operations	▪ Waste inventory management ▪ Compaction and size reduction ▪ Landfilling ▪ Daily cover ▪ Leachate management (i.e., collection, treatment and disposal) ▪ Landfill gas management (i.e., monitoring, collection, flaring) ▪ Environmental monitoring
MRF and Compost Site Operations	▪ Material Recovery Facility operations ▪ Composting Facility Operations
General Operations	▪ Admin block operations ▪ Maintenance of equipment and machinery ▪ Vehicle servicing ▪ Disposal of solid waste and wastewater generated during operations ▪ Workers Health and Safety ▪ Site Security

4.6.2 Operation Equipment and Machinery

323. The equipment required during the operation phase of the landfill site can be divided into three functional categories: waste movement and compaction, earth cover transport and compaction, and support functions. The **Table 4-3** below provides the equipment expected to be required for operation phase of the landfill site.

Table 4-3: List of Equipment and Machinery for operation phase of Landfill Site

Sr. No.	Machinery / Equipment	Equipment use in landfill operations	Quantity required*
1	Bucket Loader	It is used to fill earth cover material into vehicles at landfill site.	1
2	Chain Dozer	It is used for levelling of waste or excavated soil at the landfill site.	1
3	Trash Compactor	It is used for compaction, propulsion and spreading of waste in a landfill.	1
4	Hydraulic Excavator	It is used for Excavation purposes.	1

* Number of machineries is indicative and can be changed subject to working schedule.

4.6.3 Manpower Requirement

324. Estimated manpower requirements during construction phase of the landfill would be about 150 persons while during the operation phase would be 50 persons.

4.7 Landfill Site Construction:

325. The development of the landfill area will consist of the following activities:

- Excavation for landfill cell and bottom lining along with leachate collection system & gas collection pipes;
- Construction of the access ramps, leachate treatment ponds;
- Construction of Gas Flaring System and CNG Dispensing Unit
- Run off and run-on collection network;
- Final capping arrangements.

4.8 Construction of BWMC Office Building at Hasilpur Road

326. BWMC office building infrastructure must be designed, constructed and maintained to a high standard and should include:

- Ground floor plus 4 storeys, first aid area and general reception area
- Sanitary facilities: showers and toilets
- Offices, meeting rooms and canteen
- Equipment maintenance and fuel storage and
- Parking area.

Construction Machinery Requirement

327. For storing materials, stocking equipment and parking machinery and vehicles, the Contractor(s) shall require open and accessible sites close to the labour camps. The Contractor(s), at his own expense, but keeping in view his contractual obligations

to honor the applicable national and international guidelines regarding level of pollution, shall make the arrangements.

328. The **Table 4-4** below outlines the approximate number of major machinery and vehicles that are envisaged to be required for the project construction works.

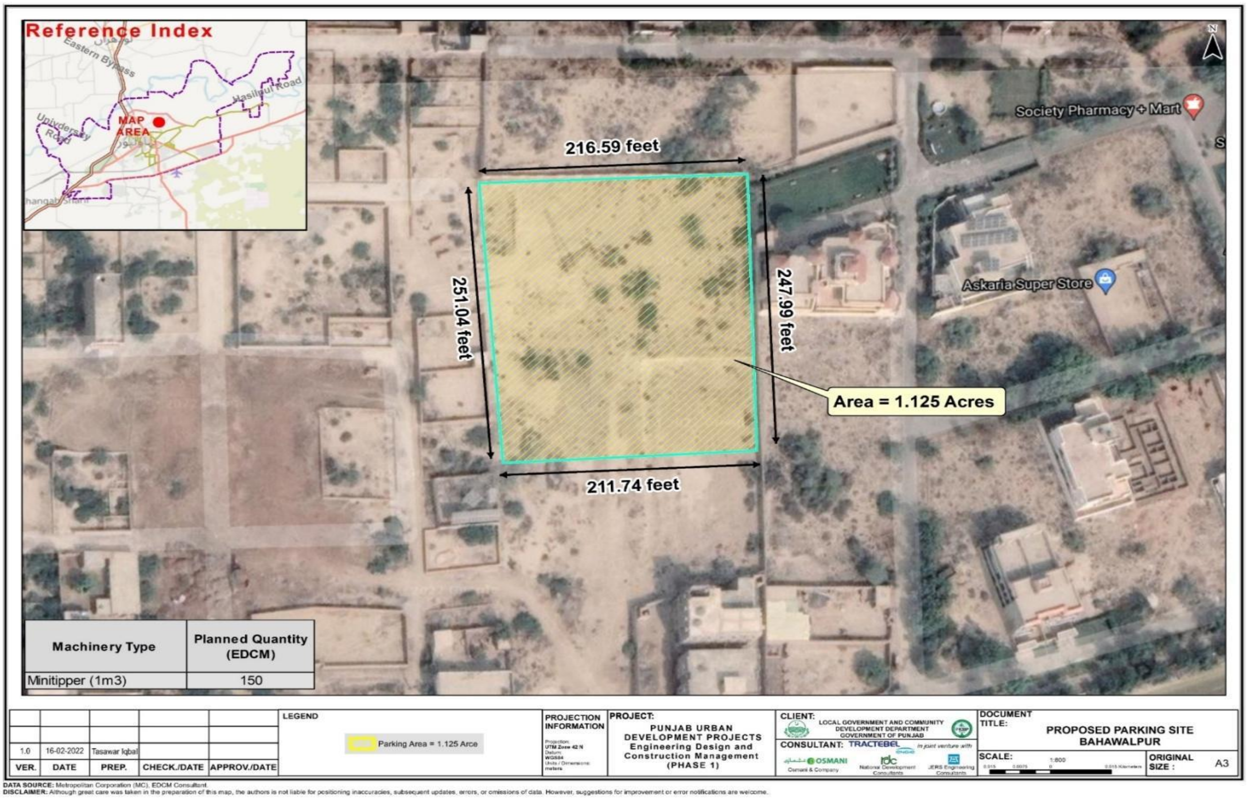
Table 4-4: Estimated Contractor's Equipment and Machinery

Sr. No.	Machinery / Equipment	Quantity required*
1	Excavators	4
2	Dumpers	4
3	Batching Plants	1
4	Loaders	3
5	Power Generators	4
6	Rollers	2
7	Tractor Trolley	6
8	Transit Mixer	3
9	Compactor / Roller	3
10	Crane	1
11	Crush Plant	1
12	Concrete Pump	2
13	Vibro Hammer	1
14	Welding Generators	2
15	Watering Tanks (moveable)	5
16	Haulage Trucks	20
17	Cars/Pickups	8

* Number of machineries is indicative and can be changed subject to working schedule.

329. Parking area of 1.125 acres will be reserved to accommodate the machinery and equipment required during construction and operational phases**. Table 4-4** shows the parking area for the proposed landfill.

Figure 4-12: Proposed Parking Area



Construction Materials Requirement

330. During the construction phase, construction materials in considerable volumes will be required. Typical material required for landfill cell development include base mineral liner, cap barrier layer, leachate drainage blanket; other drainage layers e.g. capping layer and groundwater/surface water, gas collection and venting system, road material and daily cover. The common source of the material require for civil work are described in **Table 4-5** below.

Table 4-5: Source of Raw Material

Sr.#	Raw Material	Source
1	Earth Material	Available locally, borrowed from the lands acquired for the project.
2	Aggregate	Available at many sources within the vicinity of the site.
3	Rip-rap material	Available locally from nullah bed deposits and rock excavations.
4	Sand	Sand is available in the near vicinity and riverbed.
5	Water	Ground water is available at depth of 15-20 metre, and it will be used for construction purpose.
6	Cement	Ordinary Portland Cement is suitable, which is available at various factories in Pakistan.

Sr.#	Raw Material	Source
7	Reinforcement steel	Steel re-rolling mills in Bahawalpur meeting the standards from the billet produced either by Pakistan steel or imported. These will serve the purpose of steel availability.
8	Energy	Electricity supplies are available at the site through MEPCO grid.

4.9 Closure and Post Closure Plan for Landfill

331. Both the Closure and Post Closure plans will come into effect towards the end of the Landfill's useful life, usually 40 to 50 years from commencement of operation of the landfill. In this time, there could be marked changes made to them depending on how environmental and socioeconomic conditions in and around the site and Bahawalpur city have evolved. Furthermore, the existing dumpsite will undergo rehabilitation once waste dumping operations cease in 2028. A well-formulated bio-remediation plan has been established for the rehabilitation of the existing dumpsite, and its execution is scheduled to commence shortly after the discontinuation of waste dumping activities. The landfill closure plan will include:

- Landfill cover and landscaping of the completed site;
- Long term plans for the control of runoff, erosion, gas and leachate collection & treatment.

332. Post closure plan will include:

- Routine inspection of completed landfill;
- Maintenance of surface water diversion facilities, landfill surface grades, the condition of liners;
- Maintenance of landfill gas and leachate collection equipment;
- Long term environmental monitoring plan so that no contaminants are released from the landfill site.
- These plans have yet to be developed but will be customized to the proposed landfill facility and will be prepared within first few years after commencement of the landfill.

4.10 Short Term Design Horizon

333. The short-term design horizon proposed by EDCM is detailed below.

- Environmental awareness programme will be developed and implemented throughout the project life. This programme must be translated in Urdu and any other local language prior to start-up of the project. The print and audio visuals material for environmental awareness will be developed in first six month of year 2023 and implementation should start from seventh month of year 2023.
- The CSR program will be developed in parallel and integrated in the environmental awareness programme.

- The training of current management and staff to enable them to operate the redesigned waste collection system and landfill must be started by April of year 2024.

4.11 Long Term Design Horizon

334. The long-term design horizon proposed by EDCM is detailed below:

- Design and development of four MSW disposal cells sequentially. The first cell will be developed in phase -1 of cell development process with a capacity to receive waste for 6-7 years.
- The TS and MRF buildings and infrastructure have a designed life of more than 25 years.
- The equipment recommended for the TS and MRF together with landfill operation will have a useable life of 25 years with regular maintenance and a refurbishment after 12 years (in 13th year). The refurbishment funding is incorporated in the project FS. Please note that refurbishment also includes replacement of some equipment.

335. The financial sustainability of project is ensured through following sources of revenue:

- Revenue from residential
- Revenue from MRF
- Revenue from LFG

5 Project Program and Design - Component 2

5.1 Construction Details of MRF & Legacy Landfill Closure

336. Constructing a MRF along with its associated machinery involves several key steps to ensure its successful establishment and operation. Below is a general outline of the procedure or steps for constructing an MRF:

Project Planning and Design:

- Conduct a detailed site analysis and feasibility study to determine the most suitable location for the MRF.
- Develop a comprehensive design plan that includes layout, infrastructure requirements, equipment placement, and workflow.

Obtain Necessary Approvals:

- Obtain the required permits and approvals from local authorities and regulatory agencies to ensure compliance with environmental and zoning regulations.

Site Preparation:

- Clear the chosen site of any existing structures, debris, or obstacles.
- Level the ground and prepare the foundation for the MRF building and equipment.

5.2 Construction of MRF Building:

- Build the main structure of the MRF, including the sorting area, conveyor systems, processing zones, administrative offices, and any necessary utilities.

5.3 Installation of Equipment:

- Procure and install the necessary machinery and equipment, such as conveyor belts, sorting screens, balers, compactors, shredders, and any specialized machinery for handling specific types of waste.

Electrical and Mechanical Works:

- Install electrical systems, lighting, HVAC (heating, ventilation, and air conditioning), and other mechanical components required for the smooth functioning of the facility.

Safety Measures:

- Implement safety features and protocols, such as fire suppression systems, emergency exits, and proper signage, to ensure the safety of workers and compliance with safety standards.

Waste Segregation and Sorting Setup:

- Designate specific areas for waste segregation and sorting based on the types of materials being processed.
- Set up proper bins, containers, and collection points for various recyclable materials.

Testing and Quality Control:

- Test each piece of equipment to ensure its proper functioning and efficiency.
- Implement quality control measures to ensure that the sorting and processing procedures meet established standards.

Staff Training:

- Train the staff on equipment operation, safety protocols, waste handling practices, and quality control procedures.

Operational Readiness:

- Conduct trial runs and simulations to ensure that the MRF is fully operational and able to handle the expected waste volume efficiently.

Soft Launch and Monitoring:

- Gradually transition to full operations by initially processing a controlled volume of waste.
- Monitor the facility's performance, identifying any operational issues and making necessary adjustments.

Full Operation:

- Once the facility's performance has been verified and any issues resolved, the MRF can be fully operational, processing and sorting waste materials efficiently.
- Throughout this process, it's important to adhere to environmental and safety regulations, conduct regular maintenance of equipment, and continuously train staff to ensure the smooth and sustainable operation of the Material Recovery Facility.

5.4 Framework Management Plan

337. Framework management plan for operation of LFS shall be prepared by the Design Build Operation (DBO) contractor in consultation with BWMC and PMU PICIIP. This framework management plan will guide the LFS DBO contractor to manage the facilities operations in compliance to requirements of IEE, ADB SPS, 2009 and PEPA, 2012. Draft framework management plan is prepared for the project which will be further updated once DBO contractor will be one board. The DBO contractor will complete the framework management plan with supplementary information and layouts and then submit to PMU/ADB for review and approval before start of operations at LFS. Draft framework management plan is attached as **Appendix A-22**.

5.5 Environmental Awareness and Community Outreach Program

338. The main components of environmental awareness program are provided below.

- Environmental Awareness at Primary, Secondary and High School Levels through developed environmental and waste management program
- Direct Contact through Door-to-Door visits by Awareness Coordinators and Volunteers
- Mass Media Utilization: Televisions, radios and seminars.
- Awareness teams will start these mass media awareness program as soon after approval of awareness from the department of local government and the education department.

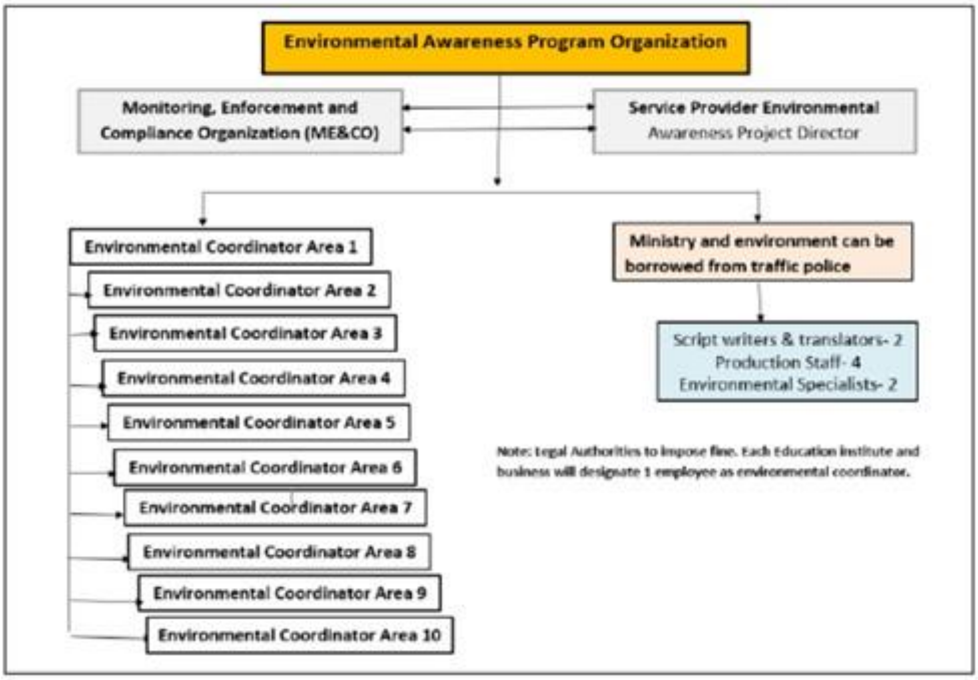
339. Punjab LG&CDD will develop a media interface through existing channels and also start publishing an environmental and waste management bi-monthly newsletter. It is suggested that an Environmental Awareness FM radio may be established to organise talk shows and light entertainment. All programs will be in English, Urdu or any other major spoken language.

340. The local government entity (Mayor's office) will allocate a full-time environmental education expert to the organization who will head the organization and community awareness programs. He will be assisted by four environmental education specialists.

341. Segregation of waste is being practiced at UC-14 as pilot project. However, after few years of ISWMS operation, segregation at source will be practiced based on the results of pilot project and environmental awareness and community outreach program. Community awareness sessions will be conducted to promote segregation practices in the city.

342. Organization of the environmental awareness program is illustrated in **Figure 5-1** below.

Figure 5-1: Organization of environmental awareness program



343. Organization to stop littering is illustrated in below **Figure 5-2**

Figure 5-2: Organization of stop littering

6 Description of the Baseline Environment

6.1 Socio-economic Environment

344. This section includes a summary of the prevailing socio-economic conditions in the project area and the population that will be potentially affected by the Project. To ascertain the socio-economic condition of the project area, primary and secondary data was collected including social and physical infrastructure in the project area.

345. A report jointly produced by TAMA and the Centre for Economic Research (2010), Pakistan (CERP) regarding estimation of baseline indicators (other than livestock) and assisted in development of indicators[7].

346. According to the study, the district of Bahawalpur has the highest poverty headcount ratio, and the variation at sub district level is even higher. Bahawalpur City, which is district headquarter as well, has the lowest poverty rate 41%, whereas Ahmadpur East is the tehsil with highest poverty rate of 62.09%. Bahawalpur Sadar has a higher poverty rate.

347. To assess the socioeconomic conditions of the project area, consultations were carried out with 160 participants including 65% male and 33% female participation. Households (HH) have been studied during the field survey based on individual interviews as well as focus group discussions/ public consultations. These people are considered as project affected people and during the socio-economic survey, interviews were held with them to brief them about the project and to seek their views. In addition, the secondary data, including Economic Survey of Pakistan (2021-2022), Bureau of Statistics (2017-18), and MICS of Punjab have been consulted. Survey questionnaire for conducting FGDs is provided as **Appendix A.2.**

348. For the purpose of the environmental and social assessment and sensitive receptor data collection, a two-kilometre-wide corridor along the proposed project site was considered as the study area or the project area. Most of the field data collection was carried out within this corridor though where relevant data was also collected from a wider area along the proposed project site. The reason for selecting this corridor is to cover those areas that have a potential to be affected by the project activities.

6.1.1 Administrative Setup

349. The area of Bahawalpur City is about 96 square kilometres. The city has buildings; places built by the former Rulers of Ex-Bahawalpur State, with prime importance for Bahawalpur City. Noor Mahal, Darbar Mahal Gulzar Mahal and Doulat Khana are remarkable buildings. Bahawalpur (city) is a walled city with two major intersecting roads running east to west and north to south respectively and terminating at four gates. It is linked to other cities by major railway and four sub-regional roads.

350. The project area falls in the administrative jurisdiction of District Bahawalpur, which is under general charge of the Deputy Commissioner, followed by five Assistant Commissioners and ten Magistrates responsible for the coordination of function of all the nation building departments in the district. The judicial administration of the district is under the charge of district and session judge along with five additional district judges. Administrative division of Bahawalpur is shown in **Table 6-1** below.

[7] https://www.theigc.org/wp-content/uploads/2014/11/Cheema-Khwaja-2010-Working-Paper.pdf

351. The names of the major settlements falling in the project area are Mari Sheikh Shijra, Basti Yar Muhammad, Masti Rasheedabad, Basti Rama and Basti Chachran.

Table 6-1: Administrative Division of Bahawalpur City

S.No.	Name of Tehsil	No of Union Councils
1	Ahmad pur sharqiya	31
2	Bahawalpur	36
3	Hisalpur	14
4	Khairpur Tamewali	8
5	Yazman	18
Total		107

6.1.2 Demography and Population

352. The population of Bahawalpur district is 3,668,106 as per 2017 Census Report. The urban parts of the project area are densely populated due to the availability of resources and employment opportunities. In the rural parts, population varies in villages and settlements depending on several factors e.g. water, accessibility, employment etc.

353. The average annual growth rate of population in the district during intercensal period 1998-2017 was 3.07 percent. The total area of the district is 24,830 square kilometres which gives population density of 98 persons per square kilometre as against 59 persons observed in 1981 indicating a fast growth rate of the district.

354. Later in 1998, the massive efforts were made to count the population and census bureau carried out latest census and released the latest statistics. of 2017 at the national, provincial and district level.

355. By the annual growth rate of 2.18%, the population of District Bahawalpur is estimated as 3,668,106 persons out of which 1,879,311were male and 1,788,578were female. Sex ratio is measured as 105.07 percent. The following table gives population, its intercensal increase and average annual growth rate.

Table 6-2: Demography of Bahawalpur District

Household s	Population-2017				Population 1998	1998-2017 Average Annual Growth Rate
	Male	Female	Trans-gender	All Sexes		
584,864	1,879,311	1,788,578	217	3,668,106	2,433,091	2.18

*Source District wise population Census 2017 by Pakistan Bureau of Statistics: Government of Pakistan.

6.1.3 Religion

52. The population of the district is predominantly Muslims i.e. 98.1 percent. The next higher percentage is of Hindu with 0.9 percent followed by Christian 0.6 percent. While other minorities like Ahmadis, Schedule Castes etc. are very small in number as shown in the table given below:

Table 6-3: Major Religions in Bahawalpur

Religion	Bahawalpur		
	All Areas (%)	Rural (%)	Urban (%)
Muslims	98.1	98.1	98.0
Christians	0.6	0.3	1.4
Hindu	0.9	1.1	0.3
Ahmadis	0.1	0.1	0.1
Scheduled Castes	*	*	*
Others	0.3	0.3	0.1

* Refers to a very small **number**

Source: Pakistan Bureau of Statistics 2017

6.1.4 Cultural and Archaeological sites

356. In Bahawalpur, following sites are of cultural significance:

- Tomb of Abu Hanifa, Uchh Sharif, Bahawalpur.
- Tomb of Bibi Jawidi, Uchh Sharif, Bahawalpur.
- Tomb of Nuria, Uchh Sharif, Bahawalpur.
- Tomb of Bhawal Halee, Uchh Sharif, Bahawalpur.
- Tomb of Musa Pak Shaheed, Uchh Sharif, Bahawalpur.

357. No archaeological and cultural site was observed in proximity of Bahawalpur landfill site.

358. The city of Bahawalpur has a rich heritage and is an important hot spot for historians as well as archaeologists. Bahawalpur is known for its cotton, silk, embroidery, carpets, and extraordinarily delicate pottery. The Punjab Small Industries Corporation (PSIC) has established a Craft Development Centre for Cholistan area, outside Farid Gate, Bahawalpur from where handicrafts manufactured in Cholistan can be purchased.

6.1.5 Ethnicities in Project Area

359. According to baseline survey, it was found that the largest part of the respondents i.e. 38% were Larah, 24% were Jutt, 14% were Lashari, 08% were Qureshi, and 06% were Bhutta. While 04% were Syed and Khokar each and 02% were Chohan. No indigenous people are present in the project area. The castes of the sampled respondents are given in **Table 6-4** below.

Table 6-4: Ethnicities in Project Area

Caste / Ethnic Group			
Sr. No.	Caste / Ethnic Group	Number	Percentage (%)
1	Larah	38	38
2	Jutt	24	24
3	Lashari	14	14

Caste / Ethnic Group			
Sr. No.	**Caste / Ethnic Group**	**Number**	**Percentage (%)**
4	Qureshi	08	08
5	Bhutta	06	06
6	Syed	04	04
7	Khokar	04	04
8	Chohan	02	02
Total		**100**	100

6.1.6 Languages

360. The mother tongue refers to the language used for communication between parents and their children in any household. Siraiki is the predominant language being spoken by majority (64.3 percent) of the population of the district followed by Urdu, Pushto and Punjabi being spoken by 5.5, 0.6, and 28.4.

6.1.7 Main Sources of Livelihood/Income

361. Socioeconomic survey findings depicted that out of 100 respondents, majorities i.e. 46% are labourers, 36% of the respondents are working as farmers in agricultural fields, 08% are doing their own businesses, 04% of the respondents are doing services and livestock and 02% belongs to some other source of income which they do not want to mention here. Source of income of the respondents are shown in **Table 6-5.**

Table 6-5: Source of Income of Respondents

Sr. No.	Source of Income	Number	Percentage (%)
1	Business/shop	08	08
2	Labor	46	46
3	Agriculture	36	36
4	Livestock	04	04
5	Service	04	04
6	Any Other	02	02
Total		**100**	100

6.1.8 Transport

362. The road infrastructure in Bahawalpur is generally good for existing requirements. As with other cities under review, there are no signals on any Chowk and no urban bus or van services are available. Mixed motorised and non-motorised traffic increase congestion on roads.

363. Bahawalpur has its own airport built by the Dubai Civil Aviation Department. Bahawalpur Airport links the city with various Pakistani cities such as Dera Ghazi Khan, Islamabad, Karachi and Lahore with the national flag carrier, Pakistan National Airlines. The airline has launched international flights to Dubai and plans to introduce more international destinations. There are also daily bus and train services to and from Multan, Lahore, Sukkur and Karachi.

6.1.9 Industry

364. The Most famous industries lying in Bahawalpur area include Fertilizer, Sugar, Cotton, and Textile, Beverages, flour & Cottage Industries. Fuji Fertilizer Company,

Unilever, Jamal Din wali Sugar Mill, Hamza Sugar mill, Itehad Sugar Mills are the most important industries playing fundamental role in the economy of the area.

365. Being an industrial expanding city, the government has revolutionized and liberalised various markets allowing the Caustic Soda, Cotton Ginning & Pressing, Flour Mills, Fruit Juices, General Engineering, Iron & Steel Re-rolling Mills, Looms, Oil Mills, Poultry Feed, Sugar, Textile Spinning, Textile Weaving and Vegetable Ghee & Cooking Oil industries to flourish.

366. There is no industry in the proximity of the proposed Bahawalpur Landfill site.

6.1.10 Health Care

367. Health conditions are one of the major determinants of a society's social development and quality of life. Healthy manpower is imperative for advancement and economic growth. The major health facilities available in the district are District Headquarter Hospital, Tehsil headquarters Hospital at each Tehsil along with M.C. Health Centre, Primary Rural Health Centres, Primary Dispensaries, Basic Health Units, TB Centres and 72 Dispensaries. The Zila Council is also running dispensaries, MC Centres and Veterinary Hospitals.

368. In the project area, there is a Victoria hospital located at 950 m from landfill and a couple of maternity facilities (in isolated homes) to facilitate the health of communities residing in the project area. Victoria hospital has a capacity of 1409 beds which produces 1.2 tons of hospital waste. This is either burnt or disposed openly in barren areas. As reported by the locals, diseases like Flu, Chest Infection, Dengue, Skin diseases like Scabies and typhoid has rapidly increased due to the presence of uncovered and untreated municipal solid waste here in Mari Sheikh Shijra.

6.1.11 Literacy Rate

369. The district has a literacy rate of 35% (2007-2008) with male literacy rate at 44.9% and female at 24%. Looking across regions, 57% of urban population (Male: 52.9%; Female: 47.1%) and 26.3% rural population (Male: 36.4%; Female: 15.1%) of Bahawalpur are literate. However, according to (Multiple Indicator Cluster Surveys) MICS 2017-18 survey, the literacy rate above 10 years is 45% (Male 51.66%; Female: 48.34 %). Similarly, urban rural distribution shows 65% urban population (Male: 52.5 %; Female: 47.5%) and 37% rural population (Male: 51.3 %; Female: 48.7%) is literate.

6.1.12 Education

370. Education plays a pivotal role in changing social and economic condition of the individuals. There are over 1600 government primary schools- 45% of which are for girls. Middle schools are 226, over 60% are for girls, and 39% for boys, while high schools are 125 and 62% are for boys. As the level of education increases, the percentage of boys' schools increases in the district. However, higher secondary schools are the same in the district, 14 each.

371. Total number of arts and science degree colleges are 18 having enrolment of almost 20,000 students and teaching strength of 543. The higher education institutions in Bahawalpur district include Islamia University of Bahawalpur, Asian college of Technology Hasilpur Road Bahawalpur, Rise School of Accountancy, Tebiya College, Four Elementary colleges for teaching training, Quaid-e-Azam Medical College (QAMC), Government Sadiq Egertin College (SE College), Government Sadiq Degree College for Girls, Millat College and Post Graduate

College Baghdad Road. Number of educational institutions by sex and type is given in the **Table 6-6** below.

Table 6-6: Educational Institutions by Sex and Type

Sr. No.	Name of Institutions	Institute		
		Male	Female	Private
1	Primary	797	756	138
2	Middle	80	85	120
3	High/Secondary	04	03	-
4	Intermediate Colleges	03	02	-
5	Degree Colleges	02	03	-
6	Vocational Institute	02	01	-
Total		**888**	**850**	**258**

Source: Pakistan Bureau of Statistics 2017

6.1.13 Types of Dwellings

372. Housing conditions of the respondents have been analysed according to the type of houses in which they were residing. The house or building constructed with concrete or burnt bricks fall in pacca category whereas house or building constructed with burnt bricks with mud comes under semi-pacca category while house constructed with mud bricks or temporary wooden logs etc. are categorized as kacha house. Project area population is mostly living in semi-pacca and pacca houses.

373. A high concentration of residential settlements is located to the south of the proposed site, a part of which is already being used for dumping of solid waste at proximity to the proposed site. Furthermore, sparsely scattered residential settlements are lying at varying distances around other sides of the proposed landfill site.

374. Based on the survey, 08% of them live in the pacca houses made up of bricks and concrete whereas 16% live in the semi-pacca houses. While majority i.e. 76% respondents live in the kaccha houses. **Table 6-7** shows the type of construction of the houses.

Table 6-7: Type of Construction of the Houses

Type of Construction of the Houses			
Sr. No.	**Type**	**Number**	**Percentage (%)**
1	Pacca	08	08
2	Semi-Pacca	16	16
3	Kaccha	76	76
Total		**100**	**100**

6.1.14 Energy Supplies

375. The residents of project area are reliant on electricity available from the grid through MEPCO (Multan Electric Power Company). Due to long duration load-shedding particularly during summer, there is an increasing trend of using diesel generators and installing solar PV systems in both residences and businesses to ensure energy reliability.

6.1.15 Major Source of Drinking Water

376. Sampled respondents are depending upon several sources of water for domestic use which is shown in **Table 6-8** below. Hand pumps/Electric motors are the main source of water for domestic use in the proposed project area (93%) respondents get water from this source and remaining 07% respondents use filtration plants as the source of water for domestic purpose.

Table 6-8: Source of Water for Domestic use

Source of Water in Project Area			
Sr. No.	**Source of Water**	**Number**	**Percentage (%)**
1	Hand pumps/Electric motor	93	93
2	Filtration plant	07	07
Total		**100**	**100**

6.1.16 Sewerage System

377. The sewerage system in Bahawalpur covers 70% of the city and serves 82% of the population. There are 5 existing wastewater disposal (pumping) stations, which are periodically out of order. At present there is no facility for treatment of the wastewater.

378. The wastewater pumped from disposal stations is utilised without any treatment by farmers for irrigation, presenting a potential health hazard. The excess wastewater from the disposal stations is pumped either into the Sutlej River or into canals.

379. A major component under the Southern Punjab Basic Urban Services Project (SPBUSP) for TMA Bahawalpur City is the construction of a new sewerage system. However, a proper sanitation plan has still not been developed.

6.1.17 Social amenities in the project area

380. During the field survey, the access/ availability of the social amenities/ basic infrastructure in the vicinity of the proposed landfill site was asked from the surveyed households as well as physically observed at site. It was noted that facilities such as Electricity, Sui Gas, Water Supply, Telephone, Sewerage Drainage, school are available in the settlement or in its vicinity.

6.1.18 Existing Scavenging Practices

381. It is estimated that nearly 483 tons of waste is being generated and collected in Bahawalpur, most of it is being dumped in open dumping sites. These open dumping sites are openly accessible to scavengers that search through and collect items of a recyclable nature i.e. paper, metals, plastic. These items they then either sell to scrap dealers or bring to their specific warehouses to be sold onwards.

382. Currently, there is not any properly designed sanitary landfill site for waste disposal in the town. No proper solid waste plan has been developed. 60% of the waste generated is being collected and disposed of. This situation will worsen with the increasing population. There is no proper solid waste management system in the town that places waste in sanitary landfills.

383. An estimated 50-60 warehouses are being operated at different locations, on average employing about 50 scavengers. Another estimate places the total number of scavengers, whether employed or operating privately, somewhere between 5000

and 7000, mostly male but an overwhelmingly high proportion lying in the age bracket of 10-20 years.

384. Studies on a limited scale have tried to assess their socioeconomic conditions, from their mean monthly income figures to their motivation for this line of work and their working conditions (Alam et al, 2011). Generally, a scavenger on average makes between PKR 2000 and 3000 per month (Dawn, 2017). In most cases, this income supports the primary income source in the household, but there are cases where the scavenger's income is the primary or even sole income of the household (Alam et al, 2011). The major concern observed within this line of work is the overall health and safety risk that scavengers are under, as they constantly must deal with sharp or dangerous objects with usually no protective measures or gear. Scavenging activities are observed to be mostly concentrated in commercial market areas of the city, with not as much outreach into residential neighbourhoods.

385. There is a considerable potential to positively channel the work that these scavengers put in towards waste reduction and recycling, possible immediately after door-to-door collection takes place as well as at a MRF. The informal networks of scavengers can be brought on board by the BWMC operations by subcontracting them these waste sorting activities. This is likely to significantly secure both their livelihoods and their working conditions. Some level of vocational training will be required to ensure a uniform basic skill level; however, it is expected that these workers will bring to the job considerable experience from having performed it in an informal and unregulated sector.

386. There is much tendency in the scavenging industry to employ young children. Once under a formalised umbrella, care will be taken to ensure that Child Labour Laws and best practices are fulfilled. Examples of global brands like Levi’s and Nike (Dawn, 2017) retaining their underage workforce in Bangladesh, investing in their education and bringing them to work once they were of legal age, is a good precedent to look up to, determined ultimately by financial feasibility in addition to ethical considerations.

387. A study places the present rate of recovering recyclables from Bahawalpur's total waste at 30%, which is predominantly done by these scavengers. Making use of their service in a formal, regulated system of operation which emphasizes can improve this rate to as high as 90% (Asma et al, 2017).

388. Considering all these factors, an overall positive effect is anticipated from the SWM system on scavenging and recycling. In addition, detailed consultations with scavengers, scrap dealers and personnel involved in the waste management business were conducted and the details are provided in **Chapter 8 (Stakeholder Consultations)**.

6.2 Bahawalpur Region Environmental Characteristics

6.2.1 General

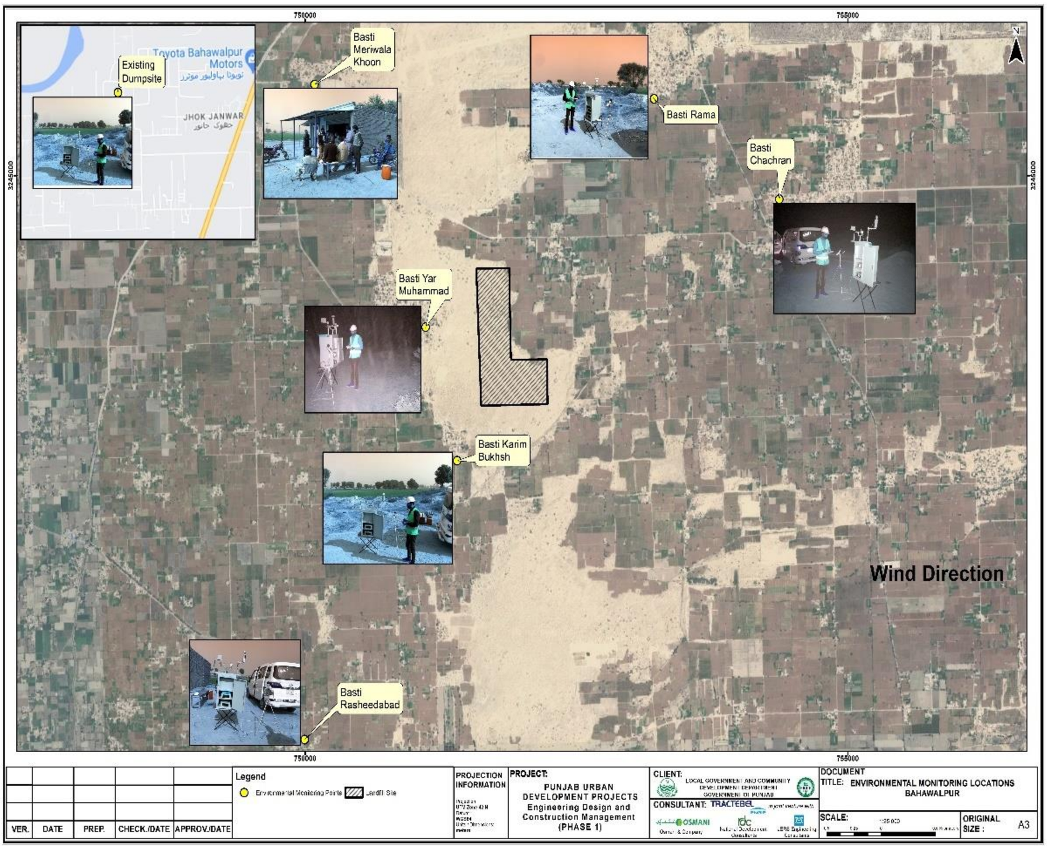
389. Component 1 and 2 discussed in this IEE can be found west of Bahawalpur city. Bahawalpur, lies just south of the Adamwahan Empress Bridge on Sutlej River, is situated 17 km from Lodhran, 90 km from Multan, 420 km from Lahore, 122 km from Burewala, 90 km from Vehari, 270 km from Faisalabad and about 700 km from the national capital, Islamabad.

390. It is a fertile alluvial tract in the Sutlej River valley. East of Bahawalpur is the Pat, still inhabited or Bar, a tract of land considerably higher than the adjoining valley. It is mostly desert. Farther east, the Cholistan, is a barren desert tract, bounded on the north and west by the Hakra depression with mound ruins of old settlements along its high banks; it is by nomads. Bahawalpur district has a total area of 24,830 km2. Approximately two-third of the district (16,000 km2) is covered by the Cholistan Desert, which extends into the Thar Desert of India.

391. Baseline environmental and social profile of the project area was developed by collecting information through field surveys, literature review of available secondary data including maps prepared by the Geological survey of Pakistan, electronic and print media, published literature, District Census Reports (DCRs), and studies previously conducted in district and archives of the experts and on-site environmental monitoring and surveys.

392. As part of the IEE, baseline instrumental monitoring was planned for collection of filed data regarding environmental parameters for air, water, noise, etc. An environmental laboratory; accredited with Environment Protection Agency; was engaged for this purpose. The monitoring locations were selected keeping in view the nearest residential dwellings, waste transportation route, downstream wind directions and availability of the sensitive receptors. Sampling location map of new landfill and MRF is provided in **Figure 6-1**.

Figure 6-1: Sampling location map of proposed LFS and MRF



393. **Air Monitoring:** Six different locations around the new landfill site (Component 1) were selected for ambient air quality monitoring. These locations namely Basti Rama, Basti Yar Muhammad, Basti Karim Bukhsh, Basti Meriwala Khoon, Basti Rasheedabad and Basti Chachran were monitored for PM_{10}, $PM_{2.5}$, CO, NO, NO_2, SO_2 etc. for 24hrs, the monitored results then compared with PEQS and WHO for air standards. Monitoring was also carried out at existing khanuwali dumpsite. As part of the long-term ambient air quality monitoring, the air quality parameters will be monitored over a two-to-three-month period to assess the variation of the air quality parameters during this period.

394. **Noise Levels Monitoring:** Six different locations around new landfill site (Component 1) were selected for ambient noise monitoring. These locations namely Basti Rama, BastiYar Muhammad, Basti Karim Bukhsh, Basti Meriwala Khoon, Basti Rasheedabad and Basti Chachran were monitored for ambient noise for 24hrs, the results then were compared with PEQS and WHO for noise standards.

Table 6-9: GPS Coordinates of Air and Noise Sampling Points

Sampling Point	Monitoring Date	GPS Coordinates	
Basti Rama	Sept 30, 2022	29°18’51.28”N	71°36’25.93”E
Basti Yar Muhammad	Dec 01, 2023	29°17’52.57”N	71°35’6.50”E
Basti Karim Bukhsh	Dec 02, 2023	29°17’17.15”N	71°35’16.32”E
Basti Meriwala Khoon	Dec 03, 2023	29°18’57.28”N	71°34’30.18”E

Basti Rasheedabad	Dec 04, 2023	29°16’4.64”N	71°34’22.46”E
Basti Chachran	Dec 05 2023	29°18’23.96”N	71°37’8.01”E
Existing Dumpsite	May 16, 2023	29°42’533.3ºN	71°633’52.4ºE

395. **Water Monitoring:** Ground and surface water sampling and analysis was carried out from the available sources in the project area.

396. **Soil Quality:** Soil quality analysis of existing dumpsite was also carried out

397. **Groundwater Sampling:** Sampling was carried out in May 2023. Locations consisted of the legacy landfill (Component 2) and the new landfill site (Component 1). The details of the sampling and monitoring outputs are given in below paragraphs.

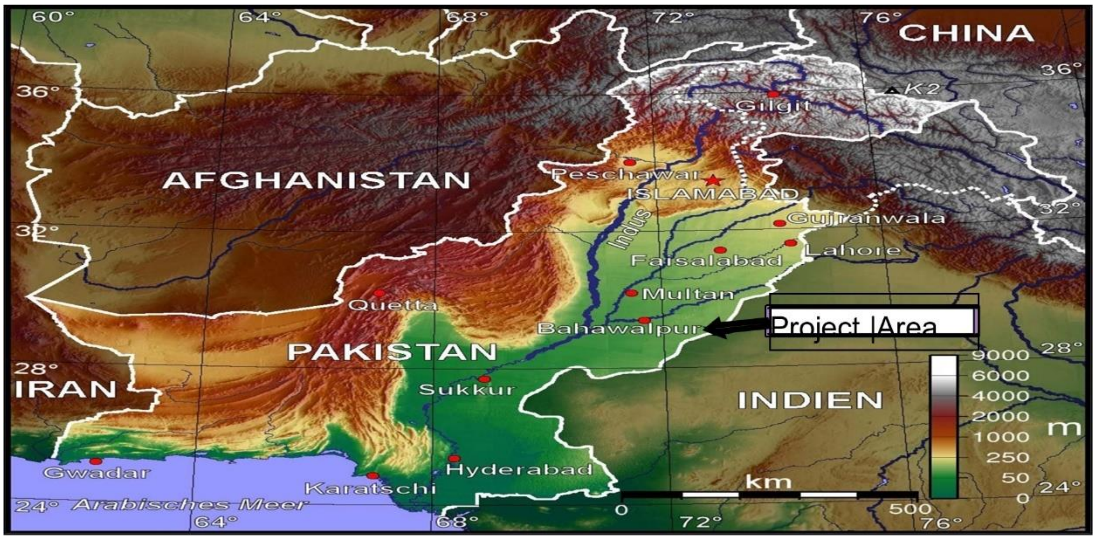
6.2.2 Topography

398. The District Bahawalpur can be divided into three parts i.e. the riverain area, the plain area and the desert area. The riverain area lies close to the River Sutlej, which flows in the north along its boundary with Lodhran and Vehari Districts. The area is inundated during floods. The irrigated track is higher than the riverain area. Most of the land has been brought under cultivation.

399. The desert area is known as the Cholistan. It runs along the entire eastern boundary of Bahawalpur District in the north and Rahimyar Khan District in the south. The surface of the desert consists of a succession of sand dunes rising in some places to a height of 150 meters. The project site is in the desert land of the Nouaabad[8].

400. Regions to its west are fertile alluvial tracts irrigated by the Sultej River. East of Bahawalpur is the Pat, or Bar - a tract of land at considerably higher altitude than the adjoining valley. Farther east, the Cholistan, is a barren desert tract, bounded on the north and west by the Hakra depression. **Figure 6-2** represents the topography of the project.

Figure 6-2: Topography of the Study Area



8 *Bahawalpur". Punjab Portal. Retrieved 17 August 2022*

6.2.3 Geology and Soil

401. The distribution of Tertiary rocks in the project area is unknown, except in the Pabbi Hills area, in the northeastern Chaj Doab, where rocks of the Siwalik system are exposed. In the area of -the buried bedrock ridge, in Chaj, Rechna, and Bari Doabs, exploratory drilling has revealed that the Precambrian basement rocks are overlain directly by Quaternary alluvium. The northeast and southwest of the bedrock ridge, test holes drilled to a maximum depth of about 1,500 feet bottomed in alluvium. Hence, no information is available concerning the total thickness of the alluvial deposits, the southward extension of Tertiary or older sedimentary rocks from the Salt Range and the Pabbi Hills, and the depth to the basement complex in most of the area.

402. The alluvial complex consists principally of fine to medium sand, silt, and clay. Beds of gravel or very coarse sand are uncommon. Pebbles of siltstone or mudstone may be found embedded in silty or clayey sand in many places. Also associated with fine- grained strata are concretionary zones or nodules of kankar, a calcium carbonate deposit of secondary origin. The study of drill cuttings and electric logs has shown the absence of thick horizons of pure clay within the alluvium. Except for local clay lenses, a few feet thick, the finer parts of the alluvium consist generally of sandy, gravelly, or silty clay. Although there are local concentrations of fine-grained sediments of considerable thickness, individual strata are generally lenticular and have little horizontal or vertical continuity. The random distribution of coarse and fine-grained sediment within the alluvial complex is entirely consonant with its mode of deposition by large constantly shifting streams.

403. The soil is sandy, while the soil of central Bahawalpur mostly consists of the plains of Indus basin which is at the height of not more than 150 meters above sea level. But the southwestern desert, which is called Rohi or Cholistan, is mostly undulated due to the presence of sand dunes. The height of the sand dunes does not exceed 150 meters (according to Imperial Gazetteer of 1901 height of dunes was not more than 500 feet). Before the construction of Sutlej valley Project’s Canal system, the irrigation was carried out with the flood water of Sutlej. This area is called “Otarh.” The second major area in terms of topography, extending between the railway line and the passage of Hakra, comprises of clay. The special ingredients are silt and sand dunes. Locally this is known as “Hitarh” and this is the prosperous and fertile area of the dwellings and markets of the colonies of Sutlej valley Project. Imperial Gazetteer concluded had divided this area lengthwise into three great strips: Rohi or Cholistan (desert); the central tract was Bar or Pat (upland); and the third was fertile alluvial tract in river valley called Sind.

6.2.4 Climate

404. Seasonal climatic conditions must be considered for the design and execution of the project. The climate including air, temperature and precipitation is an influencing factor, affecting the construction and other engineering structures. However, to determine the overall effect of the climatic stresses, daily and seasonal temperature changes and precipitation must be considered.

405. Bahawalpur lies on elevation of 117m above mean sea level. The climate here is dry. During the year, there is virtually no rainfall in Bahawalpur. According to Köppen and Geiger, this climate is classified as BWP. The city witnesses some of the extreme temperatures in the country. The summer season starts from the month of April and continues till October, while the weather is pleasant and cold from November to February. Besides, dust storms are also common in the area.

Rainfall and Temperature

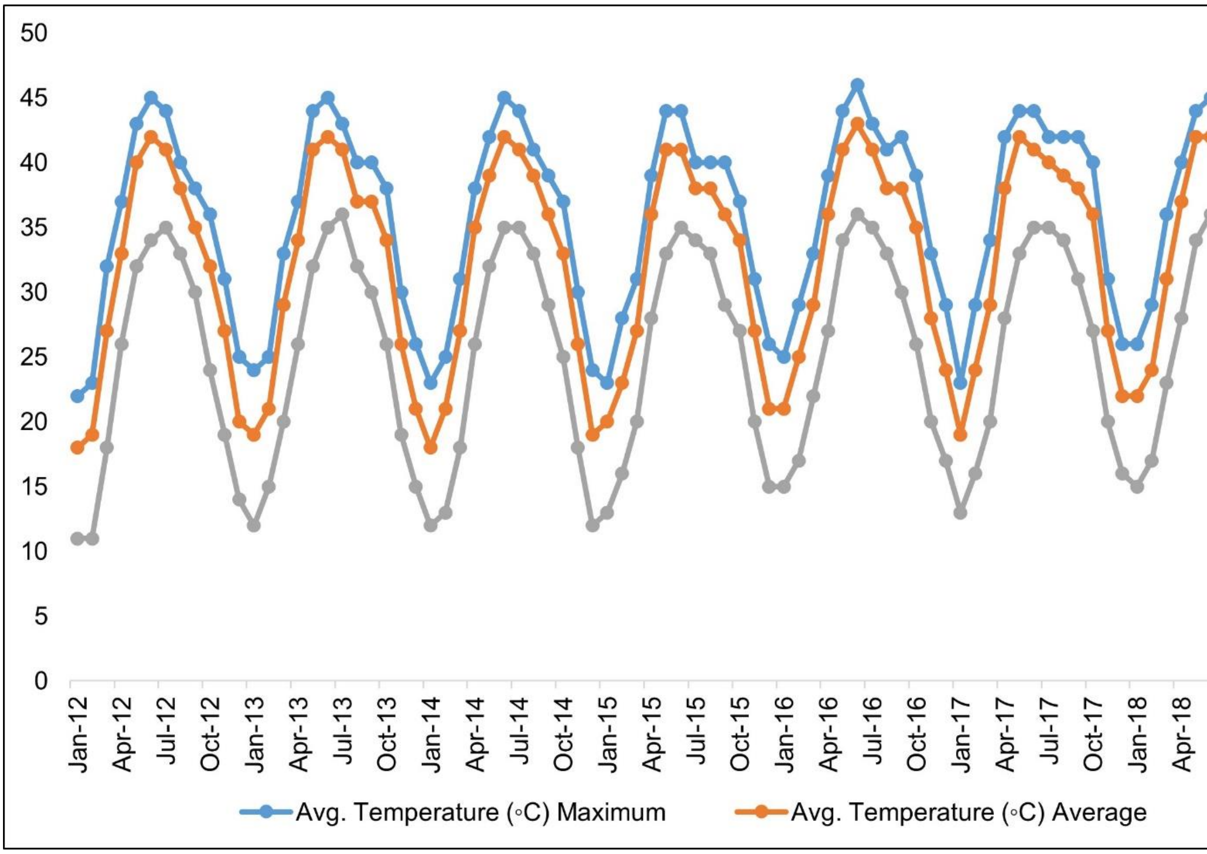
406. Due to less average annual rainfall (143 mm) the city features an arid climate with sweltering summers and cold winters. The wettest year observed was 2021; with an annual total rainfall of 166.2 mm. Minimum annual rainfall was 119 mm recorded in 2017.

407. Based on the past decade of data, the month with the maximum precipitation on average is July with 27.67 mm of precipitation. The month with the least precipitation on average is October with an average of 2.33 mm.

408. The average temperature for the past decade in Bahawalpur is 89.6°F (32°C). The warmest month, on average, is July with mean temperature of 104.36°F (40.2°C). The coolest month on average is January, with mean temperature of 66.56°F (19.2°C).

409. Data of average temperatures, precipitation and soil temperature recorded is provided in **Table 6-10**. **Figure 6-3 and**

410.



412. **Figure 6-4** showing monthly temperature and precipitations for project area during the past decade (Year 2012-2021).

Table 6-10: Metrological Data Records of Bahawalpur9

Month-Year	Parameters					
	Average Temperature (◦C)			Average Rainfall (mm)	Humidity (%)	Average Wind (kmph)
	Maximum	Minimum	Average			
Jan-12	22	11	18	0	37	7.7
Feb-12	23	11	19	0	34	10
Mar-12	32	18	27	0.1	27	10.7
Apr-12	37	26	33	16.2	27	10.9
May-12	43	32	40	13.8	14	10.3
Jun-12	45	34	42	6.2	22	16
Jul-12	44	35	41	5.5	29	15.5
Aug-12	40	33	38	37.43	40	12.1
Sep-12	38	30	35	44.9	41	11.2
Oct-12	36	24	32	0.2	27	7.4
Nov-12	31	19	27	0	28	6.8
Dec-12	25	14	20	0.6	32	7.8
Jan-13	24	12	19	0	27	7.6
Feb-13	25	15	21	28.3	45	10.4
Mar-13	33	20	29	2	29	10.2
Apr-13	37	26	34	13.6	22	10.1
May-13	44	32	41	0.4	12	12
Jun-13	45	35	42	9.5	23	15
Jul-13	43	36	41	9.8	31	14.3
Aug-13	40	32	37	57.1	40	13

9 Source: https://www.worldweatheronline.com/bahawalpur-weatheraverages/punjab/pk.aspx

Month-Year	Parameters					
	Average Temperature (◦C)			Average Rainfall (mm)	Humidity (%)	Average Wind (kmph)
	Maximum	Minimum	Average			
Sep-13	40	30	37	0	32	13.1
Oct-13	38	26	34	0.1	29	7.5
Nov-13	30	19	26	1.9	31	6.4
Dec-13	26	15	21	0	31	6.7
Jan-14	23	12	18	0	36	7.4
Feb-14	25	13	21	2.2	34	9.2
Mar-14	31	18	27	5.67	32	10.6
Apr-14	38	26	35	3.15	22	10.2
May-14	42	32	39	20	21	9.8
Jun-14	45	35	42	0.7	24	18
Jul-14	44	35	41	14.63	30	14.8
Aug-14	41	33	39	5.68	34	14.5
Sep-14	39	29	36	49.67	37	13.9
Oct-14	37	25	33	1	26	8
Nov-14	30	18	26	0	26	6.8
Dec-14	24	12	19	0	27	6.6
Jan-15	23	13	20	0	38	7.6
Feb-15	28	16	23	2.9	34	11
Mar-15	31	20	27	19.94	31	11.2
Apr-15	39	28	36	12.71	21	11.8
May-15	44	33	41	5.3	13	11.8
Jun-15	44	35	41	8.73	23	13.1
Jul-15	40	34	38	76.86	38	14.8
Aug-15	40	33	38	46.7	38	14.1

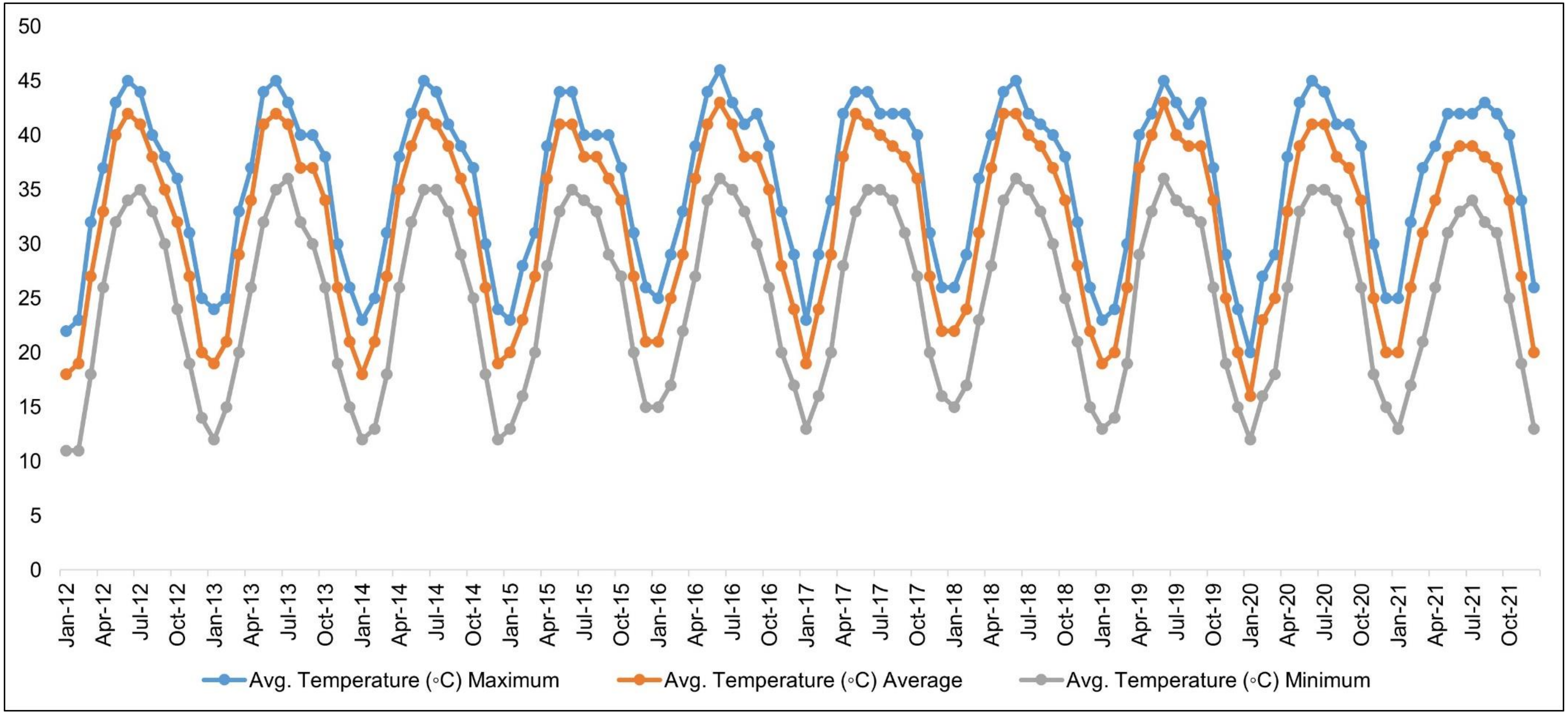
Month-Year	Parameters					
	Average Temperature (◦C)			Average Rainfall (mm)	Humidity (%)	Average Wind (kmph)
	Maximum	Minimum	Average			
Sep-15	40	29	36	24.8	30	13
Oct-15	37	27	34	5.6	23	9.5
Nov-15	31	20	27	0	23	8.1
Dec-15	26	15	21	0.07	22	7.1
Jan-16	25	15	21	0.2	27	7.8
Feb-16	29	17	25	0.3	20	8.2
Mar-16	33	22	29	37.4	33	10.1
Apr-16	39	27	36	5.25	17	10.4
May-16	44	34	41	8.54	17	13.9
Jun-16	46	36	43	5.48	22	13.9
Jul-16	43	35	41	15.71	33	13
Aug-16	41	33	38	23.9	36	10.7
Sep-16	42	30	38	0	28	10.8
Oct-16	39	26	35	0	16	7.6
Nov-16	33	20	28	0	17	6.9
Dec-16	29	17	24	0	21	6.9
Jan-17	23	13	19	5.1	41	9.2
Feb-17	29	16	24	0.7	22	8.9
Mar-17	34	20	29	0.4	22	9.5
Apr-17	42	28	38	3.5	15	10.7
May-17	44	33	42	3.2	16	10.9
Jun-17	44	35	41	29	27	13.8
Jul-17	42	35	40	7.8	33	13.2
Aug-17	42	34	39	11.1	32	14.7

Month-Year	Parameters					
	Average Temperature (◦C)			Average Rainfall (mm)	Humidity (%)	Average Wind (kmph)
	Maximum	Minimum	Average			
Sep-17	42	31	38	0.3	23	9.3
Oct-17	40	27	36	0	13	6.8
Nov-17	31	20	27	3.5	21	6.7
Dec-17	26	16	22	16.3	22	7
Jan-18	26	15	22	0	20	7.6
Feb-18	29	17	24	0.7	27	9.7
Mar-18	36	23	31	0.1	21	10.2
Apr-18	40	28	37	5.2	16	11.3
May-18	44	34	42	7.9	12	11.1
Jun-18	45	36	42	17.6	23	15.7
Jul-18	42	35	40	23.7	33	16.3
Aug-18	41	33	39	4.5	36	16.7
Sep-18	40	30	37	0.7	31	13.7
Oct-18	38	25	34	0	16	7.3
Nov-18	32	21	28	0	20	7.4
Dec-18	26	15	22	0	22	7.3
Jan-19	23	13	19	6	31	9.6
Feb-19	24	14	20	35.3	38	10.9
Mar-19	30	19	26	30.9	35	11.3
Apr-19	40	29	37	15.1	20	11.8
May-19	42	33	40	22.2	17	12.9
Jun-19	45	36	43	12.7	19	16
Jul-19	43	34	40	42.8	35	20
Aug-19	41	33	39	41.4	37	16.4

Month-Year	Parameters					
	Average Temperature (◦C)			Average Rainfall (mm)	Humidity (%)	Average Wind (kmph)
	Maximum	Minimum	Average			
Sep-19	43	32	39	24.7	32	15.8
Oct-19	37	26	34	4.4	25	10.5
Nov-19	29	19	25	12.1	34	9.9
Dec-19	24	15	20	19	29	6.8
Jan-20	20	12	16	9.6	45	10.9
Feb-20	27	16	23	0	29	11.4
Mar-20	29	18	25	61.9	42	13
Apr-20	38	26	33	14.7	25	12.6
May-20	43	33	39	16.1	17	14
Jun-20	45	35	41	10.9	24	21.3
Jul-20	44	35	41	29.2	31	20.5
Aug-20	41	34	38	93.4	40	18.7
Sep-20	41	31	37	25.3	32	14.4
Oct-20	39	26	34	0	13	9.7
Nov-20	30	18	25	0.1	23	9.5
Dec-20	25	15	20	0.5	29	8.4
Jan-21	25	13	20	0	24	8.7
Feb-21	32	17	26	0	18	9.6
Mar-21	37	21	31	7.4	19	11.8
Apr-21	39	26	34	2.7	16	13.3
May-21	42	31	38	28.5	23	16.2
Jun-21	42	33	39	23.5	31	21.9
Jul-21	42	34	39	50.7	37	20
Aug-21	43	32	38	4.2	33	21.9

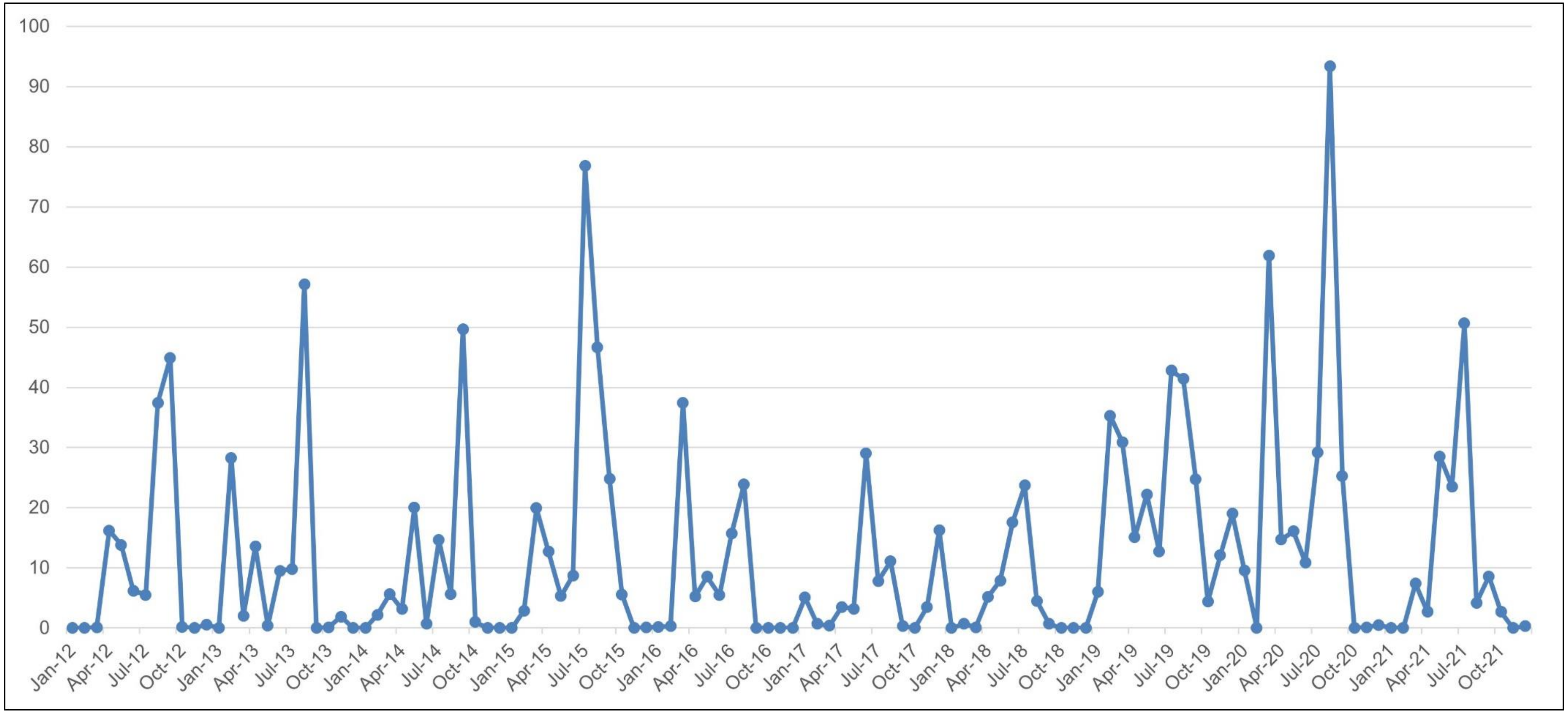
Month-Year	Parameters					
	Average Temperature (◦C)			Average Rainfall (mm)	Humidity (%)	Average Wind (kmph)
	Maximum	Minimum	Average			
Sep-21	42	31	37	8.6	41	14.8
Oct-21	40	25	34	2.7	25	12.7
Nov-21	34	19	27	0	17	8.6
Dec-21	26	13	20	0.3	22	6.7

Figure 6-3: Graphical Representation of Temperature of Bahawalpur (Year-2012-2021)10



[10] ***Source:*** https://www.worldweatheronline.com/bahawalpur-weather-averages/punjab/pk.aspx

Figure 6-4: Graphical Representation of Average Rainfall in Bahawalpur (Year 2012-2021)11



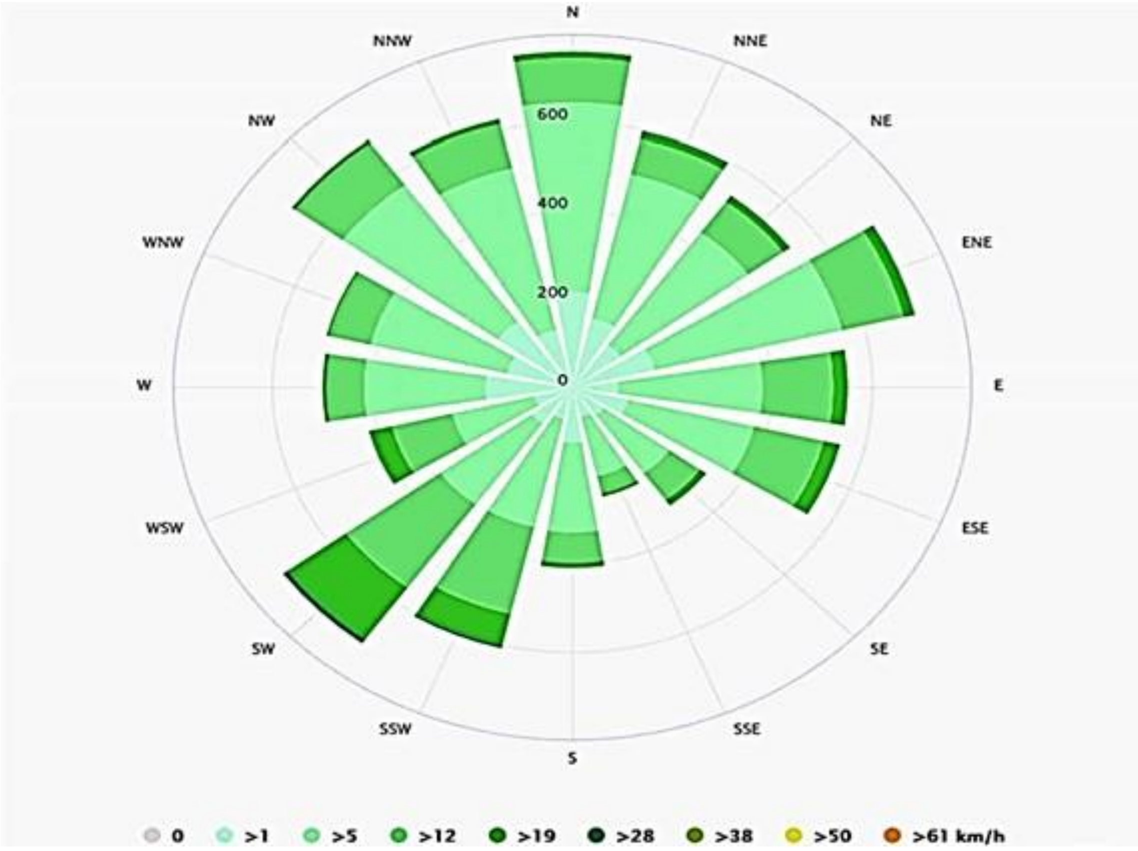
[11] ***Source:*** https://www.worldweatheronline.com/bahawalpur-weather-averages/punjab/pk.aspx

Wind Speed and Wind Direction

413. Based on the past decade of data, the maximum average wind speed of 8.8 kmph is recorded in the month of June while average minimum wind speed of 1. Kmph was observed in December.

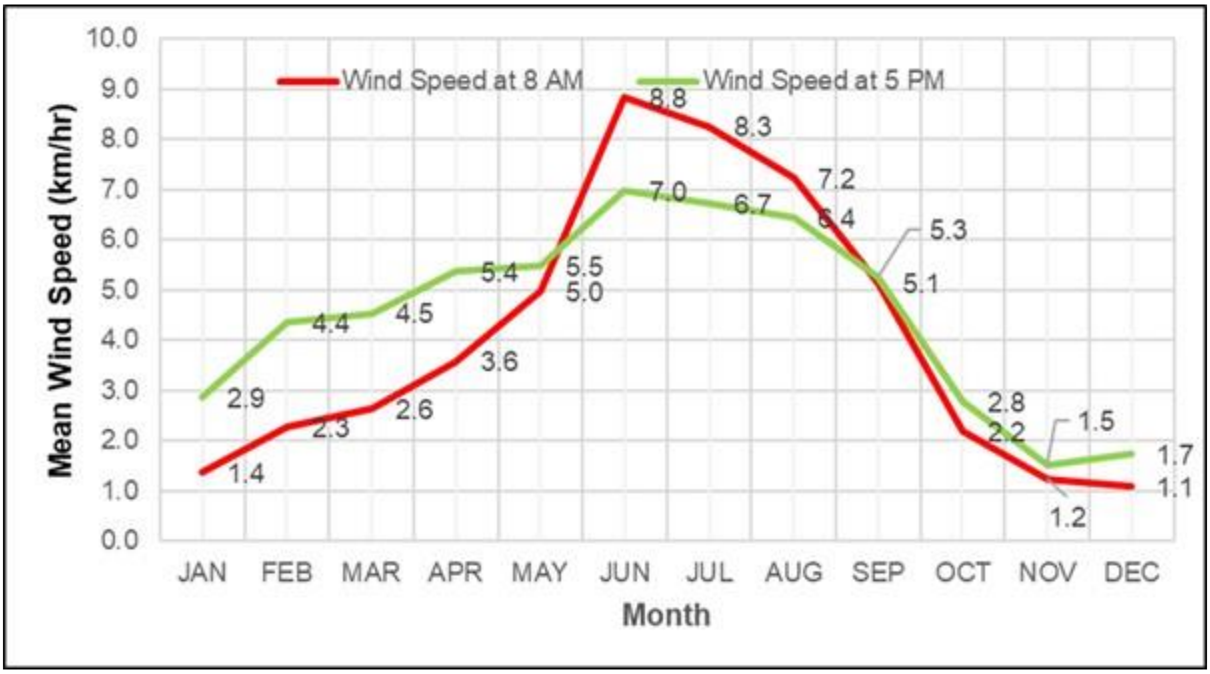
414. The wind experienced at any location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages. Wind speed usually blows from the north to south after the wind has arrived strongly and steadily from those quarters for a day or more. In fall season, the rain **Figure 6-5** show that dominant wind direction of Bahawalpur is from North to South. **Figure 6-6** represents the wind speed.

Figure 6-5: Wind Rose for the Bahawalpur[12]



[12] ***Source:*** https://www.meteoblue.com/en/weather/forecast/modelclimate/bahawalpur_pakistan_1183883

Figure 6-6: Wind Speed in Bahawalpur

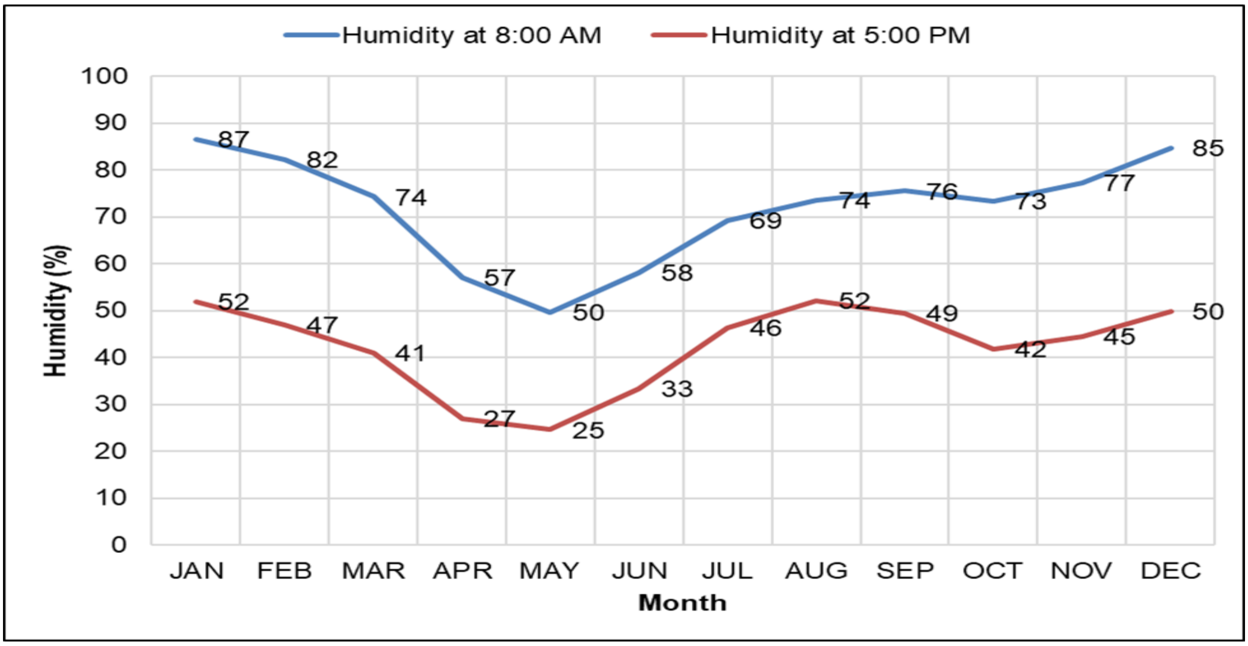


Relative Humidity

415. During the past decade, the city is experiencing on average maximum humidity of 87% in January and a minimum of 5% in the evenings in May.

416. Heat waves occur during the hottest months of May and June and can result in temperatures approaching 45°C. Longer periods of rate of increase of maximum temperature together with heat waves and increased precipitation can cause increases in humidity and water consumption. Graphical representation of Humidity is shown in **Figure 6-7**.

Figure 6-7: Graphical Representation of Humidity (Year-2012-Year 2021)



6.2.5 Seismology

417. According to the Seismic Zoning Map of Pakistan, Bahawalpur falls in Zone 2A (Lower limit of moderate damage).

418. Pakistan Building Code (PBC) and Unified Building Code (UBC) provide guidelines for ascertaining parameters for design of foundations. The project site falls in southern part of Punjab plain which shows very low to moderate level of seismicity. The project region has also been subjected to shaking in the past due to earthquakes in the Suleiman Range located about 140 km northwest to the site.

419. The basement rocks underlying the southern part of the Punjab Plain show very low seismicity indicating stable basement region. Therefore, the main source of shaking at the project site is related to moderate to large earthquakes in the seismically active Suleiman Range.

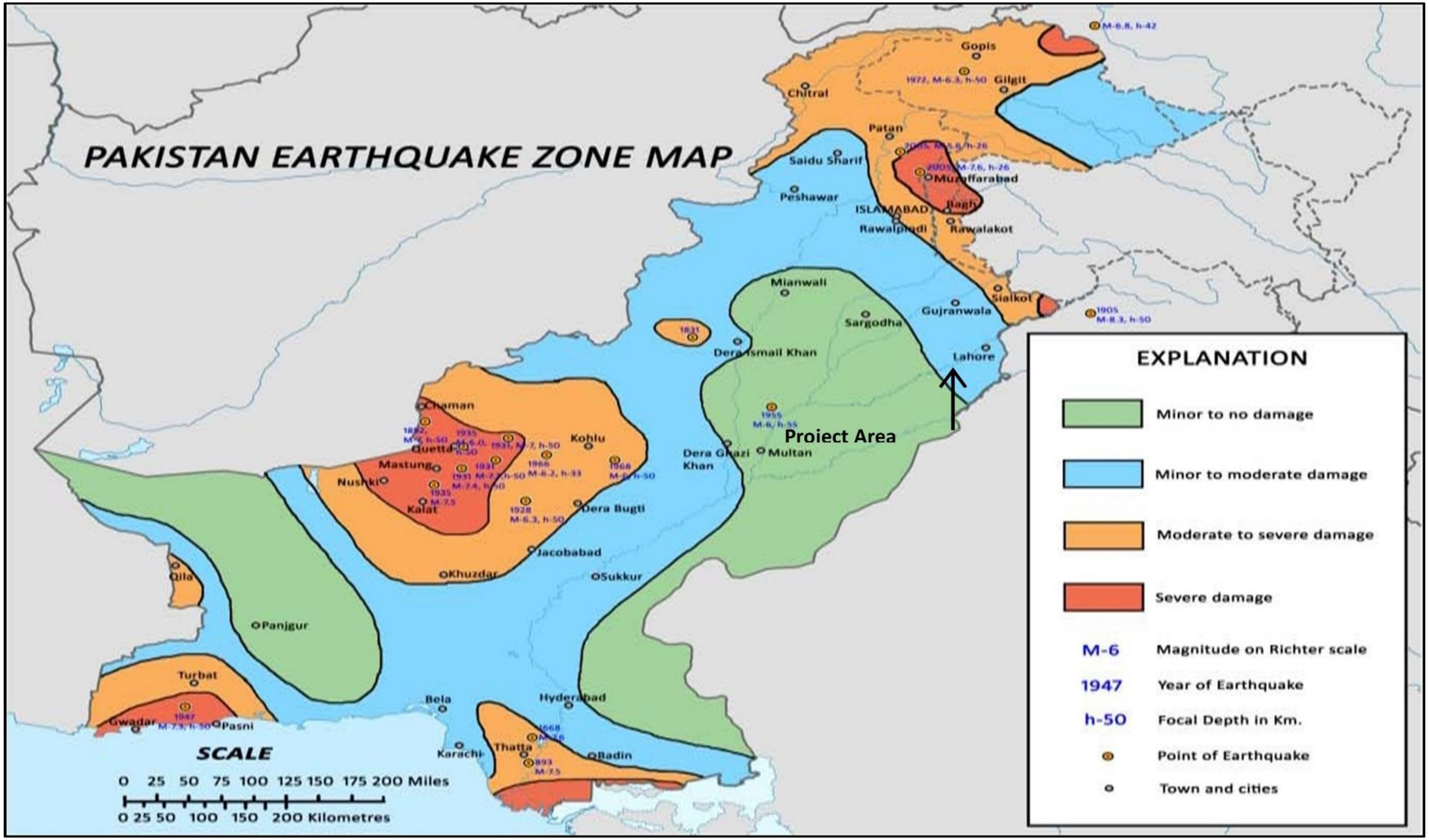
420. Probabilistic seismic hazard assessment shows that the project area falls in Zone-2A with peak horizontal ground acceleration of 0.08g-0.16g i.e. negligible damage as given in Figure 6-8. Based on project location, Seismicity influencing the project area, area geology, field and laboratory investigation data and proposed structures, design parameters are given in **Table 6-11** in accordance with guidelines of Pakistan Building Code (PBC-2007).

Table 6-11: Seismic Design Parameters

Design Parameters	Design Value
Seismic Zone	2A
Peak Horizontal Ground Acceleration	0.08g to 0.16g
Seismic Zone Factor “Z”	0.15
Type SD & SE Seismic Coefficient “Ca”	0.22 & 0.30
Soil Profile Seismic Coefficient “Cv”	0.32 & 0.50
Seismic Source	Type C
Near Source Factor “Na” 1	1
Near Source Factor “Nv”	1

421. It is therefore recommended that the project should be designed to cater the requirements of Zone 2A of seismic provisions after giving due consideration to the soil profile at site. **Figure 6-8** shows seismic zoning map of Punjab indicating location of the proposed project.

Figure 6-8: Seismic Zones of Pakistan



6.2.6 Surface water

Regional Hydrology

422. The Sutlej River flows in a northwest direction through northern India and into Pakistan. Near Bahawalpur, the Sutlej River forms the eastern border of the city, running alongside its eastern bank. The river is fed by snowmelt from the Himalayas, and it carries a significant amount of water, especially during the summer months when the snow in the Himalayas begins to melt.

423. Historically, the major source of irrigation was the water of Hakra River but with the drying of the river the area was desiccated and left with only grazing lands. The river supplied water regularly to this region until 1200 BC but near 600 BC it became irregular in flow and subsequently vanished.

424. The Sutlej River, also spelled as Satluj, is one of the major rivers of the Indian subcontinent, and it plays a significant role in the geography and hydrology of the Bahawalpur region in Pakistan. The Sutlej River, originating in Tibet, flows through India and Pakistan before joining the Indus River in Pakistan. It is an international river and subject to agreements and arrangements between India and Pakistan regarding water sharing.

425. The Sutlej River and its canals are a crucial source of irrigation water for agriculture in Bahawalpur and the surrounding areas. The river's waters are channelled through an extensive network of canals and barrages, allowing for the cultivation of crops such as cotton, wheat, sugarcane, and rice.

426. The river can be prone to flooding during the monsoon season. To manage floodwaters and protect the surrounding areas, flood control infrastructure and embankments have been built along the river.

Floods

427. Pakistan ranks among the top 10 countries worldwide most affected by climate change[13]. Between June and August 2022, torrential rains and a combination of riverine, urban, and flash flooding led to an unprecedented disaster in Pakistan. According to the National Disaster Management Authority (NDMA), around 33 million people that is, one in seven have been affected by the floods, including nearly 8 million displaced. The floods have taken the lives of more than 1,700 people, one-third of which were children.[14] Rain-induced floods, accelerated glacial melt, and resulting landslides devastated millions of homes and key infrastructure, submerging entire villages and destroying livelihoods. Preliminary estimates suggest that, as a direct consequence of the floods, the national poverty rate will increase by 3.7 to 4.0[15] percentage points, pushing between 8.4 and 9.1 million people into poverty. As of October 11, 94 districts were declared as “calamity hit,” accounting for more than half of all districts in the country. The majority were in the provinces of Baluchistan, Sindh, and Khyber Pakhtunkhwa (KP). Out of the 25 poorest districts in the country, 19 were calamity-affected.

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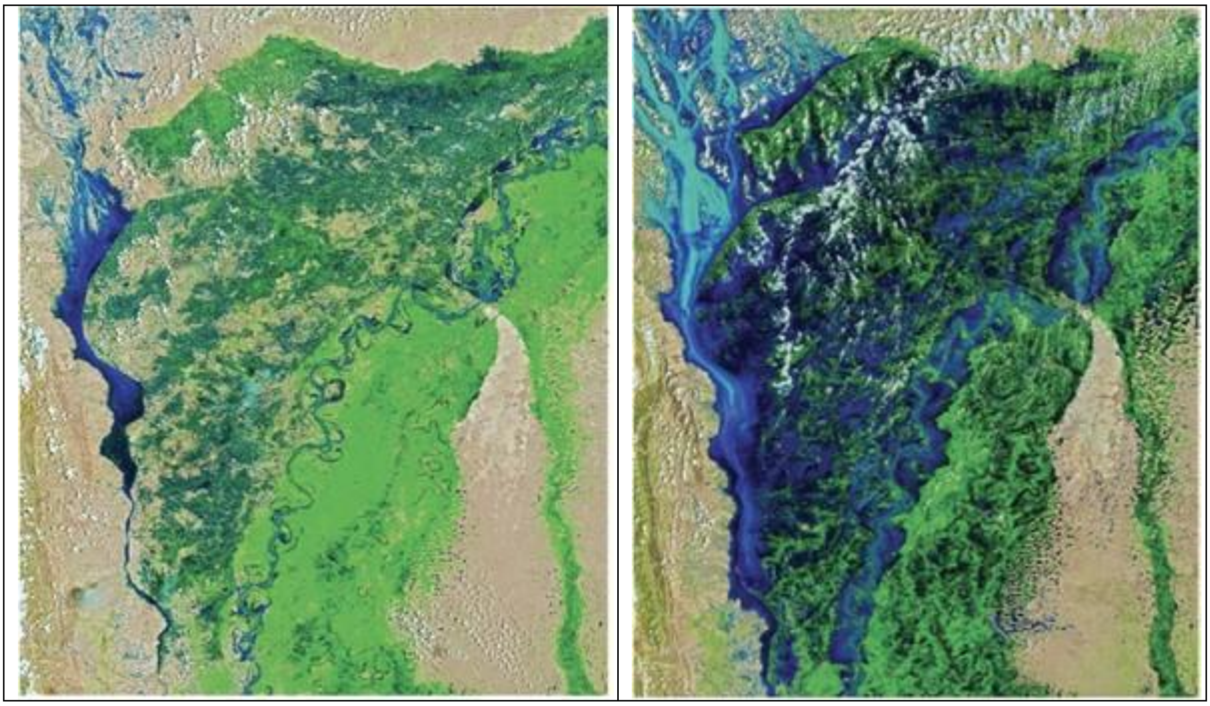
[13] *Eckstein, David, Vera Künzel, and Laura Schäfer. 2021. “Global Climate Risk Index 2021.” German watch Briefing Paper. https://www.germanwatch.org/en/19777.*

[14] *NDMA. October 19, 2022. “NDMA Floods (2022): Sitrep Report No.128.”https://cms.ndma.gov.pk/storage/app/public/situation-reports/October2022/QECa7rSLzWINuxZFHrHV.pdf.*

[15] *Source: https://www.worldweatheronline.com/bahawalpur-weather-averages/punjab/pk.aspx*

Figure 6-9: Extent of Flooding Comparison in Pakistan Between August 4 And 28, 2022[16]



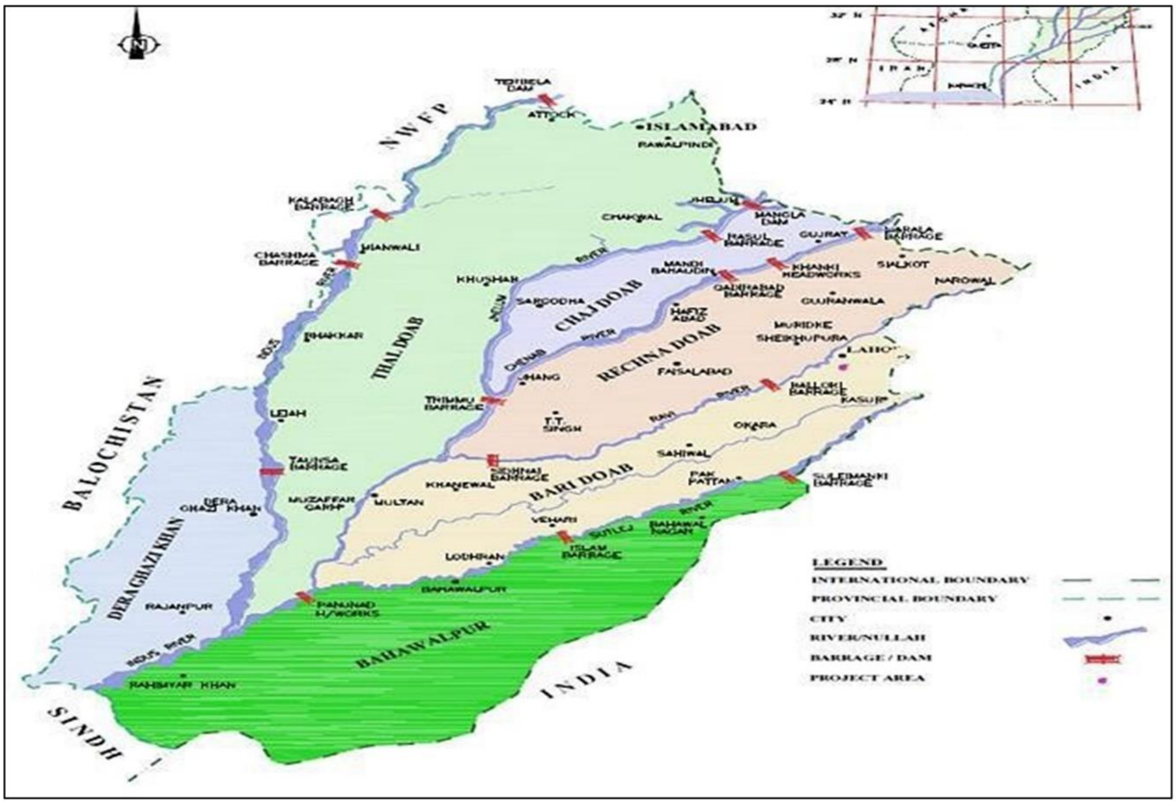
6.2.7 Groundwater

Hydrogeology

428. The alluvium of the Punjab Plains, derived from the mountain ranges to the north, has been deposited by the present and ancestral tributaries of the Indus River. The alluvial complex of Pleistocene and Recent age represents the latest phase of sedimentation in an environment that had its beginnings in mid-Tertiary time: the deposition of predominantly fluviatile sediments in a subsiding trough adjacent to the rising Himalayan ranges. The ground-water reservoirs of the area are almost exclusively unconfined and semi-confined alluvial aquifers. These aquifers store and transmit groundwater and are recharged primarily by river water, canal seepage, and to a limited degree precipitation. The depth of the water table in these aquifers varies depending on the location and season. Recharge from the River principally occurs during the summer months when the flow volume is at its maximum and the river is in flood. **Figure 7 10** shows the hydrology of the project region.

[16] *The images combine shortwave infrared, near infrared, and red light (bands 6-5-4) to better distinguish flood waters (deep blue)beyond their natural channels. Original image sourced from: https://earthobservatory.nasa.gov/images/150279/devastating-floods-inpakistan.*

Figure 6-10: Hydrology of Component 1 Project Area



429. Water well drilling industry is well developed in Bahawalpur. As reported by the local drillers, sub-surface formations, up to 400 feet depth, are mostly sands with intermittent thin layers of clay.

430. Most of the town is served with water supply system whereas rest of the area is without it and people have their own sources of water mostly hand pumps / power pumps.

431. Presently PHED is executing rehabilitation and augmentation of Urban Water Supply Scheme for Bahawalpur City. This would help in drinking water supply needs and increase in service coverage.

Groundwater Quality

432. Groundwater in the Bahawalpur area is known to exhibit contamination by several analytes which can present issues for human health or the environment. In 2011 a study by the Universities of Bahawalpur and Sargoda[17] summarised the groundwater situation as follows:

> Analysis of ground water of Bahawalpur city, Pakistan, has been made to evaluate its suitability for domestic use. Water samples from populated areas of the city were subjected to various physicochemical investigations. Physical properties of ground water were assessed by determining colour, odour, electrical conductivity (EC), total dissolved salts (TDS), alkalinity, hardness and dissolved oxygen (DO).

[17] **J.Chem.Soc.Pak., Vol. 34, No.5, 2012:** Physicochemical Profile of Ground Water in Bahawalpur City, Pakistan: Hazardous Aspects, 1 Karamat Mehmood, 2 Umer Younas, 2 Shahid Iqbal*, 2 Muhammad Ashraf Shaheen, 1 Abdul Samad and 1 Saqib Ibnul Hassan 1= Department of Chemistry, The Islamia University of Bahawalpur, Pakistan. 2 = Department of Chemistry, University of Sargodha, Sargodha-40100, Pakistan.

*

Whereas, its chemical nature was evaluated by estimating pH, Cl-, F-, NO3-, SO4 -2, Cl-, F-, essential (Na, K, Ca, Mg) and heavy (Fe, Ni, Cr, As, Pb) metals. The presence of coliform bacteria was also checked, and 75% samples were found contaminated. The analysis of physicochemical data, with reference to PSI and WHO standards, revealed that some of the estimated parameters were well within the limit, while others exceeded hydro chemical standards. The data was also subjected to correlation study to check the association among estimated parameters. Relation of important water quality parameters with pH was sketched graphically to understand variation in their amount with the change in pH. The study suggests proper treatment of ground water to ensure citizen's safety from hazardous effects associated with elevated concentration of toxic components.

433. The conclusions of the Study were as follows:

The present study indicates much higher values of EC and TDS than WHO and PSI standards that may lead towards many health issues. The population in this city may be the victim of problems associated with high concentration of fluoride ions as 55% samples contain fluoride more than allowable limit. Similar is the case with iron and arsenic i.e. 85% samples contain iron above safer limits and 75% samples possess arsenic above human tolerable limit, which may contribute towards severe health dilemma. One more threatening factor is that pH of all the samples fall in the alkaline range, which favours the accommodation of high amounts of components, and it is justified with the relationship between pH and their concentration. This research work provokes concern about the evaluation of ground water quality having drinking interest in other regions adjacent to desert; it also recommends the implementation of any treatment process according to the chemistry of water to remove high concentration of sulphates, fluoride, iron and arsenic.

6.2.8 Noise

434. Noise measurement was carried out at existing Khanu Wali dumpsite and at six locations near Basti Rama, Basti Yar Muhammad, Basti Karim Bukhsh, Basti Meriwala Khoon, Basti Rasheedabad and Basti Chachran. Noise monitoring was also carried out at the existing Khanu wali dumpsite. The results are presented in **Table 6-12** below.

435. The monitoring locations were selected keeping in view the nearest residential dwellings, waste transportation route, downstream wind directions and availability of the sensitive receptors in the area.

436. While the results indicate the ambient noise levels being within the PEQS guidelines during the daytime, however, exceedance was observed at the night time at only one location (Basti Chachran) in the project area. Exceedance was also observed during night time at the legacy landfill. These exceedances are due to the increased construction and commercial activities at these locations as compared to the other locations in the project area. There are no sensitive receptors with regards to noise levels within 500 metres from the proposed landfill site.

Table 6-12: Noise Levels Monitored data (Leq)

Sr. No.	Locations	Unit	Minimum	Maximum
Day Time (06:00 AM – 10:00 PM)				
1	**Basti Rama**	**dB(A)**	**46.5**	**48.37**

Sr. No.	Locations	Unit	Minimum	Maximum
2	BastiYar Muhammad		48.9	50.49
3	Basti Karim Bukhsh		59.5	60.57
4	Basti Meriwala Khoon		51.5	52.01
5	Basti Rasheedabad		49.5	50.46
6	Basti Chachran		58.0	59.0
7	Existing Dumpsite		59.8	62.4
Night Time (10:00 PM – 06:00 AM)				
1	Basti Rama	dB(A)	46.5	47.80
2	BastiYar Muhammad	dB(A)	48.0	49.81
3	Basti Karim Bukhsh	dB(A)	47.5	48.15
4	Basti Meriwala Khoon	dB(A)	49.5	50.6
5	Basti Rasheedabad	dB(A)	46.5	47.86
6	Basti Chachran	dB(A)	55.5	56.3
7	Existing Dumpsite		57.4	60.3

PEQS: Punjab Environmental Quality Standards for Noise	Day Time	Night Time
a) Residential Area	55	45
b) Commercial Area	65	55
c) Industrial Area	75	65
WHO Guidelines	45	70

6.2.9 Land Use

437. Bahawalpur is the 11th largest city in Pakistan by population as per a 2017 census, with a population of 762,111. It's also the largest city by land area consisting of Cholistan, the largest desert of Punjab.

438. Ahmed T, Nawaz R, Ahmed A (2021) conducted a study to monitor the land use/land cover changes and urban sprawl of Bahawalpur city with the application of geo-information techniques by using remote sensing data. The study identified built up area, agricultural land, barren land and water body as four major classes that have provided a substantial change in the city of Bahawalpur.

439. The study observed significant changes in land use and land cover pattern in the city of Bahawalpur. Forest land, agricultural land, barren land and urban land use classes were defined, and their areas were estimated using downloaded satellite images. A decrease in area of forest land was observed from 23.28 km^2 (2003) to 2.48 km^2 (2018). Reduction in barren area was also found from 8.11 km^2 during the study period of sixteen years. In contrast, an increase has been observed in urban area from 41.42 km^2 in 2003 to 60.28 km^2 in 2018. An increase of agricultural land was also estimated from 19.16 km^2 (2003) to 25.77 km^2 (2018). Agriculture should be made environmentally friendly by enhancing technology of land use and better assessment of environmental health.

6.3 Climate Risks of Project

6.3.1 Climate Change Trends and Extremes in Bahawalpur

440. Bahawalpur lies on elevation of 117m above mean sea level. The climate here is dry. During the year, there is virtually no rainfall in Bahawalpur. According to Köppen

and Geiger, this climate is classified as BWP. The city witnesses some of the extreme temperatures in the country. The summer season starts from the month of April and continues till October, while the weather is pleasant and cold from November to February. Besides, dust storms are also common in the area.

441. Due to less average annual rainfall (143 mm) the city features an arid climate with sweltering summers and cold winters. The wettest year observed was 2021; with an annual total rainfall of 166.2 mm. Minimum annual rainfall was 119 mm recorded in 2017

442. Based on the past decade's data, the month with the maximum precipitation on average is July with 27.67 mm of precipitation. The month with the least precipitation on average is October with an average of 2.33 mm.

443. The average temperature for the past decade in Bahawalpur is 89.6°F (32°C). The warmest month, on average, is July with a mean temperature of 104.36°F (40.2°C). The coolest month on average is January, with mean temperature of 66.56°F (19.2°C).

444. The wind experienced at any location is highly dependent on local topography and other factors, and instantaneous wind speeds and directions vary more widely than hourly averages. Wind speed usually blows from the north to south after the wind has arrived strongly and steadily from those quarters for a day or more. In fall season, the rain clouds come mostly from west due to western depression/ disturbance.

445. Based on the past decade data, the maximum average wind speed of 16.70 kmph is recorded in the month of July while average minimum wind speed of 7.71 kmph was observed in November.

446. The quantity of leachate generated in a landfill is strongly dependent on the quantity of infiltrating water. This in turn, is dependent on weather and operational practices. The amount of rain falling on a landfill largely controls the leachate quality generated. The daily leachate amount generated from the proposed Bahawalpur site is calculated which is 6.06 m^3/d because area received less precipitation as compared to other districts. All the rainwater outside the landfill site will be expelled and does not enter the landfill cells.

447. Dust storms in the area will be a source of wind-blown litter which can scatter away from the landfill sites and can be a source of soil pollution and public nuisance.

6.3.2 Climate Change Considerations for the Component 1 Landfill Site

448. Climate change can greatly influence different aspects of the landfill site due to projected increased temperatures and intense floods from heavy rainfalls at the location of the landfill site. These climatic changes in the nearby areas can also have serious consequences at the landfill site due to flash flooding.

449. In addition to the effects of changing climate, landfill sites can also be a source of greenhouse gas emissions which need to be considered for climate change mitigation options. These gases can also create a fire hazard due to a change in the decomposition rates caused by increased temperatures.

450. Three aspects of landfill sites are assessed for potential climate change impacts (temperature, precipitation, winds, fire hazard) in terms of exposure and sensitivity: 1) underground components, 2) over-ground components and 3) site infrastructure and operations, provided as **Table 6-13** below.

Table 6-13: Sensitivity Considerations for Landfill Site

System Components		Vulnerabilities		
		Physical Damage	**Water Related Damage**	**Access**
Landfill Components	Pipe systems for leachate treatment and disposal of landfill gas collection and transfer	X	X	X
	Transfer pumps for leachate and landfill gas	X	X	
	Treatment pond for leachate	X		X
	Pre-treatment of landfill gas (coolers, condensers, blowers)	X	X	
	Landfill gas flares	X	X	X
	Storage containers for chemicals	X	X	X
	Disposal system for treatment residuals	X	X	X
	Discharge system for treated leachate	X	X	
	Auxiliary and monitoring equipment	X	X	
	Synthetic materials (e.g. geomembrane in liners or cover system, geotextile for leachate filtration)	X	X	
	Bottom layer of unlined waste		X	
	Vegetative layer for an evapotranspiration cover	X	X	
	Groundwater or landfill gas monitoring wells	X		X
	Composting facility & AD plant	X	X	
	Material Recovery Facility	X	X	
Infrastructure and Landfill Site Operations	Surface water drainage systems	X	X	X
	Mobile TSs		X	X
	Fencing, boundary walls for access control and litter prevention	X		
	Unpaved road to landfill site			X
	Buildings, sheds etc.	X	X	X
	Natural gas and electricity connections/lines	X	X	X
	Fuel storage and transfer	X	X	X
	Water supply	X	X	X
	Machinery and vehicles	X	X	X
	Solarization		X	

451. The above-mentioned sensitivity and exposure analysis is based on available information in the concept designs, detailed design, other reports and information on general components of a landfill site.

452. Development of Bahawalpur Landfill is aligned with ADB's commitments of the Paris agreement as it will control landfill gas emissions particularly methane emissions which is potent GHG. Landfill gas is composed of roughly 50 percent methane (the primary component of natural gas), 50 percent carbon dioxide (CO2) and a small amount of non-methane organic compounds.

453. GHG emissions are often measured in carbon dioxide (CO_2) equivalent. To convert emissions of a gas into CO_2 equivalent, its emissions are multiplied by the gas's Global Warming Potential (GWP).

454. Landfilling organic waste is the most GHG-intensive option on a per-tonne basis, with a GHG footprint of almost 400 kg CO_2 per tonne of organic waste. Any option for diverting organic waste, particularly higher-moisture material such as food waste that releases substantial fugitive methane, provides GHG benefits. The footprint will be roughly doubled if organics are sent to a landfill without a functioning gas capture system in place. If all digestate is landfilled, the GHG footprint is 40 kg CO_2 per ton of organic waste. Landfill methane emissions, resulting in a net GHG footprint of 27 kg CO_2 per ton of organic waste. The choice to clean and upgrade the biogas for use as a drop-in replacement for natural gas results in greater GHG reductions.

455. Methane is a potent greenhouse gas 28 to 36 times more effective than CO2 at trapping heat in the atmosphere over a 100-year period. Methane possesses the combustible and explosive properties and a Green House Gas responsible for global warming. Further development of well-engineered landfill will control climate risks such as increased surface run off entering the existing dumping and proposed landfill cells. Application of daily cover on waste will control windblown litter and will reduce public nuisance. Further project includes landfill gas recovery and reuse which will ultimately reduce carbon emission resulting from combustion of conventional fuels.

6.3.3 Climate Change Considerations for the Component 2 Legacy Landfill Site

456. Many of the considerations presented above in relation to the new landfill which will be constructed under Component 1 are equally valid with respect to the current Legacy Landfill. In addition, the location of the Legacy Landfill near the Sutlej River is likely to make it more susceptible to the effects of climate change in relation to flooding and scouring. The site will need long term management and regular risk review in relation to the effects of climate change.

6.4 Critical Habitat Assessment (CHA)

457. 'Critical Habitats' are defined in Paragraph 16 of the IFC PS6 (2019) as areas harbouring high biodiversity value. This includes areas that meet at least one or more of the following seven criteria:

i. Habitat of significance importance to globally or nationally Critically Endangered (CR) or Endangered (EN) species;
ii. Habitat of significance importance to endemic and/or restricted-range species;
iii. Habitat supporting globally significant concentrations of migratory and/or congregator species;
iv. Highly threatened and/or unique ecosystems;
v. Areas associated with key evolutionary processes;
vi. Areas either legally protected or officially proposed for protection; and
vii. Areas having biodiversity of significant social, economic, or cultural importance to local communities.

ADB SPS 2009 Definition of Critical Habitat

458. A subset of both natural and modified habitat that deserves particular attention, critical habitat includes areas with high biodiversity value, including habitat required for the survival of critically endangered or endangered species; areas having special significance for endemic or restricted-range species; sites that are critical for the survival of migratory species; areas supporting globally significant concentrations or numbers of individuals of congregatory species; areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and areas having biodiversity of significant social, economic, or cultural importance to local communities.
27. Critical Habitat is a subset of natural or modified habitats. Paragraphs 11 and 13 of the IFC PS 6 (2012, updated 2019) provide definitions for, respectively, modified and natural habitats:

459. **Modified Habitats:** Modified Habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands.

460. **Natural Habitats:** Natural Habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.

461. Keeping in view the baseline ecological survey conducted by the EDCM team and the IBAT proximity analysis, it is concluded that the project area is in the urban sprawl of Bahawalpur city and the habitat has been now modified and converted into human settlements at large scale, therefore, no impact on Critical Habitat Species (CHA) is expected. NOC is also obtained from the wildlife department which states that IUCN species are no longer endemic to the project area. NOC is attached as **Appendix A-18** of the report.

462. The nearest protected area of Lal Suhanra is located at a distance 44.6 km from the nearest project Component site. The park is situated some 35 kilometres east of Bahawalpur and presents a synthesis of forest and desert life. It occupies land on both sides of Desert Branch canal and is spread over an area of 127,480 acres.

The park's terrain is generally flat, interspersed with sand dunes measuring between 1 and 6 meters in height and occupying as many as thousands of acres a piece. The biosphere reserve is crossed by the dried-up bed of the Ghaggar-Hakra River and comprises Patisar Lake and irrigated land. Indigenous trees like Indian rosewood and Acacia karroo will also be planted over 1,212 acres of barren land in the wildlife reserve.

6.5 Sensitive Receptor Mapping to assess compliance with IFC EHS Clause[18]

463. The IFC EHS clause specific to Landfill Siting states the following:

464. ‘’The location of the landfill should consider potential impacts associated with releases of polluting substances including the following:

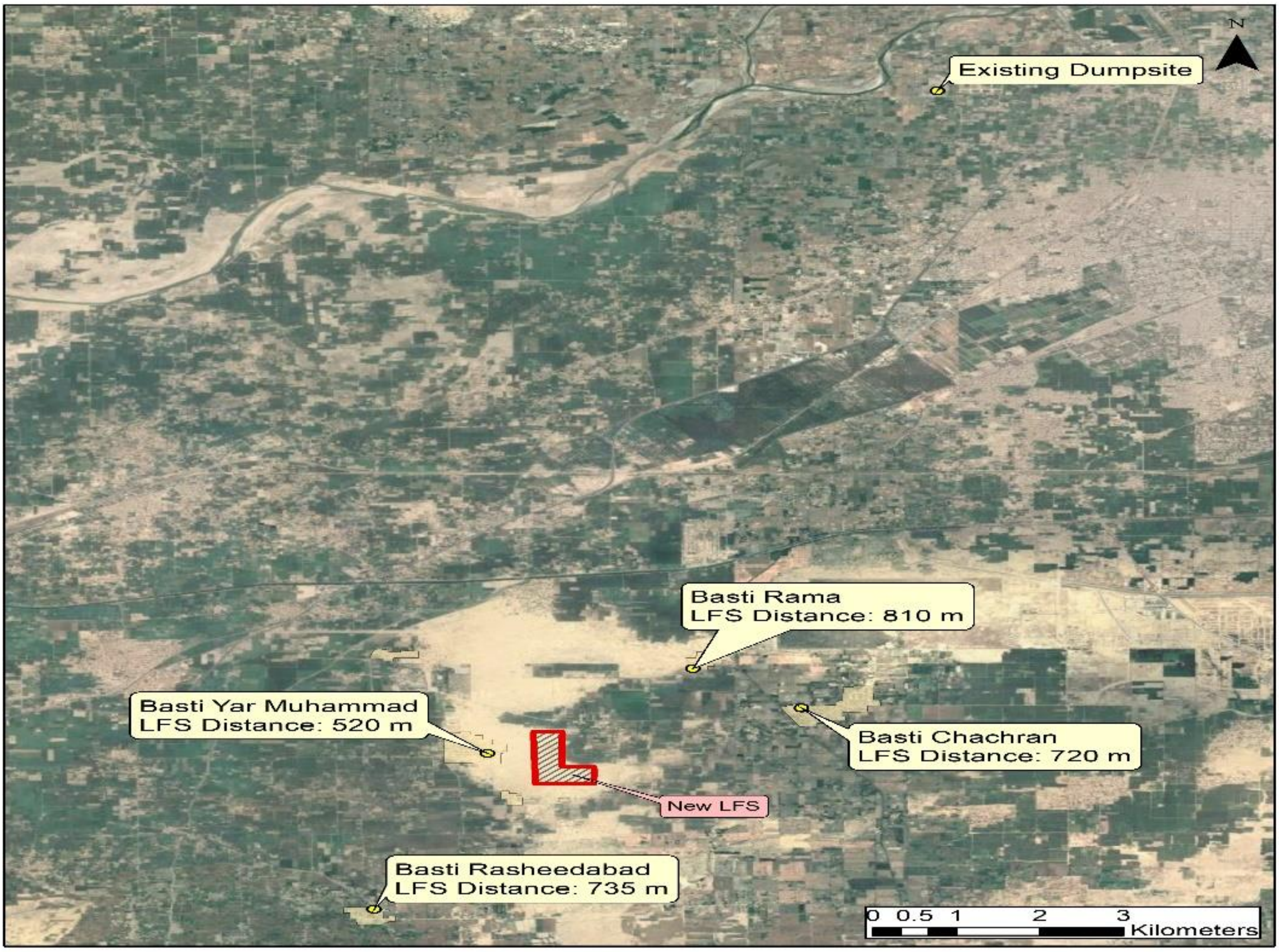
465. Proximity to residential, recreation, agricultural, natural protected areas, or wildlife habitat and areas prone to scavenging wildlife, as well as other potentially incompatible land uses.

466. Residential development should be typically further than 250 metres from the perimeter of the proposed landfill cell development to minimise the potential for migration of underground gaseous emissions.

467. A detail site survey was conducted by a team of social specialist, environment specialist of EDCM, project engineer of city implementation unit and local area representative during the November 2022.

There are clusters of settlements including Bastic Rama (810 m), Basti Chachran (720 m), Basti Yar Muhammad (520 m) and Basti Rasheedabad (735 m) around the project site. All the settlements are located at a safe distance from the landfill site. The nearest settlement is situated at a distance of 520m from the boundary of the landfill site.

[18] https://www.ifc.org/wps/wcm/connect/5b05bf0e-1726-42b1-b7c9-33c7b46ddda8/Final%2B-%2BWaste%2BManagement%2BFacilities.pdf?MOD=AJPERES&CVID=jqeDbH3&id=1323162538174


N
Existing Dumpsite
Basti Rama
LFS Distance: 810 m
Basti Yar Muhammad
LFS Distance: 520 m
Basti Chachran
LFS Distance: 720 m
New LFS
Basti Rasheedabad
LFS Distance: 735 m
0 0.5 1 2 3
Kilometers

468. Nearest receptors of BWMC office building are Islamia University of Bahawalpur, Government Employees Cooperative Housing Scheme (GECHS) High School, Bahwalpur A Block Market, CRC Wasaib Explorer campsite, Shahida Islam teaching hospital, Mubarak Hotel Almukhtar Hotel. Sensitivity of all the receptors is low since construction of building is limited to its acquired area and no impact on these receptors is anticipated.

469. The Table below gives and pictorial view of the receptors. The details of these survey findings are provided in the **Figure 6-12** below.

Table 6-14: Pictorial View of the Receptors

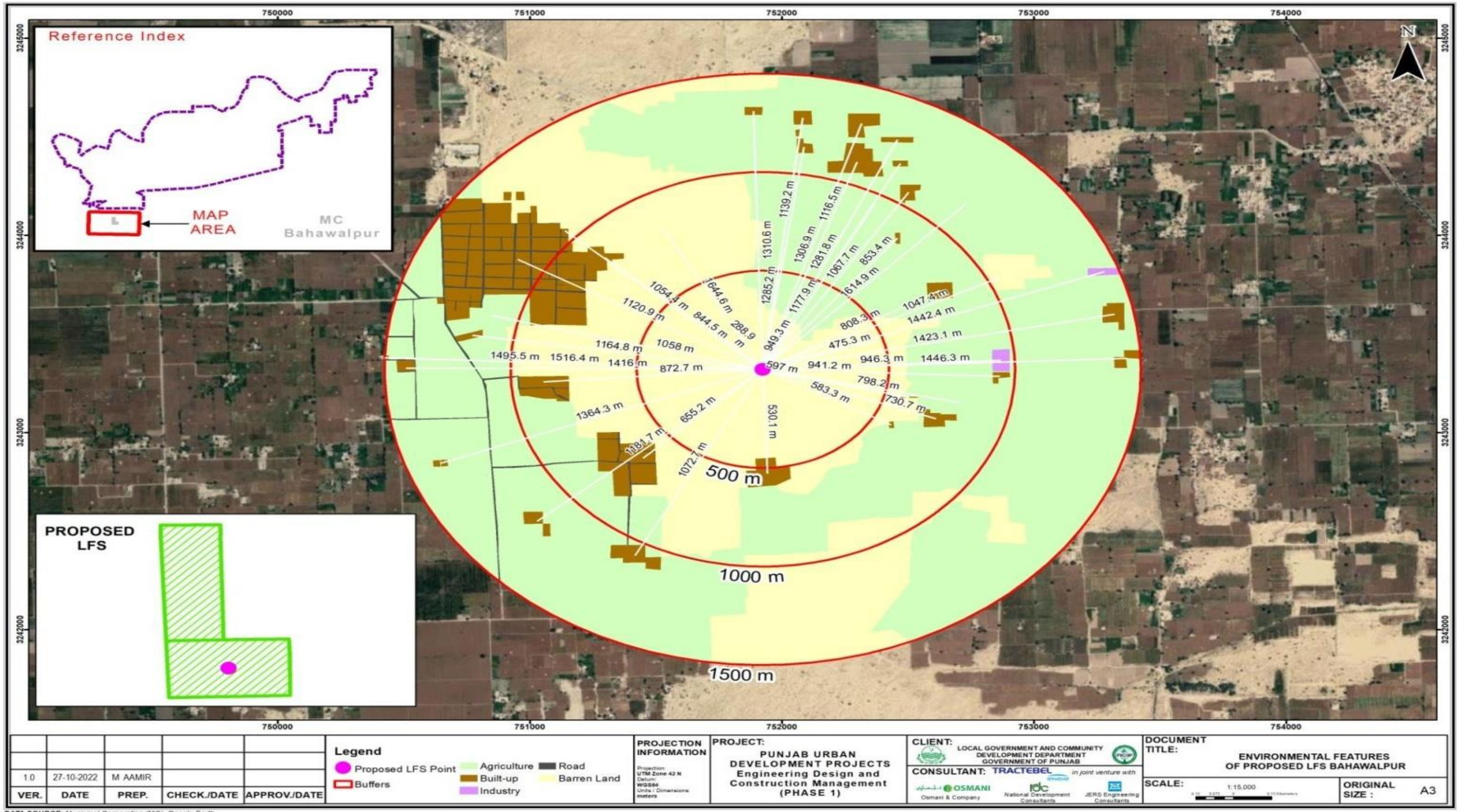
Types of Receptors	Aerial Distance from Landfill / Work Site in meters	Sensitivity	Pictorial view
School	1570	Low	
School	2080m	Low	
School	2640m	Low	

School	2480	Low	
School	1960	Low	
School	3855	Low	
School	1270	Low	
School	1960	Low	

School	4540	Low	
Hospital	6130	Low	
School	5360	Low	
School	9970	Low	
Hospital	10030	Low	

Fire Emergency	9890	Low	
Teaching hospital	10010	Low	

Figure 6-12: Nearest Receptors in Project Area



DATA SOURCE: Municipal Corporation (MC), Google Earth
DISCLAIMER: Although great care was taken in the preparation of this map, the authors is not liable for positioning inaccuracies, subsequent updates, errors, or omissions of data. However, suggestions for improvement or error notifications are welcome.

6.6 Component 1 Local Environmental Setting

Construction of a new SWMF.

6.6.1 General

470. The proposed landfill site is located at Mari Sheikh Shijra mouza Nouabad in the outskirts of Bahawalpur city at approximately 13km from the city centre. Field surveys for the project area were carried out in November and December 2022 by EDCM team with additional specialist investigations being completed in 2023. The description of various features of the project area environment including the physical, ecological, cultural and socio-economic environmental aspects are presented in the following sub-sections.

6.6.2 Topography

471. The project site on Component 1 has flat terrain. The sand dunes are deposited all over the project area which comprises of mostly flat terrain with scattered vegetation consisting of bushes, grasses and some trees across the site.

472. The project area is a fertile alluvial tract that is irrigated by canal waters and tube wells with widely grown crops wheat, cotton, and sugar cane, while palm dates are also planted at various locations near the project site (1-2Km distance). The soil is formed by alluvial or alluvial deposits dominated by silt and large particles of sand. The surface is irregular throughout the project site as shown in **Figure 6-13**

Figure 6-13: View of Component 1 Project Site

473. The project area comprises of small sand dunes amidst of Bahawalpur agricultural areas located near villages Mari Sheikh Shijra and Basti Yar Muhammad. Total area of the project is 110 acres, and its coordinates are 29°17’44.86 N and 71°35’30.34 E.

6.6.3 Geology and Soil

474. The major chunk of the project land comprises of sandy and clay patches. The soil in general is made up of alluvial deposits having clayey loam at “Dahars” (flat areas between dunes) with low sand dunes at scattered places. The size of sand

dunes ranges from 0.01 to 0.50 km^2 and up to the height of 6m. clayey loam deposits are about 1.5 to 5.0 m thick and pure sand starts below the hard clayey surface[19]

475. The project area is positioned in the southern part of the Punjab Plain which is a vast plain of the alluvial material deposited by the five main rivers of the Indus River System crossing the Punjab Plain. The alluvial deposits at the site are deposited by the old course of one of these rivers, the river Sutlej. The alluvial deposits around the site comprise stream beds, meander-belt deposits and flood plain deposits, deposited by the shifting of river course. The alluvial plain at the site mainly consists of silty clay/clayey silt, sandy silt and sand layers of varying thickness.

Site Specific Investigations

476. M/S GEO BAND was hired by the EDCM to provide its services for Geotechnical Investigation of Bahawalpur Landfill Site. The team mobilized to Landfill site on 14 October 2022 with all necessary equipment and tools along with skilled staff and one (01) experienced civil engineer and after getting NOC from EDCM the field work was started on 16 October, 2022 and the field investigations were completed on 21 October, 2022.

477. The exploratory boreholes were drilled in the project area by M/s GEO BAND**.** Five (05) boreholes were explored by using auger drilling method. Visual inspection and logging of in-situ substrata were carried out at site by an experienced engineer of the M/s GEO BAND. The engineers completed borehole logs detailing, reference number of boreholes, the lithological description of the material encountered with depth, structural details of each layer, method of drilling. The results of in-situ testing, the depth and elevation of the borehole and the depth of the ground water table are present in geotechnical investigation of report of the project**.**

Table 6-15: Details Boreholes Locations and Depth –Bahawalpur Landfill Site

Sr No.	Borehole No.	Coordinates		Drilling Depth (m)
		N	E	
1	BH-01	3243377	752238	15
2	BH-02	3243267	751984	18
3	BH-03	3243229	751750	20
4	BH-04	3243218	751460	16
5	BH-05	3243357	751471	18

478. Test pits were excavated manually to physically examine and delineate the sub-surface strata and evaluate the pavement design parameters. Four test pits were excavated as per the given plan. Field density tests were performed with the core cutter method. Details of excavated test pits are given in **Table 6-16**

Table 6-16: Details of Excavated Test Pits

Sr No.	TP No.	Coordinates		TP Depth (m)
		N	E	
1	TP-01	3243444	751402	2
2	TP-02	3243348.63	752291.77	2
3	TP-03	3243171.82	751835.63	2
4	TP-04	3243334	751408	2

[19] *Bahawalpur". Punjab Portal. Retrieved 17 August 2022*

479. Based on detailed geotechnical investigations, it has been assessed that the whole proposed landfill site consists of sand dunes with a considerable elevation difference between boreholes. Generally Silty Sand (SM / SP) dominates up to 4-6 m depth afterward 2-3m Silty Clay/Lean Clay and Sandy Strata (SP-SM)/Silty Sand (SM) is observed till borehole termination depth. A Silty Clay (CL-ML)/Lean Clay (CL) layer of 1-2m is observed at varying depth of 12-14m in all boreholes except BH-03. However, in all four excavated test pits, Silty Sand (SM) is dominant up to termination depth. Soil consistency is loose up to 3 m in two boreholes (BH-01 & BH-02) while medium dense up to 20m depth.

480. The GWT was encountered at 14m, 16m, 14.80m and 16.5m in BH-01, BH-02, BH04 and BH-05 respectively. GWT is not encountered in BH-03 during the period of investigations.

481. For sub-surface soil classification, 31 selected soil samples were subjected to sieve analyses. Sieve analyses of all representative samples show that fines range from 15% - 100%. However, four (04) soil samples, one from each test pit were subjected to sieve analysis. Tests reveal that the percentage of fines range from 8% to 28%. Out of tested samples selected from boreholes, plasticity index ranges from 28 -38%.

482. Maximum dry density ranges from 1.663 – 1.69 gm/cc and optimum moisture content ranges from 13.2 % to 14.5 %.

Table 6-17: Summary of ground conditions across Project Site

Borehole No.	Depth (m)	Description
BH-01		
BH-01	2	Silty Sand
BH-01	3	Silty Sand
BH-01	4	Silty Clay
BH-01	5	Lean Clay
BH-01	6	Lean Clay
BH-01	7	Sandy Silt
BH-01	9	Silt
BH-01	12	Lean Clay
BH-02		
BH-02	2	Sandy Silt
BH-02	5	Lean Clay
BH-02	6	Lean Clay
BH-02	7	Lean Clay
BH-02	8	Lean Clay
BH-02	9	Silty Sand
BH-02	12	Silt with Sand
BH-02	14	Lean Clay
BH-02	16	Silty Sand

Borehole No.	Depth (m)	Description
BH-02	16	-
BH-03		
BH-03	2	Silty Sand
BH-03	5	Silty Sand
BH-03	7	Silty Clay
BH-03	8	Lean Clay
BH-03	10	Silty Sand
BH-03	12	Silty Sand
BH-04		
BH-04	1	Silty Sand
BH-04	3	Silty Sand
BH-04	4	Silty Sand
BH-04	9	Silty Sand
BH-04	10	Silty Sand
BH-04	11	Silty Sand
BH-04	14	Lean Clay
BH-04	14.8	Silty Sand
BH-05		
BH-05	2	Silty Sand
BH-05	7	Silty Sand
BH-05	10	Silty Sand
BH-05	11	Silty Clay
BH-05	16	Silt

483. Baseline quality of the soil at the existing dumping area and surrounding proximity of the landfill site will be carried out prior to closure of the existing dumping site and commencement of MRF operation to assess any possible contamination.

484. In addition, the recommendations of the geotechnical investigation of the project site are as follows:

- The foundations will be placed at such a depth which is not influenced by weather, flooding and erosion besides any cavity structure within subsurface.
- For shallow foundation, if weak/soft soil is encountered at the excavation base level, further excavation up to 1 to 1.5 m and replacement with selected engineering fill is recommended. This select fill should be compacted in layers appropriate to the type and size of compaction equipment, to at least 75 % relative density or 95 % of Modified Proctor dry density, as appropriate. Alternatively, to place four layers (of 6 inches' thickness) having proportions of 70% crushed stone and 30 % sand before the placement of lean concrete and foundation.

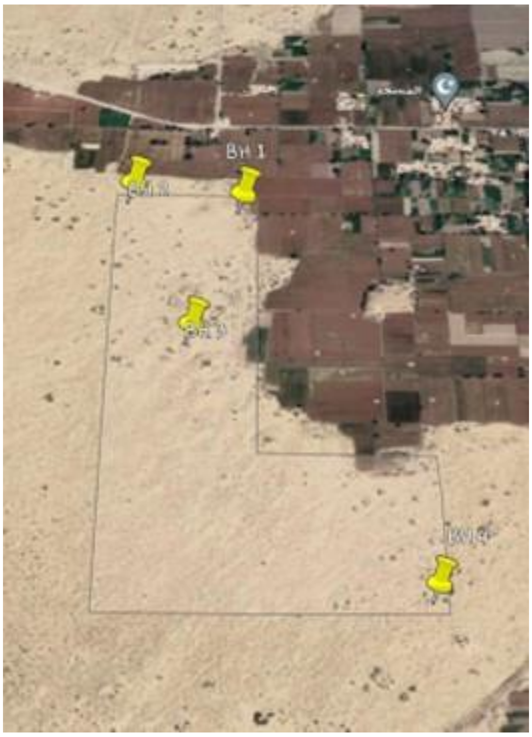
- It must be ensured that compaction on each layer must not be less than 95% of modified Proctor dry density. In this way, bearing the capacity of the area can be increased.
- Proper factors of safety against the uplift and lateral loads should also be checked for the adequacy of the foundation depth.
- Type A and Type B protection (based upon BS8102) is recommended along with reinforced concrete designed to BS8007. Type C with wall and floor cavity and DPM.
- The drainage provisions at the time of construction must be checked to ensure that there is no risk of flotation, from flooding of excavations around the structure.
- Excavation support system requirements may be recommended at a later stage by the geotechnical engineer after architectural plans are finalised.

485. During excavation and construction of foundations, before pouring lean concrete, the excavation should be inspected by an experienced geotechnical engineer.

January 2023 Geotechnical Investigation

486. A second phase of geotechnical investigation was conducted in January 2023 by the Company M/S Productive Engineers. The investigation comprised the drilling of four boreholes (see **Figure 6-14**) to a depth of 16m. As with the other investigations, the sub-soil was found to comprise beddings of Silty Clay, Silt with Sand and Silty Sand.

Figure 6-14: January 2023 Geotechnical Borehole Locations



487. Field tests indicated soil moisture contents of between 6.2% and 10.7%, as summarised in **Table 6-19**. No permeability testing was undertaken.

Table 6-18: Subsurface Soil Water Content and Permeability Findings June 2023

BH No.	Depth (m)	Moisture Content
1	0-2.2m	6.5%
1	2.2-5.4m	6.2%
1	5.4-8.2m	7.4%
1	8.2-14m	9.6%
1	14-16m	W.T=14m
1	Composite	7.1%
2	0-5.2m	5.2%
2	5.2-8.4m	5.9%
2	8.4-11.2m	10.2%
2	11.2-16m	W.T=14.6m
2	Composite	7.6%
3	0-4.6m	5.8%
3	4.6-6.4m	6.3%
3	6.4-9m	7.4%
3	9-12.8m	9.8%
3	12.8-16m	10.7%
3	Composite	8.4%%
4	0-6.4m	4.6%
4	6.4-8.6m	7.4%
4	8.6-11.4m	8.2%
4	11.4-16m	W.T=14.9m
4	Composite	6.4%

June 2023 Slope and Permeability Investigation

488. A third phase of geotechnical investigation was conducted in June 2023 by the Company GKW Consult. The investigation comprised the drilling of a single borehole to a depth of 40ft (c12m) close to the centre of the new landfill site at coordinates N 29.2944723, E71.5912466. Soil was characterised as Light Brown Silty Clay with Sand. Groundwater was not encountered at any point in the borehole. Tests indicated soil moisture contents of between 8.2 and 10.3% and falling head permeability (K_{20}) as summarised in **Table 6-19.**

Table 6-19: Subsurface Soil Water Content and Permeability Findings June 2023

Sample No	Depth (ft)	Moisture Content (%)	K_{20} (cm/s)	K_{20} (m/day)
UDS-1	17	8.2%	0.000041	0.035
UDS-2	22	9.3	0.0000388	0.034
UDS-3	27	9.8	0.0000315	0.027
UDS-4	32	10.3	0.0000871	0.075

6.6.4 Surface water

489. Component 1 is located at 13 km on the south of the Sutlej River and lies in the Cholistan region near the Thar Desert, where effect of recharge is significant. As such, the sub soil water quality has improved over time. The ground surface in the Component 2 development area is approximately ten to fifteen metres above the elevation of the Sutlej River banks.

490. A non-perennial irrigation canal Shimshahi canal flows through the project area at 10.7 km from the project site. The canal is operated from April to September (Kharif Season). One surface water sample was collected from this canal and analysed from EPA certified lab. The results of the tests are presented in **Table 6-20** and **Appendix A.4.** The coordinates of the Shimshahi canal are 29° 31′34.03″ N and 71° 59′33.72″ E. The elevated TDS concentrations are reported due to increased alkalinity and calcium concentrations and accelerated dissolution of calcium carbonate. Also, high sulphate concentrations is due to spilling of sulphur compounds from impervious areas and wastewater leaks or illicit discharges.

Table 6-20: Surface Water Quality Analysis

Parameters	Analysis Method	Unit	Standard Value	Result
Temperature	-	Deg C	10-15	11.0
pH	APHA-4500H^+ B	pH unit	0.1	7.60
Total Dissolved Solid (TDS)	APHA-2540 C	mg/l	1.0	250.0
Color	APHA-2120 B/C	Pt/Co	5.0	68.0
Odor	In-house	-	Odorless	Odorless
Turbidity	APHA-2130 B	NTU	0-1.0	N.D
Salinity	APHA 2520-B	Ng/l	0-3.0	0.125
Oil and Grease	USEPA-1664	mg/l	1.0	<1.0
Biological Oxygen Demand	APHA, 5210	mg/l	2.0	26.0
Chemical Oxygen Demand	APHA-5220-D	mg/l	5.0	80.0
Total Suspended Solid	APHA-2540-D	mg/l	5.0	39.0
Phenolic Compound	APHA-5530 D	mg/l	0.001	<0.001
Chloride (Cl)	APHA-4500Cl- B	mg/l	0.5	35.22
Fluoride (F)	APHA-4500F- C	mg/l	0.01	<0.01
Detergent	APHA-4500-SO4C	mg/l	-	N.D
Sulphate	APHA-4500-SO4C	mg/l	0.41	83.14
Sulphide	APHA-4500-S2-E	mg/l	-	N.D
Ammonia	APHA-4500-NH3-B	mg/l	0.002	<0.002
Arsenic	APHA-3500As B	mg/l	0.01	<0.01
Chlorine	APHA-4500Cl-B	mg/l	1.0	<1.0
Lead	APHA-3500-Pb B	mg/l	0.01	<0.01
Total Toxic Metals	-	mg/l	-	ND
Mercury	APHA-3500-Hg B	mg/l	0.001	<0.001
Pesticides	APHA-6630 B	mg/l		ND

Source: IEE baseline survey, 2022

491. River Sutlej flows along the Northern boundary of the District Isalm Head works is located on Bahawalpur / Muzaffar Garh border of the district. Around 3.25 lacs cusecs of water passed during the monsoon season, however, the district marked as low risk due to floods. In specific the proposed project area is also low risk due to the flood's effects.

6.6.5 Groundwater

492. Currently, groundwater is being pumped by installing private tube wells for agriculture and domestic uses in all major settlements near Component 1.

Figure 6-15: Water Sampling Analysis

493. Ground water table in the project area is at depth of 15-20 meters. Ground water table is at reasonable depth from landfill cell and further bottom lining of landfill cells will control seepage of leachate.

494. Furthermore, active life of landfill cell is about 4-5 years and after that, final capping will be placed. After that, there are minimal chances of percolation of water in the landfill cell and hence limited leachate production. Furthermore, leachate collection system will be in place at bottom lining of the landfill cell, and it will work even after final capping of landfill cell to collect and treat any volume of leachate. Keeping in view these design considerations, leachate percolation to ground water is not expected. Also, ground water quality monitoring wells are incorporated in the project design. Ground water quality will be monitored on frequent intervals to assess any leachate contamination. Ground water samples of surrounding areas will also be analysed throughout the operations to trace any leachate contamination.

Local Hydrogeology

495. In general, subsurface stratigraphy at the new landfill site consists of three basic lithological units, as given below:

- Lean Clay/Sandy Strata
- Sandy Silt/Silt
- Silty fine Sand/fine Sand

496. The soil is alluvial with sandy textured sand dunes covering 50 to 60 percent of the area. These soils are the alluvial deposits of the recent geologic times. The soil of central Bahawalpur mostly consists of the plains of Indus basin, which is at the height of not more than 150 meters above sea level. But the southwestern desert, which is called Rohi or Cholistan, is mostly undulated due to the presence of sand dunes. The height of the sand dunes does not exceed 150 meters' Main soil types of Cholistan desert are sand dunes (44%), sandy soils (37%), loamy soils (2%) and saline-sodic clayey soils (17%).

497. The depth of the groundwater table at the Landfill Site (LFS) reportedly varies within the range of 15 to 20 meters and this is in keeping with the findings of the site investigations carried out for the Project. Given that the elevation of the ground surface at the site is approximately 10 to 15m above the River Sutlej, the reported depth to groundwater appears reasonable. It is also reported that the depth of water table is increasing over time due to increased number of private tube wells being installed in the area. Recharge from surface /rainwater may help in reduction of depth of the water table. During dry periods, the situation sometimes becomes quite serious.

498. Groundwater in the areas of the project is reported by local sources to be generally of good to marginal quality. Brackish water is present in the project area but in deep aquifers good to marginal quality water is also available. Ground water is also extracted for agriculture use.

499. As part of IEE baseline, one ground water sample was collected from Basti Chachran (near the proposed landfill site) on November 30, 2022, and analysed by an EPA certified lab. The GPS coordinates of the landfill site are 29°17'54.25" N and 71°35'52.19". The results of the tests are presented in **Table 6-21** and **Appendix A.4,** which indicates that all parameters of the ground water samples taken are within the applicable PEQS and WHO standards with no exceedances observed. Ground water sample collection is shown in **Figure 6-15** while ground water sampling location is provided as **Figure 6-16.**

Table 6-21: Groundwater Water Quality Analysis Proposed Landfill Site

S No.	Parameters	Analysis Method	Units	PEQS	WHO	Ground Water Sample Proposed Landfill Site
1	pH	APHA-4500H+ B	--	6.5-8.5	6.5-8.5	7.6
2	Taste & Odour	In-house	--	Non-Objectionable	Non-Objectionable	Non-Objectionable
3	Colour	APHA-2120 B/C	TCU	<15	<15	5
4	Turbidity	APHA-2130 B	NTU	<5	<5	3
5	Total Coliform	APHA:9222 B	Number/100 mL	0 Number/100 mL	0 Number/100 mL	0
6	E-Coli	APHA:9222 D	Number/100 mL	0 Number/100 mL	0 Number/100 mL	0
7	Total Dissolved Solids (TDS)	APHA-2540 C	mg/L	<1000	<1000	468
8	Total Hardness	APHA-2340 C	mg/L	<500	--	121
9	Nitrate	APHA-4500NO3 B	mg/L	≤50	≤50	4.9
10	Nitrite	APHA-4500NO2 B	mg/L	≤3	≤3	0.035
11	Ammonia	APHA-4500-NH3-B	mg/L	---	---	0.07
12	Arsenic	APHA-3500As B	mg/L	<0.05	<0.01	N.D.
13	Antimony	APHA-3500Sb B	mg/L	<0.005	<0.005	N.D.
14	Barium	APHA-3500Ba B	mg/L	0.7	0.7	N.D.
15	Chloride	APHA-4500Cl- B	mg/L	250	250	82
16	Fluoride	APHA-4500F- C	mg/L	<1.5	1.5	0.76

October 2023 Geotechnical Investigation Groundwater Findings

500. Groundwater information was gathered during the October 2022 geotechnical investigation described in **Section 7.5.3** above. The groundwater table was encountered at 14m, 16m, 14.80m and 16.5m in BH-01, BH-02, BH04 and BH-05 respectively. GWT was not encountered in BH-03 (terminal depth 20m).

January 2023 Geotechnical Investigation Groundwater Findings

501. During the January 2023 geotechnical investigation described in **Section 6.6.3** above, groundwater was encountered in three of the four boreholes. The depth to groundwater was found to be between 14m and 14.9m below ground level as shown in **Table 6-22**. These findings are consistent with previous investigations and assumptions used in the groundwater modelling presented in **Appendix A-19**.

Table 6-22: Depth to Groundwater Water during Geotechnical Investigation

Borehole No	Water Table (m)
1	14m
2	14.6m
3	Not Encountered
4	14.9m

6.6.6 Air Quality

502. Ambient Air Quality Monitoring have been carried out for 24hrs at six different locations around the proposed landfill site. i.e Basti Rama, BastiYar Muhammad, Basti Karim Bukhsh, Basti Meriwala Khoon, Basti Rasheedabad and Basti Chachran. All of which are located south of Component 2.

503. The criteria for selection of these locations were that these villages/ residential dwellings are the most immediate receptors of any pollutant at upstream and downstream wind direction of the landfill site.

504. Air Quality Monitoring System (AQMS-65[20]) was employed for NO_2, SO_X, $COPM_{10}$ and $PM_{2.5}$. AQMS is a fully integrated air monitoring station that delivers 'near reference levels' of performance parameters. This system can measure various gaseous and particulate pollutants and environmental parameters simultaneously.

505. The AQMS 65 offers the optimal balance between performance and measuring criteria pollutants to WHO air quality limits. Data of AQM 65 is traceable back to international standards-USEPA (40 CFR Part 53) and EU (2008/50/EC). 24hr continuous monitoring was employed at selected locations.

506. The concentrations of $PM_{2.5}$ in µg/m^3 were recorded 14.93 at Basti Rama, 12.34 at Basti Yar Muhammad, 15.85 at Basti Karim Bukhsh, 9.39 at Basti Meriwala Khoon, 14.61 at Basti Rasheedabad and 10.97 µg/m^3 Basti Chachran. All values were compliant with PEQS, however, exceedance of WHO value was observed at Basti Karim Baksh.

507. The concentrations of PM_{10} in µg/m^3 were 64.03 at Basti Rama, 59.37 at Basti Yar Muhammad, 68.36 at Basti Karim Bukhsh, 52.93 at Basti Meriwala Khoon, 57.95 at Basti Rasheedabad and 54.49 at Basti Chachran. All values were compliant with PEQS as well USEPA standards for PM_{10} in ambient air, however, the stringent WHO

[20] https://www.aeroqual.com/products/aqm-stations/aqm-65-air-quality-monitoring-station

guideline values were exceeded at all locations. This increase is due to the high vehicular moment and construction activities in the project area.

508. The concentrations of CO in mg/ were 0.27 at Basti Rama, 0.49 at Basti Yar Muhammad, 0.73 at Basti Karim Bukhsh, 0.39 at Basti Meriwala Khoon, 0.38 at Basti Rasheedabad, 0.30 at Basti Chachran. All values were in compliance with PEQS, USEPA and WHO standards.

509. The concentrations of NO in µg/m^3 were 6.26 at Basti Rama, 10.27 at Basti Yar Muhammad, 13.22 at Basti Karim Bukhsh, 7.01 at Basti Meriwala Khoon, 9.46 at Basti Rasheedabad and 8.93 at Basti Chachran. All values were following the PEQS as well USEPA standards for NO in ambient air, however, the stringent WHO guideline values were exceeded at all locations.

510. The concentrations of NO_2 in µg/m^3 were 7.53 at Basti Rama, 12.40 at Basti Yar Muhammad, 14.34 at Basti Karim Bukhsh, 8.44 at Basti Meriwala Khoon, 10.24 at Basti Rasheedabad and 10.42 at Basti Chachran. These results indicated the currently ambient air was following the PEQS, USEPA and WHO standards.

511. The concentrations of SO_2 in µg/m^3 were 6.60 at Basti Rama, 12.08 at Basti Yar Muhammad, 15.95 at Basti Karim Bukhsh, 8.42 at Basti Meriwala Khoon, 11.07 at Basti Rasheedabad and 10.09 at Basti Chachran. All values were in compliance with the PEQS as well USEPA standards for SO_2 in ambient air, however, the stringent WHO guideline values were exceeded at all locations.

512. The ambient air and noise level monitoring was conducted for 24 hours at the existing Khanu Wali dumpsite from 16th May to 17th May 2023.

513. The time-averaged (24h) concentrations of SO_2, CO, NO, NO_2, PM_{10} and $PM_{2.5}$, were found to be 18.27 µg/m3, 0.82 mg/m3, 16.02 µg/m3, 20.91 µg/m3, 121.11 µg/m3 , and 32.35 µg/m3 respectively, which meet the PEQS limits of (i.e., 120 µg/m3, 5 mg/m3, 40 µg/m3, 80 µg/m3, 150 µg/m3, 35 µg/m3).

514. The map showing the selected air quality monitoring locations and their respective ambient air quality readings are provided as **Figure 6-16** below with the comparison of the results presented as **Table 6-23** below.

Figure 6-16: Sampling Locations for Environmental Monitoring

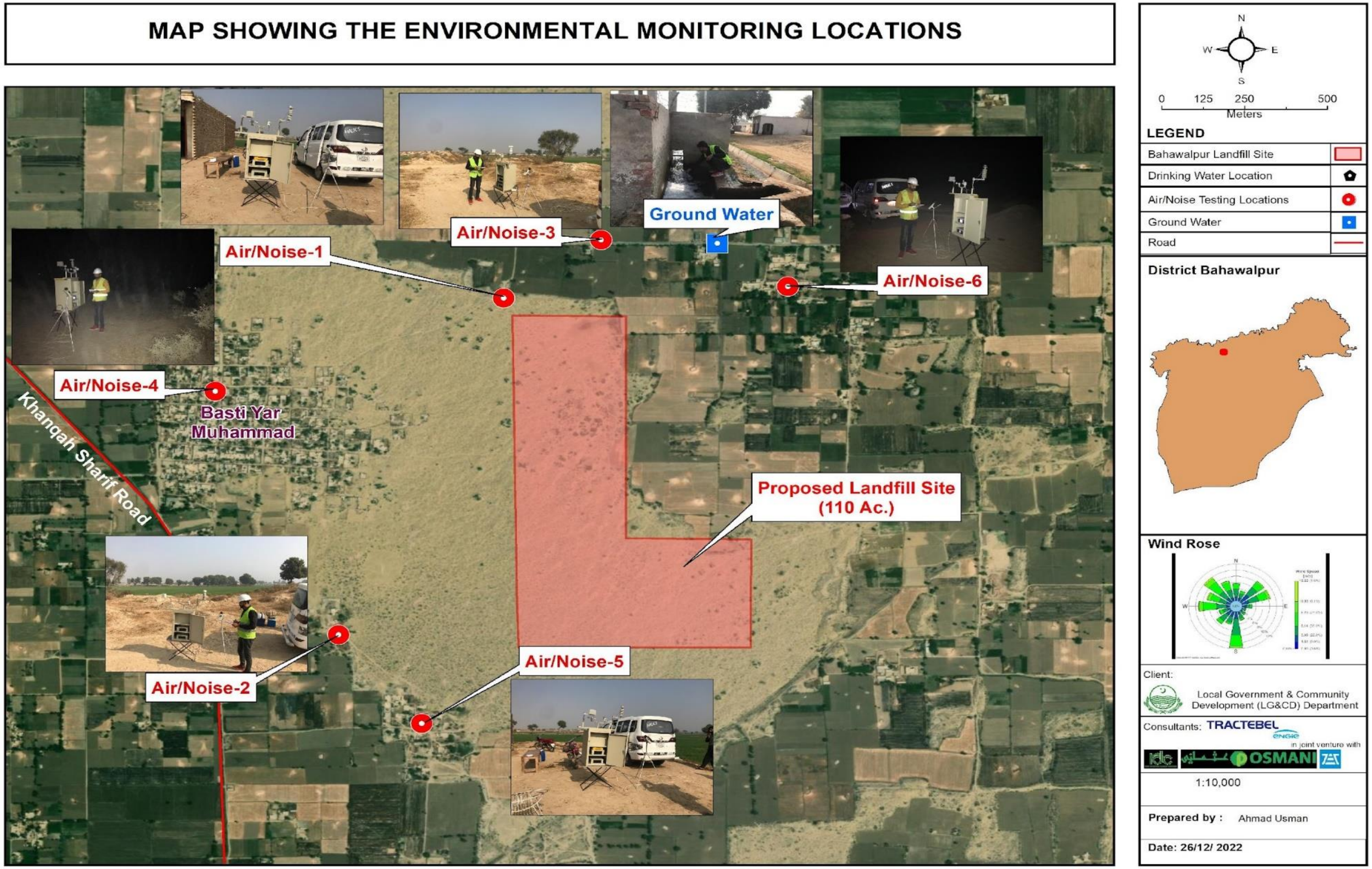


Table 6-23: Ambient Air Quality Monitoring Results (24 hrs) in Project Area[21]

Sr. No.	Parameter	Results							USEPA	WHO/IFC	PEQS
		Basti Rama	**Basti Yar Muhammad**	**Basti Karim Bukhsh**	**Basti Meriwala Khoon**	**Basti Rasheedabad**	**Basti Chachran**	**Existing Dumpsite**			
		Sept 30, 2022	**Dec 01, 2023**	**Dec 02, 2023**	**Dec 03, 2023**	**Dec 04, 2023**	**Dec 05 2023**	**May 16, 2023**			
		29°18'51.28"N 71°36'25.93"E	**29°17'52.57"N 71°35'6.50"E**	**29°17'17.15"N 71°35'16.32"E**	**29°18'57.28"N 71°34'30.18"E**	**29°16'4.64"N 71°34'22.46"E**	**29°18'23.96"N 71°37'8.01"E**	**29°42'533.3ºN 71°633'52.4ºE**			
1	$PM_{2.5}$	14.93 ($\mu g/m^3$)	12.34 ($\mu g/m^3$)	15.85 ($\mu g/m^3$)	9.39 ($\mu g/m^3$)	14.61 ($\mu g/m^3$)	10.97 ($\mu g/m^3$)	32.35 ($\mu g/m^3$)	35 ($\mu g/m^3$) (24hrs)	15 ($\mu g/m^3$) (24hrs)	35 ($\mu g/m^3$) (24hrs)
2	PM_{10}	64.03 ($\mu g/m^3$)	59.37 ($\mu g/m^3$)	68.36 ($\mu g/m^3$)	52.93 ($\mu g/m^3$)	57.95 ($\mu g/m^3$)	54.49 ($\mu g/m^3$)	121.11 ($\mu g/m^3$)	150 ($\mu g/m^3$) (24hrs)	45 ($\mu g/m^3$) (24hrs)	150 ($\mu g/m^3$) (24hrs)
3	CO	0.27 (mg/m^3)	0.49 (mg/m^3)	0.73 (mg/m^3)	0.39 (mg/m^3)	0.38 (mg/m^3)	0.30 (mg/m^3)	0.82 (mg/m^3)	11 (mg/m^3)(08 hr)	-	05 (mg/m^3)(24 hr)
4	NO	6.26 ($\mu g/m^3$)	10.27 ($\mu g/m^3$)	13.22 ($\mu g/m^3$)	7.01 ($\mu g/m^3$)	9.46 ($\mu g/m^3$)	8.93 ($\mu g/m^3$)	16.02 ($\mu g/m^3$)	-	-	40 ($\mu g/m^3$) (24 hr)
5	NO_2	7.53 ($\mu g/m^3$)	12.40 ($\mu g/m^3$)	14.34 ($\mu g/m^3$)	8.44 ($\mu g/m^3$)	10.24 ($\mu g/m^3$)	10.42 ($\mu g/m^3$)	20.91 ($\mu g/m^3$)	100 ppb (1hr)	25 ($\mu g/m^3$)(24 hr)	80 ($\mu g/m^3$) (24 hr)

[21] The ambient air quality was monitored using the AQM 65, which is a fully integrated air monitoring station that delivers near reference levels of performance. The AQM 65 offers the optimal balance for measuring criteria pollutants to WHO air quality limits. With the AQM65 continuously measuring of common air pollutants was carried out and then results are produced on 24 hours average. AQM 65 ensures air quality data is reliable and robust in compliance to USEPA (40 CFR Part 53) and EU (2008/50/EC).

6	SO_2	6.60 (µg/m^3)	12.08 (µg/m^3)	15.95 (µg/m^3)	8.42 (µg/m^3)	11.07 (µg/m^3)	10.09 (µg/m^3)	18.27 (µg/m^3)	75 ppb (1hr)	40 (µg/m^3)(24 hr)	120 (µg/m^3) (24 hr)

515. Secondary data was also collected during the summer season (June 2021) at two different locations near the proposed landfill site. One location was at the nearest hospital (Shahida Islam Hospital) near the site while the other was at 1km downstream of the landfill site. Results are shown in below tables.

Table 6-24: Ambient Air Monitoring Conducted at Shahida Islam Teaching Hospital22

Parameters	Units	Results
Particulate Matter ($PM_{2.5}$)	µg/m^3	29.0
Particulate Matter (PM_{10})	µg/m^3	111.0
Nitrogen Dioxide (NO_2)	µg/m^3	23.54
Nitrogen oxide (NO)	µg/m^3	17.53
Sulphur Dioxide (SO_2)	µg/m^3	4.13
Carbon Monoxide (CO)	µg/m^3	1.11

Table 6-25: Ambient Air Monitoring Conducted at 01km Downstream of Project Site

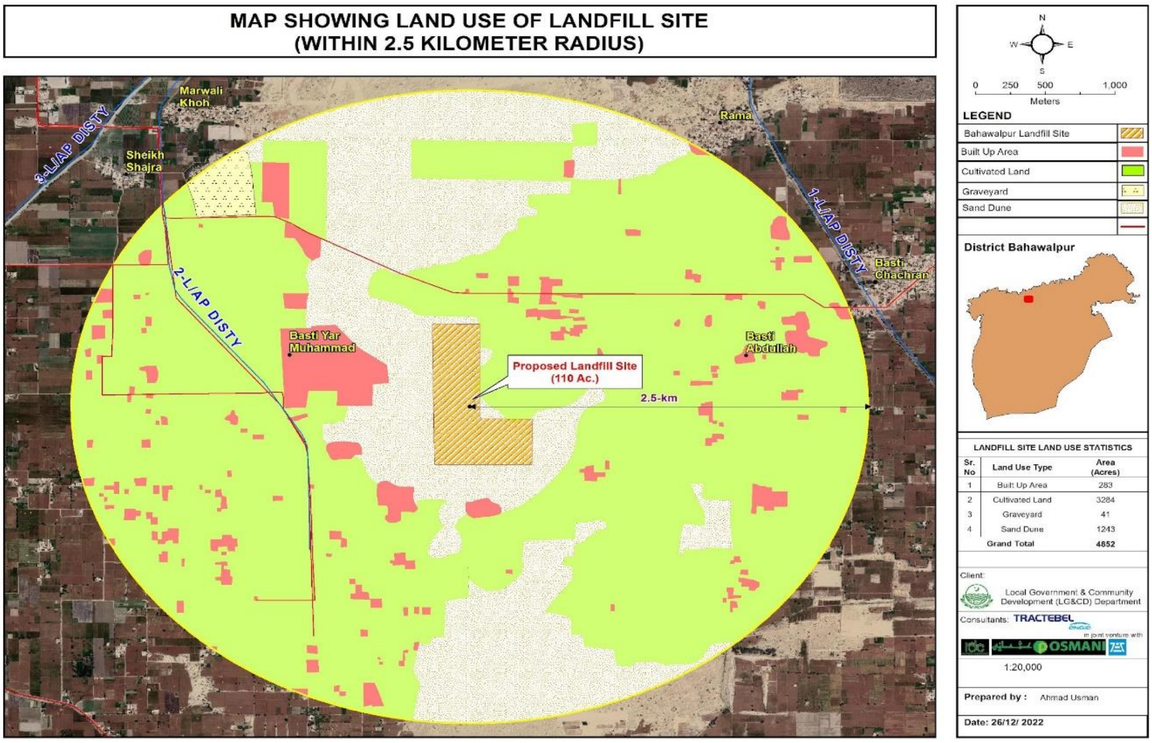
Parameters	Units	Results
Particulate Matter ($PM_{2.5}$)	µg/m^3	27.89
Particulate Matter (PM_{10})	µg/m^3	91.31
Nitrogen Dioxide (NO_2)	µg/m^3	12.25
Nitrogen oxide (NO)	µg/m^3	13.46
Sulphur Dioxide (SO_2)	µg/m^3	4.21
Carbon Monoxide (CO)	µg/m^3	1.01

6.6.7 Land Use

516. Land Use/Land Cover analysis within 2.5 km radius of the new landfill site has been carried out which shows cultivated land is major land use followed by built up area. Landfill site is surrounded by cultivated land from east side and sand dunes on west side. Land use map of the site is provided in **Figure 6-17** below.

22 EIA of Shahida Islam Teaching Hospital, Capacity Enhancement, Bahawalpur, EPA, Punjab

Figure 6-17: Land Use/Land Cover Map of the Project Area



6.6.8 Ecological Environment of Component 1

517. The Flora and Fauna survey were conducted during the month of October and November 2022. A team consisting of Botanist and environmentalists visited the project site of component 1 from 15-10-2022 to 10-11-2022 for screening and detailed analysis. The plants and animal's species observed, identified and recorded using standard biological methods.

518. Ecological survey report listed species which are dominant and common in the project area. The area around the project site is potential habitat of these species. Bahawalpur is the region cited by many research papers as the habitats of Hog Deer, Houbara bustard and Brown roofed turtles (Khurram Saeed, 2012). Hog deer is usually found along the Sindh River and its off-shooting canals, Houbara found along fresh water bodies and brown reefed turtle along wetlands of canals and fields around Chenab and Sindh river.

519. Integrated Biodiversity Assessment Tool (IBAT) screening was carried out to identify the biodiversity features and species that are located within the following buffers: 1 km, 3 km and 5 km. There were no protected and/or key biodiversity areas found within 5 km buffer from the landfill site. There are 36 threatened species that are potentially found within 50 km from area of interest, which include 18 avian species, 09 reptilian species, 05 mammalian and 04 Actinopterygii. As the project area is in urban sprawl of Bahawalpur city and habitats have been converted into human settlements at large scale, therefore no impact on such species is expected from project activities. IBAT screening report is attached as **Appendix A.15.**

520. Consultation with forest and wildlife department carried out during IEE field survey and findings are further verified through IBAT screening. IBAT findings were discussed with Wildlife department during IEE consultations and PMU requested the department to identify key species falling in the project corridor. Based on analysis there is no endangered species and key biodiversity area falling in proximity of the

site therefore no biodiversity management plan is required. NOC from Punjab Wildlife department is obtained for the project which clearly states that project area is not corridor of key species of concern and department has no objection with respect to project execution. NOC from wildlife department is attached as Annexure **A.17.**

Flora

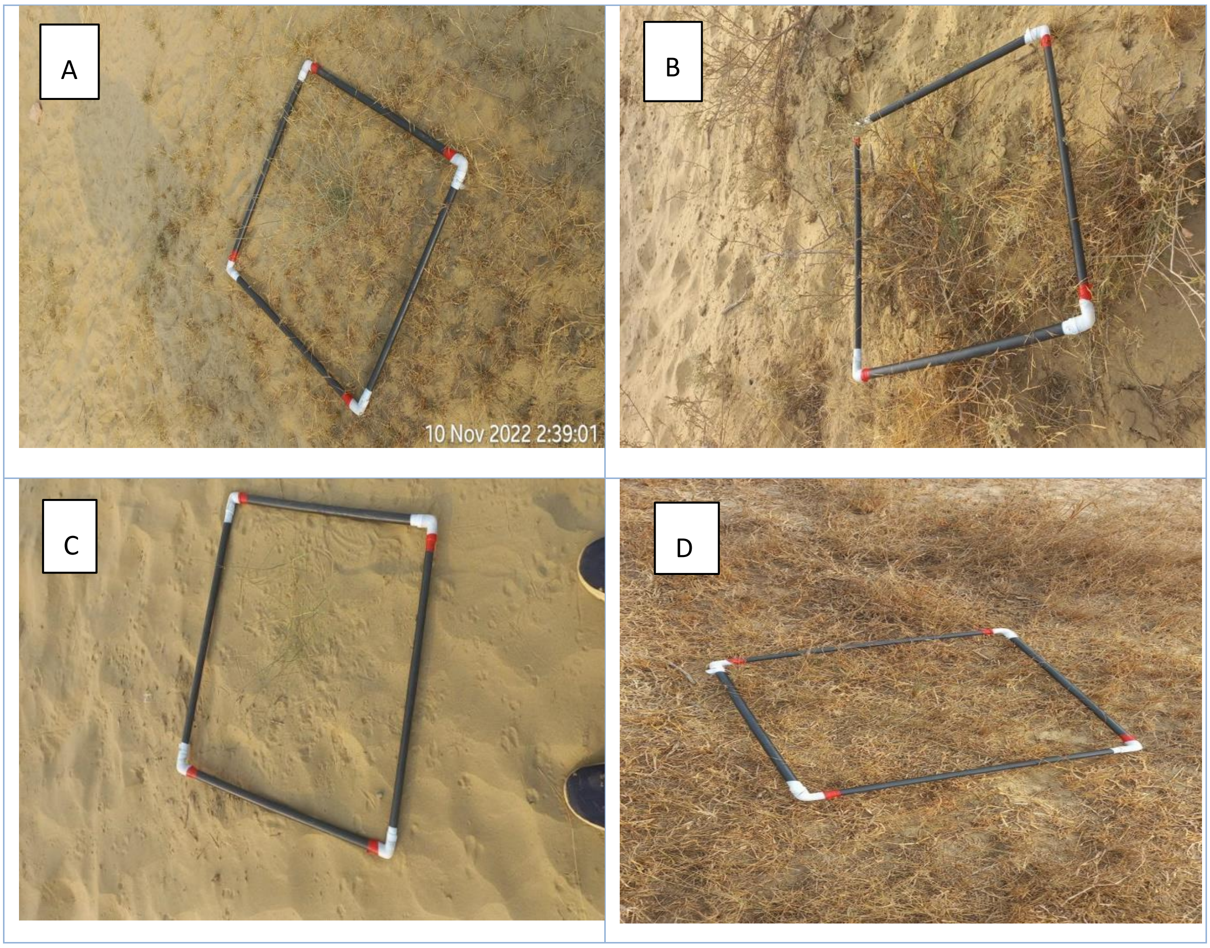
521. Ecological surveys conducted for the study of flora, which included project area. The identification of the plants and labelling of Herbarium sheets carried out by using Flora of Pakistan (Ali and Qaiser, 1992-2007; Ali and Nasir, 1990-92).

Flora Sampling Methodology

522. The sites based upon the presence of natural vegetation selected and surveyed through Transect walks. Within each sample plot, all plants were divided into four layers, i.e. tree, shrub, herb and grass layer. The size of sample was 100 m^2 at each sampling site (**Figure 4.15**). A long measuring tape (25m) was laid across the stand in the communities under study and fixed with two hooks at two ends (*Fang et al, 2012).*

523. The individual plants recorded touching the measuring tape and the distance from a particular end. For abundance and measurement 10×10m, quadrats were used for tree vegetation, 5×5m quadrats for shrubs and 1×1m were taken for herbs and grasses *(Sharma et al. 2014, Sadia et al, 2021).*

Figure 6-18: Flora Sampling of the Project area



A, B, C and D Quadrat method in Project site for species abundance

Flora Data Analysis and Interpretations

524. The abundance of species in the project areas was determined using the DAFOR scale. Specifically, the Dominant, Abundant, Frequent, Occasional, Rare and Absent (the DAFOR) scale records the vegetative cover of an area and represents the abundance of species (Hearnshaw *et al* 2010). DAFOR scale is presented in below table.

Table 6-26: DAFOR Scale to analyze abundance

Abundance (% age)	DAFOR Class	Abbreviation
51 – 100	**Dominant**	**D**
31 – 50	**Abundant**	**A**
16 – 30	**Frequent**	**F**
6 – 15	**Occasional**	**O**
1 – 5	**Rare**	**R**
0	**Absent**	**X**

525. The IUCN Red List Categories of Flora of Punjab visited to collect the relevant Data on the Flora of Punjab. Being an easily and widely understood system for classifying species at high risk of global extinction was used. The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk. However, while the Red Data List may focus attention on those taxa at the highest risk, it is not the sole means of setting priorities for conservation measures for their protection.

526. Species belonging to 18 families reported 63 plant species from project site and adjacent areas (Sadia *et al*, 2021, Ahmad *et al,* 2012). Among them 16 tree species, 09 shrubs, 20 herbs and 18 grass species found. *Acacia modesta, Dalbergia sissoo, Albizia lebbek, Phoenix dactylifera, Prosopis juliflora and Tamarix aphylla* were common trees*. Capparis decidua, Ziziphus nummularia, Calotropis procera, Parthenium hysterophorus, Convolvulus arvensis, Achyranthes aspera*and*Citrullus colocynthus*were commonly found herb and shrub species*. Aristida depressa, Eleusine indica, Cenchrus biflorus, Phragmites karka, Cymbopogon jwarancusa, Cynodon dactylon, Saccharum munja* and *Saccharum spontaneum* were common grasses and five species of sedges observed. Tree diversity of the project area is provided in **Table 6-27** and **Figure 6-19.**

Figure 6-19: Floral Families Diversity

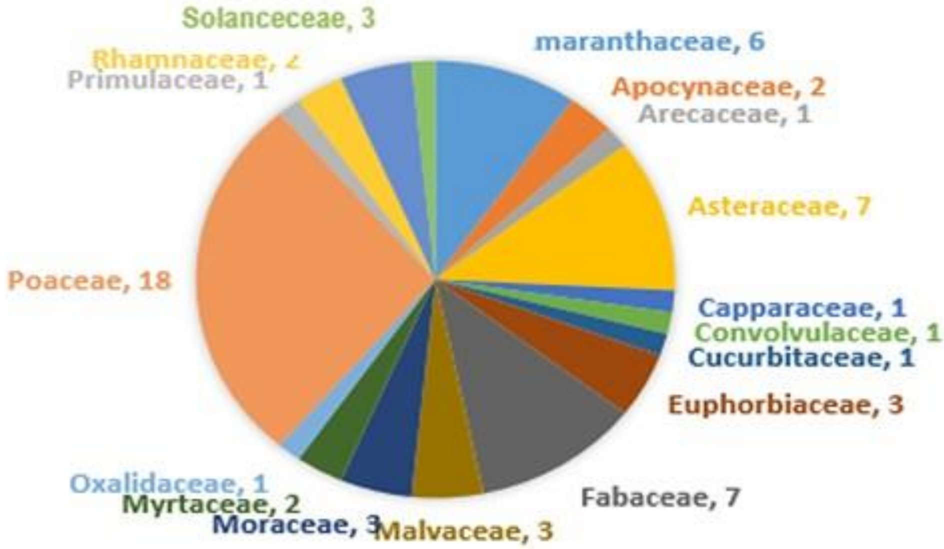


Table 6-27: Tree Diversity in Project Area

Sr. No	Scientific Names	Common Names	Families	Habitat Types		DAFOR Scale	IUCN Red List Status
				Project Area	Peripheral Area		
1	*Acacia nilotica*	Wild Acacia	Fabaceae	F	O	F	NE
2	*Acacia modesta*	Small Acacia	Fabaceae	D	A	A	NE
3	*Albizia lebbek*	Siris	Fabaceae	X	R	R	NE
4	*Azadirachta indica*	Neem tree	Malvaceae	X	O	O	LC
5	*Callistemon lanceolatus*	Bottle brush	Myrtaceae	X	O	O	NE
6	*Dalbergia sissoo*	Indian rosewood	Fabaceae	F	F	F	LC
7	*Eucalyptus camaldulensis*	Eucalyptus	Myrtaceae	X	A	F	NT
8	*Ficus virens*	Wild Fig	Moraceae	R	O	R	LC
9	*Ficus religiosa*	Sacred fig	Moraceae	X	R	R	NE
10	*Melia azedarach*	Chinaberry tree	Malvaceae	X	O	O	LC
11	*Morus alba*	Mulberry	Moraceae	X	O	O	LC
12	*Phoenix dactylifera*	Dates	Arecaceae	X	O	O	LC
13	*Prosopis cineraria*	Jand	Fabaceae	O	F	O	NE
14	*Prosopis juliflora**	Mesquite	Fabaceae	F	D	D	NE
15	*Tamarix aphylla*	Athel tree	Tamaricaceae	O	O	O	NE
16	*Ziziphus jujuba*	Jujube	Rhamnaceae	F	A	F	LC
* = Invasive, D = Dominant, A= Abundant, F= Frequent, O = Occasional and R=Rare X= Absent. IUCN Red List Status: LC=Least Concern, NE=Not Evaluated DD= Data Deficient							

Source: EDCM Ecology Survey, November 2022

527. List of Shrubs, Herbs and Grass species found in the project area are shown as **Table 6-28, Table 6-29 and Table 6-30.**

Table 6-28: List of Shrubs in Project Area

Sr. No	Scientific Names	Common Names	Families	Habitat Types		DAFOR Scale	IUCN Red List Status
				Project Area	Peripheral Area		
1	*Abutilon indicum*	Abutilon	Malvaceae	O	F	F	NE
2	*Alhagi maurorum*	Alhagi	Fabaceae	X	O	F	NE
3	*Calotropis procera*	Apple of sodom	Apocynaceae	A	F	A	NE
4	*Capparis decidua*	Karira	Capparaceae	A	A	A	DD
5	*Nerium oleander*	Kaner	Apocynaceae	X	F	F	LC
6	*Suaeda fruiticosa*	Suaeda	Amaranthaceae	F	O	F	LC
7	*Ricinus communis*	Arind	Euphorbiaceae	O	F	O	NE
8	*Xanthium strumarium*	devil fruit	Solanaceae	O	O	O	LC
9	*Ziziphus nummularia*	Lotebush	Rhamnaceae	A	A	A	NE
* = Invasive, D = Dominant, A= Abundant, F= Frequent, O = Occasional and R=Rare X= Absent. IUCN Red List Status: LC=Least Concern, NE=Not Evaluated DD= Data Deficient							

Table 6-29: List of Herbs in Project Area

Sr. No	Scientific Names	Common Names	Families	Habitat Types		DAFOR Scale	IUCN Red List Status
				Project Area	Peripheral Area		
1	*Achyranthes aspera*	Devil's horsewhip	Amaranthaceae	O	F	F	NE
2	*Aerva javanica*	kapok bush	Amaranthaceae	R	O	O	NE
3	*Ageratum conyzoides*	Ageratum	Asteraceae	R	R	R	NE
4	*Alternanthera sessilis*	Joyweed	Amaranthaceae	A	A	A	LC

Sr. No	Scientific Names	Common Names	Families	Habitat Types		DAFOR Scale	IUCN Red List Status
				Project Area	Peripheral Area		
5	*Amaranthus viridis*	Slender amaranth	Amaranthaceae	A	F	F	NE
6	*Anagallis arvensis*	scarlet pimpernel	Primulaceae	O	A	F	LC
7	*Atriplex vesicaria*	Atriplex	Amaranthaceae	X	O	O	LC
8	*Carthamus oxyacantha*	Thistle	Asteraceae	O	F	O	LC
9	*Cirsium arvense*	Lay	Asteraceae	X	R	R	LC
10	*Convolvulus arvensis*	Convulvulus	Convolvulaceae	O	F	F	NE
11	*Conyza canadensis*	Fleabane	Asteraceae	O	O	O	NE
12	*Citrullus colocynthus*	Bitter cucumber	Cucurbitaceae	F	F	F	NE
13	*Datura innoxia*	Datura	Solanaceae	O	F	F	NE
14	*Echinops echinatus*	Globe Thistle	Asteraceae	R	O	O	NE
15	*Euphorbia prostrata*	Prostrate sandmat	Euphorbiaceae	R	R	R	NE
16	*Helianthus petiolaris*	Prairie Sunflower	Asteraceae	X	O	O	LC
17	*Oxalis corniculata*	Oxalis	Oxalidaceae	X	O	O	NE
18	*Parthenium hysterophorus**	Parthenium	Asteraceae	O	A	F	NE
19	*Solanum xanthocarpum*	Yellow berry	Solanaceae	F	F	F	NE
20	*Trianthema portulacastrum*	It sit	Euphorbiaceae	R	O	O	NE

* = Invasive, D = Dominant, A= Abundant, F= Frequent, O = Occasional and R=Rare X= Absent. IUCN Red List Status: LC=Least Concern, NE=Not Evaluated DD= Data Deficient

Table 6-30: List of Grasses in Project Area

Sr. No	Scientific Names	Common Names	Families	Habitat Types		DAFOR Scale	IUCN Red List Status
				Project Area	Peripheral Area		
1	*Arundo donax*	Giant reed	Poaceae	X	X	F	LC
2	*Aristida depressa*	Wiregrasses	Poaceae	O	A	A	LC
3	*Cenchrusbiflorus*	Bhurrand	Poaceae	F	F	F	LC
4	*Cenchrus ciliarus*	Cenchrus	Poaceae	F	A	A	NE
5	*Cenchrus stigras*	Dhamal	Poaceae	X	O	O	NE
6	*Chrysopogon aucheri*	Tilla grass	Poaceae	O	X	O	NE
7	*Cynodon dactylon*	Dub grass	Poaceae	F	A	A	NE
8	*cymbopogon jwarancusa*	Oil grass	Poaceae	O	O	F	LC
9	*Digitaria ciliaris*	Crab grass	Poaceae	O	O	O	NE
10	*Echinochloa colona*	Jungle rice	Poaceae	O	F	F	NE
11	*Eleusine indica*	Crow's feet	Poaceae	F	O	F	LC
12	*Heteropogon contortus*	Tanglehead	Poaceae	X	F	F	LC
13	*Panicum antidotale*	Blue Panic Grass	Poaceae	X	O	O	NE
14	*Phragmites karka*	Common reed	Poaceae	X	X	A	LC
15	*Poa annua*	Poa grass	Poaceae	O	O	O	LC
16	*Saccharum munja*	Munj sweetcane	Poaceae	F	F	F	NE
17	*Saccharum spontaneum*	Wild sugar	Poaceae	O	O	O	LC
18	*Themeda anathera*	Lungi	Poaceae	F	A	F	LC
* = Invasive, D = Dominant, A= Abundant, F= Frequent, O = Occasional and R=Rare X= Absent. IUCN Red List Status: LC=Least Concern, NE=Not Evaluated							

528. Floral diversity of the project area is presented in **Figure 6-20** below.

Figure 6-20: Flora of the Project area

A) *Acacia modesta*

B) *Ziziphus jujuba*

C) *Phoenix dactylifera*

D) *Calotropis procera*

E) *Suaeda fruiticosa*

F) *Cenchrus biflorus*

G) ***Capparis decidua***

H) ***Citrullus colocynthus***

I) ***Alhagi maurorum***

J) ***Aerva javanica***

K) ***Solanum xanthocarpum***

L) ***Tamarix aphylla***

Fauna

529. Ecological surveys were conducted for the study of fauna, which included the project area. Data collection, analysis and interpretations as well as findings are fully described below.

Fauna Sampling Methodology

530. Fauna sampling methodology includes mammal's assessments, spoor tracking, scats survey, public survey and avifauna assessment, fish, reptile and amphibian assessment.

Mammal Assessment

531. A significant number of mammalian species are nocturnal, which means that they are predominantly active during the night and remain elusive during daytime, hence apart from direct sightings, indirect sampling methods were used. These methods compensate for the lack of night field surveys and enable detailed sampling without relying on direct observations and trappings. Mammal assessment was carried out using methods described by Roberts (1997, 2005). The survey was conducted by three surveyors from dawn till dusk for a period of three days.

Spoor tracking

532. Spoor tracking is an indirect survey method which uses observations such as footprint, burrows, den sites etc. to indicate the presence of a species. The method is simple, cost effective and comprehensive as it reduces dependency on direct sighting. However, the extent of details of a footprint and its preservation entirely depends on the suitability of soil.

Figure 6-21: Spoor tracking around landfill site

A) Trails of snakes

B) Burrow of Hare

Scats Survey

533. Another indirect method is the use of faecal matter to identify species. The morphometric analysis (size and shape) of the faecal matter allows identification of the taxonomic group (Chame 2003). The method acts as a supplement to spoor tracking and an excellent measure of mammalian diversity and its abundance.

Figure 6-22: Scat survey around landfill site

	
A) Dung of cow	**B) Dung of Jackal**

Public Survey

534. The local people at the survey sites interviewed regarding the species presence, abundance, and threats. Due to nocturnal habit and elusive nature, several mammalian species may go unreported if the survey solely relied on direct observations.

Avifauna Survey

535. The Avifauna survey was based on, line-transect, point count, general observation and call recognition. The survey was conducted from dawn till dusk the activity and detect-ability of the avifauna remained at optimal level. The birds were observed with binoculars (10 x 50) and identified with the help of acclaimed field guide Grimmett et al., 2008. The point count method involved walking on a line transect and taking observations after a settling period of one minute.

Fish Assessment

536. Fishes collected from wetlands, streams (small rainy water channel) and ponds using local available gears and nets. Local area fisherman was also interviewed to collect data regarding fishes.

Reptile Assessment

537. Active search method adopted whereby debris, logs, wetlands and ponds searched for reptiles and amphibians for signs such as shed skin. Therefore, the survey primarily focused on search of indirect evidence through active searching. Some members directly observed during the survey. Khan, M.S (2006) used for the identification key and distribution of species. The Reptile and Amphibian species found dead due to roadkill or otherwise on roads or adjacent areas within 500 m observed.

Fauna Data Analysis and Interpretations

538. The fauna species observed and recorded at and around the project site. Total seventeen bird's species, eleven mammals' species, five reptiles, two amphibians, four fish and three grazing mammals' species were observed. The common birds include Common Myna, Laughing Dove, Common Quail, and Collared-Dove, Cattle egret, Indian Robin, Indian roller, House crow, Black partridge, Common Babbler and Grey partridge. Dog, Donkeys, Squirrel, Jackals and mongoose were common mammals. Some species of birds, amphibians and reptiles were also noted.

539. Integrated Biodiversity Assessment Tool (IBAT) screening was carried out to identify the biodiversity features and species that are located within the following buffers: 1 km, 3 km and 5 km. There were no protected and/or key biodiversity areas found within 5 km buffer from the landfill site. There are 36 threatened species that are potentially found within 50 km from area of interest, which include 18 avian species, 09 reptilian species, 05 mammalian and 04 Actinopterygii. As project area is located in urban sprawl of Bahawalpur city and habitats have been converted into human settlements at large scale, therefore, no impact on such species is expected from project activities. The Lal Suhanra National Park is located at approximately 33 km from the proposed landfill site, which is an important Bird Area (IBA). IBAT screening report is attached as **Appendix A.15**.

540. IBAT screening report has identified below potential threatened species that may fall within 50 km radius of the site.

Table 6-31: Potential threatened species

Species Name	Local Name	IUCN Status
Vanellus gregarius	Sociable Lapwing	Critical
Gyps bengalensis	White-rumped Vulture	Critical
Geoclemys hamiltonii	Spotted Pond Turtle	Endangered
Hardella thurjii	Crowned River Turtle	Endangered
Nilssonia gangetica	Indian Softshell Turtle	Endangered
Nilssonia hurum	Indian Peacock Softshell Turtle	Endangered
Platanista minor	Indus River Dolphin	Endangered
Axis porcinus	Hog Deer	Endangered
Oxyura leucocephala	White-headed Duck	Endangered
Rynchops albicollis	Indian Skimmer	Endangered
Haliaeetus leucoryphus	Pallas's Fisheagle	Endangered
Neophron percnopterus	Egyptian Vulture	Endangered
Falco cherrug	Saker Falcon	Endangered
Leptoptilos dubius	Greater Adjutant	Endangered
Glyptothorax punjabensis	-	Endangered
Panthera tigris	Tiger	Endangered
Varanus avescens	Yellow Monitor	Endangered
Aquila nipalensis	Steppe Eagle	Endangered

Source: IBAT Screening Report, 2022

IBAT findings were further verified through comparison with field observations and consultation with wildlife department. During EDCM Ecology Survey, Nov 2022 no sighting of such species identified in IBAT was observed. Wildlife department has issued NOC for the project which states that project is not corridor of such species. Further due to modified habitat such species does not use the project area as their range.

541. The fauna present in the project area of the landfill site is provided in **Table 6-32** below.

Table 6-32: Existing Fauna in Project Area

Scientific Names	Common Names	IUCN Status	Scientific Names	Common Names	IUCN Status
BIRDS			**MAMMALS**		
Acridotheres tristis	Common Myna	LC	*Vulpes vulpes*	Red Fox	LC
Spilopelia senegalensis	Laughing Dove	LC	*Bos Taurus*	Cow	LC
Alcedo atthis	Common kingfisher	LC	*Canis aureus*	Golden jackal	LC
Coturnix coturnix	Common Quail	LC	*Canis familiaris*	Dog	LC
Streptopelia decaocto	Collared-Dove	LC	*Equus asinus*	Donkey	LC
Bubulcus ibis	Cattle egret	LC	*Felis catus*	Cat	LC
Centropus sinensis	Greater or Brown Coucal	LC	*Funambulus palmarum*	Indian squirrel	LC
Copsychus fulicatus	Indian Robin	LC	*Herpestes edwardsi*	Mangoose	LC
Coracias benghalensis	Indian roller	LC	*Lepus capensis*	Cap/wild hare	LC
Corvus splendens	House crow	LC	*Rattus rattus*	Common rat	LC
Dicrurus macrocercus	Black drongo	LC	*Sus Scrofa*	Wild Boar	LC
Eudynamys scolopaceus	Asian koel	LC	**AMPHIBIANS**		
Francolinus francolinus	Black patridge	LC	*Hoplobatrachus tigerinus*	Indian Bull Frog	LC
Argya caudata	Common Babbler	LC	*Duttaphrynus melanostictus*	Asian Toad	LC
Ortygornis pondicerianus	Grey patridge	LC	**FISHES**		
Passer domesticus	House Sparrow	LC	*Gibelion catla*	Thaila	LC

Scientific Names	Common Names	IUCN Status	Scientific Names	Common Names	IUCN Status
Pycnonotus cafer	Red-vented bulbul	LC	*Channa puctata*	Daula	LC
REPTILES			*Labeo calbasu*	Kalbans	LC
Hemidactylus frenatus	Common house gecko	LC	*Labeo rohita*	Rahu	LC
Anguis fragilis	Slow worm	LC	**GRAZING MAMMALS**		
Bungarus caerules	Common krait	LC	*Bos Taurus*	Cow	LC
Urosaurus ornatus	Tree lizard	LC	*Capra hircus*	Domestic goat	LC
Testudines spp.	Turtle	LC	*Equus asinus*	Donkey	LC
D = Dominant, A= Abundant, F= Frequent, O = Occasional and R=Rare X= Absent. IUCN Red List Status: LC=Least Concern, NE=Not Evaluated					

Source: EDCM Ecology Survey, Nov 2022

542. Species of special concern found in the vicinity of the project area are mentioned below in the **Table 6-33** with their respective IUCN status in the Red List. No endangered species are present in the project area.

Table 6-33: IUCN Status of Fauna in Project Area

Sr. No	Species of Concern	Expected habitats	Observations	IUCN Status
1	***Hog deer** (**Axis porcinus**)*	**Along the belt of Sind River and other Plains nearby the Sind rivers off shooting canals.**	**Not Found in IEE Ecology Survey, 2022**	**Endangere d**
2	***Houbara bustard** (**Chlamydotis undulata**)*	**All the South and central Punjab found in freshwater bodies and canals.**	**Not Found in IEE Ecology Survey, 2022**	**Vulnerable**

Source: EDCM Ecology Survey, Nov 2022

543. There is no protected area and wildlife sanctuary in the vicinity of the project area. The fauna present in the project area of the landfill site is shown in **Figure 6-23** below.

Figure 6-23: Key Fauna of the Project area

a) Mangoose

b) Tree Lizard

c) Hare

d) Common rat

e) Laughing Dove

f) Common Krait*

g) Indian squirrel

h) House Sparrow

i) Grazing mammals

Source: EDCM Ecology Survey, Nov 2022

** https://animalia.bio/common-krait*

6.7 Component 2 Local Environmental Setting

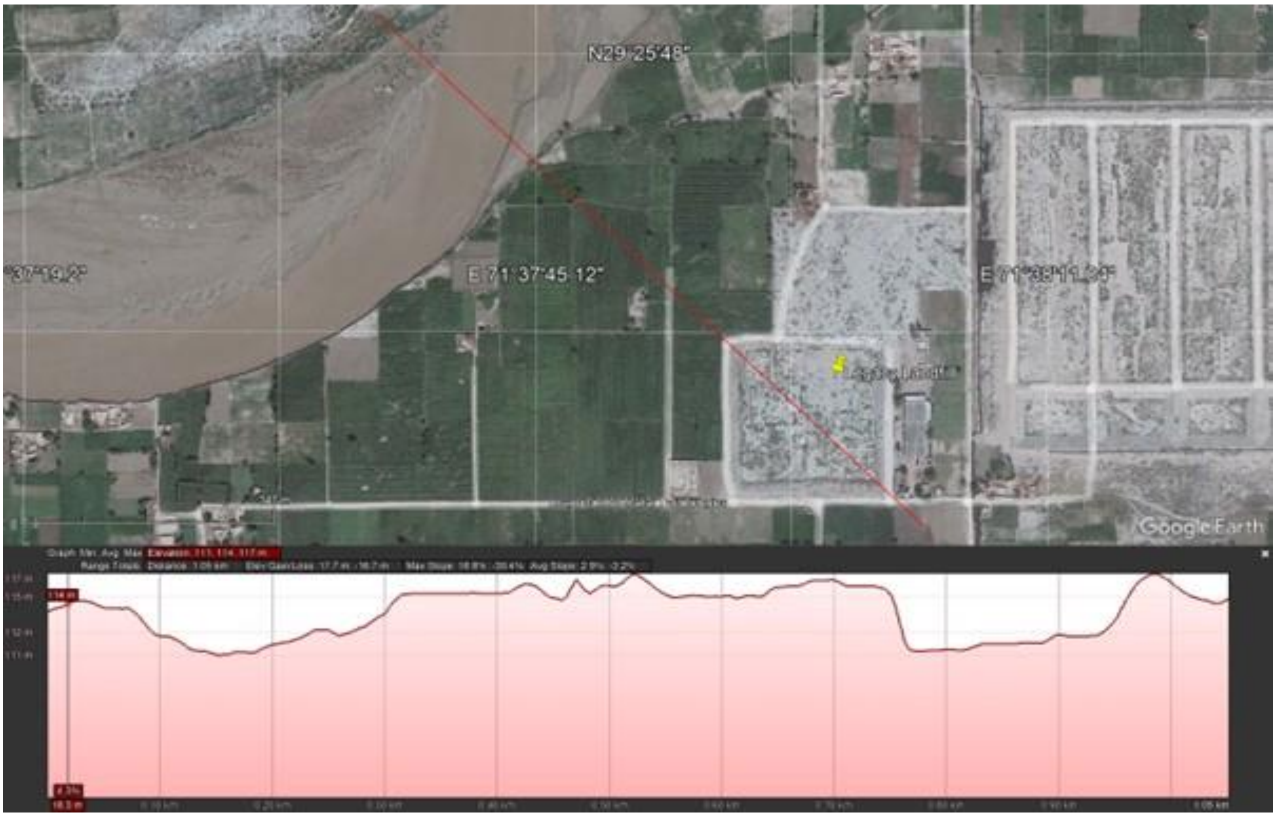
6.7.1 General

544. The legacy landfill site is located west of the township Sutej Valley, around 1km northwest of the outskirts of Bahawalpur city. Monitoring of this site was conducted in November and December of 2022, however, at a lesser extent of the new landfill site (Component 1). The description of various features of the project area environment including the physical, ecological, cultural, and socio-economic environmental aspects are presented in the following sub-sections.

6.7.2 Topography

545. Component 2 is located on the flood plain of the Sutlej River. As such, the local topography comprises generally flat terrain sloping very gently towards the north and east of the project site. The geographic setting and indicative cross section of the Component 2 Site is illustrated in **Figure 6-24**.

Figure 6-24: Geographic Setting of Project Component 2



6.7.3 Geology and Soil

546. The soil is formed by alluvial or alluvial deposits dominated by silt and large particles of sand. The surrounding of project site is fertile land suitable for agricultural activity while soil near canal comprises fertile alluvial tract.

Soil Analysis of Existing Legacy Landfill Site

547. Two soil samples were collected, one from the surface and the other from a depth of 3 feet of the existing dump site. These samples were placed in core boxes and analysed at EPA certified Integrated Environmental Lab. The soils were classified according to the Unified Soils Classification System (USCS), utilising field classification procedures outlined in ASTM D 2488.

548. Soil characteristics of the legacy landfill are shown in the table below. Soil analysis report is attached in **Appendix A-4** of the report.

Figure 6-25: Characteristics of Soil Sample Collected from the Surface

Sr. No.	Parameters		Results
1	Soil Texture	Sand %	23
		Silt%	41
		Clay %	36
		Texture Class	Sandy Clay Loam
2	pH		7.8
3	Electrical Conductivity EC (μSm^{-1})		236
4	Phosphorus ($mgkg^{-1}$)		3.5
5	Sodium Absorption Ratio		3.69
6	Oil & Grease ($mgkg^{-1}$)		0.67

Figure 6-26: Characteristics of Soil Sample Collected at 3 Feet Feet Depth

Sr. No.	Parameters		Results
1	Soil Texture	Sand %	15
		Silt%	46
		Clay %	39
		Texture Class	Sandy Clay Loam
2	pH		8.6
3	Electrical Conductivity EC (μSm^{-1})		231
4	Phosphorus ($mgkg^{-1}$)		3.2
5	Sodium Absorption Ratio		3.54
6	Oil & Grease ($mgkg^{-1}$)		1.03

Soil Analysis of Proposed MRF Site

549. A geotechnical investigation for the MRF area was carried out by the company Productive Engineers of Lahore in January 2023. During the investigation three (3) boreholes were drilled to a maximum depth of 16m using a percussive boring method (**Figure 6-27**.) Representative disturbed and undisturbed samples were collected from all boreholes and subjected to a range of field and laboratory testing.

Figure 6-27 Borehole Drilling and locations at the MRF Site

550. The investigation characterized the subsoil as greyish silty sand throughout. Field moisture content of the soil is in each borehole is summarised in **Table 6-34**

Table 6-34: Soil Moisture Content at MRF Boreholes

BH No.	Depth (m)	M.C %	BH No	Depth (m)	M.C %
1	0-1.8m	14.0%	2	2.1-4.0m	13.2%
1	1.8-5.5m	10.5%	2	4.0-5.5m	13.4%
1	5.5-10.7m	12.1%	2	5.5-8.5m	12.3%
1	10.7-16m	W.T=14.6m	2	8.5-13.1m	13.1%
1	Composite	12.9%	2	13.1-16m	W.T=13.7m
2	0-2.1m	11.7%	2	Composite	13.1%
3	0-3.9m	5.3%	3	10.4-12.5m	12.1%
3	3.9-6.7m	6.4%	3	12.5-16m	W.T=13.4
3	6.7-10.4m	9.8%	3	Composite	10.2%

6.7.4 Surface Water

551. Component 2 is located 500m east of the Sutlej River, and within it’s flood plain. The surface water of the area is characterized by widespread irrigation canals and ditches drawing water from the river. Flooding of the legacy site is a possibility due to its close approximately to the river and the type of soil found in the project area.

6.7.5 Groundwater

552. The main recharge source of groundwater where Component 2 lies, in addition to precipitation, is the river Sutlej.

553. Historical imagery suggests that the legacy landfill void can be subject to basal ingress of groundwater under conditions of high recharge from the river, as indicated in **Figure 6-28 and Figure 6-29**

Figure 6-28 Possible Groundwater Ingress into Legacy Landfill (October 2015)

Figure 6-29 Detail of Apparent Groundwater Ingress (October 2015)

554. Groundwater in the areas of the project is reported by local sources to be generally of good to marginal quality. Brackish water is present in the project area but in deep aquifers good to marginal quality water is also available. Ground water is also extracted for agriculture use.

555. Local wells in the Component 2 project zone were sampled and analysed by the Public Health Engineering Department Punjab District Water Testing Laboratory in April 2023. The sample locations are summarised **in Table 6-35**.

Table 6-35 Well Sample Locations for Component 2

Sample No	Description	Well Characteristics	Suitability for Drinking
1	Solid Waste Dumping Station Bahawalpur	Depth 80 feet, motor pump	Unfit
2	North side of the solid waste dumping station	Depth 120ft, hand pump	Unfit
3	North side of the solid waste dumping station	Depth 120ft, hand pump	Unfit
4	West side of the solid waste dumping station	Depth 150ft, hand pump	Unfit

556. No information was provided with respect to the depth to groundwater in the sampled wells and, in any case, it appears that the wells were in active use for abstraction so the standing water level would not reflect the natural water table in the area. The depth of the wells is substantial, but this may reflect the need for volumes of yield and variation in water quality rather than simply the depth to groundwater. The analytical results, **Table 6-36**, confirm that the groundwater in the area is unfit for human consumption.

Table 6-36 Groundwater Analyses in Component 2 Area

Parameters	Units	PEQS	WHO	Sample Number			
				1	2	3	4
Temperature	C			18	18	18	18
pH	--	6.5-8.5	6.5-8.5	7.97	8.38	8.14	8.02
Odor	--	Non Objectionable	Non Objectionable	Nitrate Smell	Smell	Smell	Smell
Color	TCU	<15	<15	Yellowish	Yellowish	Yellowish	Yellowish
Turbidity	NTU	<5	<5	1.77	0.87	0.99	1.25
Total Dissolved Solids (TDS)	mg/L	<1000	<1000	882	387	417	807
Calcium	mg/L	200	100	200	49	59	119
Magnesium	mg/L	150	50	9	19	13	13
Total Hardness	mg/L	<500	--	214	200	200	350
Alkalinity	mg/L			447	194	204	382
Chloride	mg/L	250	250	146	76	84	146
Iron	mg/L		1	4	2	4	4
Conductivity	µS/Cm^2			1765	774	835	1615
Arsenic	mg/L	<0.05	<0.01	0.01	0.05	0.1	0.05
Fluoride	mg/L	<1.5	1.5	3	3.8	2	0.86
Nitrate	mg/L	≤50	≤50	3.5	4	4	3
Nitrite	mg/L	≤3	≤3	3	3.6	2.8	2.6

557. These findings are broadly consistent with the regional finings for groundwater quality summarised in Section 6.2.7. As such, although the groundwater quality is poor, there is no clear indication that it is being specifically impacted by the Legacy Landfill.

558. As part of IEE baseline, one further groundwater sample was collected from the MRF on May 16, 2023 and analysed from EPA certified lab. The results of the tests are presented in **Table 6-37** and **Appendix A.4,** which indicates that all parameters of the ground water samples taken are within the applicable PEQS and WHO standards with no exceedances observed.

Table 6-37: Groundwater Water Quality Analysis Legacy Landfill Site

S No.	Parameters	Analysis Method	Units	PEQS	WHO	Ground Water Sample Legacy Landfill Site
1	pH	APHA-4500H+ B	--	6.5-8.5	6.5-8.5	7.8
2	Taste & Odour	In-house	--	Non-Objectionable	Non-Objectionable	Non-Objectionable
3	Colour	APHA-2120 B/C	TCU	<15	<15	8
4	Turbidity	APHA-2130 B	NTU	<5	<5	5
5	Total Coliform	APHA:9222 B	Number/100 mL	0 Number/100 mL	0 Number/100 mL	0
6	E-Coli	APHA:9222 D	Number/100 mL	0 Number/100 mL	0 Number/100 mL	0
7	Total Dissolved Solids (TDS)	APHA-2540 C	mg/L	<1000	<1000	384
8	Total Hardness	APHA-2340 C	mg/L	<500	--	129
9	Nitrate	APHA-4500NO3 B	mg/L	≤50	≤50	4.1
10	Nitrite	APHA-4500NO2 B	mg/L	≤3	≤3	0.24
11	Ammonia	APHA-4500-NH3-B	mg/L	---	---	N.D.
12	Arsenic	APHA-3500As B	mg/L	<0.05	<0.01	N.D.
13	Antimony	APHA-3500Sb B	mg/L	<0.005	<0.005	N.D.
14	Barium	APHA-3500Ba B	mg/L	0.7	0.7	N.D.
15	Chloride	APHA-4500Cl- B	mg/L	250	250	137
16	Fluoride	APHA-4500F- C	mg/L	<1.5	1.5	0.86

559. The detail of water table encountered in the three boreholes drilled on the MRF site for the Geotechnical Investigation in January 2023 is given in **Table 6-38**. The geotechnical report notes that the groundwater elevation may fluctuate seasonally. Given the low river flow conditions typically experienced over the winter, it is likely that the groundwater elevations recorded were towards the lower end of the possible range.

Table 6-38: Groundwater Depth at MRF January 2023

Borehole No	Depth to Water Table (m)
1	14.6m
2	13.7m
3	13.4m

6.7.6 Air Quality

560. Air Quality was not measured in Component 2's project site.

6.7.7 Land Use

561. Land use surrounding the existing landfill is agriculture with small housing clusters seen approximately 200m southeast, 350m north and approximately 400m south.

562. The land immediately to the East of the Component 1 Project area is occupied by an abandoned wastewater treatment plant facility. We understand that this facility was constructed at the same time as the Legacy Landfill void for the purposes of treatment of domestic wastes from the city. The facility was, however, never commissioned and has now been adopted for agricultural planting.

6.8 Component 3

Improvement of existing waste collection and transport system in Bahawalpur City.

563. Component 3 is focused on improving the existing waste collection and transportation system within Bahawalpur City. Given that the actions are contained within the city's boundaries and do not involve significant alterations to the natural environment, the potential for direct ecological impacts is notably limited.

564. Therefore, Component 3 is not anticipated to have significant repercussions on the surrounding ecology. Considering these considerations, an in-depth review of Component 3 is not deemed necessary as its nature and scope do not suggest substantial environmental consequences for the surrounding ecology.

7 Analysis of Alternatives

7.1 Overview

565. Project alternatives have been studied as a part of this IEE process. The environmental, economic, and social impacts of each alternative have been thoroughly examined. This chapter also provides an overview of the various commercially available technologies for the environmentally sustainable treatment and processing of waste that are successfully operating in developed countries and recommends the most appropriate set of options for Bahawalpur city in light of its waste generation and composition.

566. Project alternatives have been studied keeping in view number of parameters including waste quantum, physio-chemical properties of waste, suitability for mixed waste handling, land requirements, technical complexities, social acceptability, environmental and legal compliance, and OPEX & CAPEX requirements. The development of the proposed landfill is based on detailed feasibility assessments focusing on assessing the city requirements with regards to SWM and then determining the most suitable and effective technology and location for development of the required infrastructure.

567. This procedure of analysing different choices for landfill site development ensures that a well-informed decision is made regarding the selection of the most preferred option among the potential alternatives that are brought into consideration.

7.2 Alternative Types

568. Types of alternatives considered for detailed analysis for Bahawalpur SWM facility are given below:

- No Project Option
- Site Selection Alternatives
- Landfill Type Alternatives and Landfill Construction Alternatives
- Waste Disposal Alternatives
- Technological Alternatives for AD and MRF
- Scenario Analysis for all possible treatment options for Bahawalpur
- Economic Analysis
- Closure/Post Closure Plan

7.3 'No Project' Option

569. The current waste disposal system has been through controlled dumpsites. These dumpsites are often characterised by an area where garbage is simply transported, unloaded, and at times levelled by a bulldozer. Nearly all these sites operate with no protection against soil and groundwater contamination.

570. The situation is further exacerbated by operators' seldom attempt to control pungent smoke, objectionable odour and vermin. Sorting is only achieved through scavenging, which at times tolerated, with no checks in place for the health and safety. Such dumpsites are inexpensive operate, but pose serious damage to the land, water, air, aesthetics, and the health of the surrounding population. These dumpsites are also difficult to rehabilitate after they are filled and abandoned. Failure to implement

the project or a “No-Action alternative” will result to allocation of land only to be subjected to the existing practice.

571. Alternatives in this context will mean the establishment of the SLF at alternative sites or the project not pushing through. Although what is obvious is such alternatives shall not negate the disadvantages of allocating land for disposal purposes only to be subjected to the existing dumping practice.

572. On the other hand, if the project is implemented, it will result in improved SWM system services and improved urban environment quality. Furthermore, project implementation will also create job opportunities during construction, thereby improving the socioeconomic condition of the local people and help in improving their quality of life. Thus, the ‘no project’ option is not a viable option.

7.4 Site Selection Alternatives

573. There are many different, often inter-related, criteria that go into the selection of an appropriate site for a landfill. These include technical, environmental, geological-hydrogeological, operational, economic, social and political factors. Environmental Sensitivity (Hydrology, Climate, Fault/fractures, Soil/topography, flora/fauna, and agriculture/nature conservation) is one of criteria which plays critical role while making decision with respect to landfill site selection. Keeping in view this set of considerations, the sites initially considered were:

574. **Yazman** - located at Marot Yazman Road Bahawalpur next to the Malot Machinery Store. No nearby human settlements are located within 1000 metres of the project site. Total area of the site is 56 acres. **Figure 7-1** shows the location of Yazman landfill site.

- The landfill operation is a biological method of waste treatment. This process is very slow and may still be going on for 25 years after the landfill closes. The proposed site is found not adequate for the waste treatment till 25 years. The surroundings of the site are as follows:

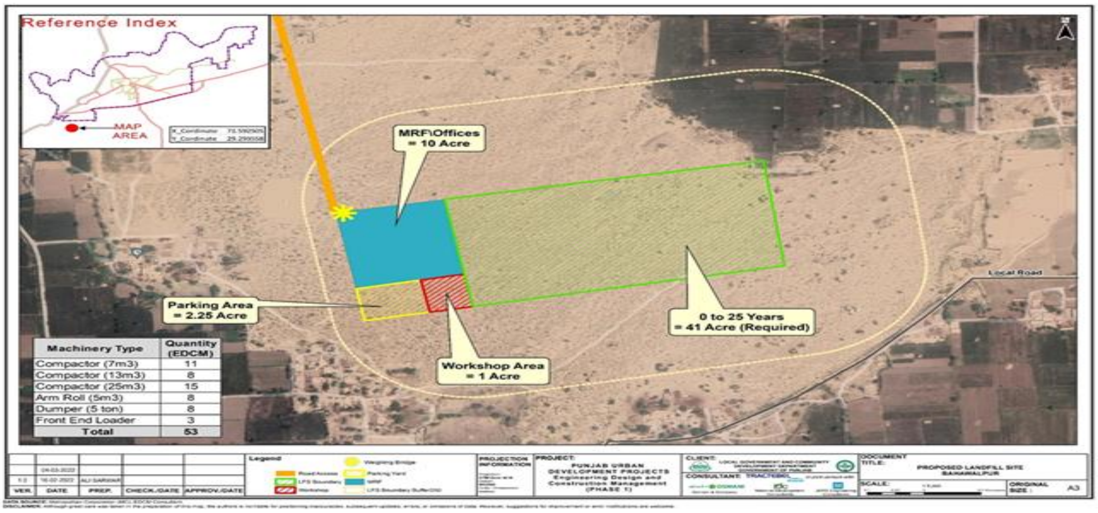
  East: Barren land, agricultural Fields and human settlements

  West: Barren land

  North: Barren land, agricultural Fields and human settlements

  South: Agricultural fields and human settlements

Figure 7-1: Yazman Landfill Site



575. **Khanu Wali**– The site is located at 0.5 km from the Sutlej River and the nearest human settlement is located within 350-400 metres radius from the project site. The proposed site area is adequate for 25 years of useable life. Location of Khanu Wali proposed landfill site is shown in **Figure 7-2.**

- Buffer zone also acts as barrier, absorber and to some extent as remedial measure against the fugitive emissions of pollutants emitted during handling of waste, storage, transportation and movements of traffics.
- Cell locations of the Khanu Wali landfill site does not meet the buffer zone requirement to ensure that potential effects of the landfilling operation may not any unacceptable impact outside the site. Also, the proposed site plan does not maintain the safe distance of nearby settlements from the waste processing facilities. The surroundings of the site are as follows:

East: Agricultural fields

West: Agricultural fields and Sutlej River

North: Agricultural fields and human settlements

South: Agricultural fields and human settlements

Figure 7-2: Khanu Wali

576. **Mari Sheikh Shijra** - located near Basti Yar Muhammad, mouza Nouabad Bahawalpur. Total area of the site is 110 acres. Proposed site is mostly surrounded by agricultural fields and located at a safe distance from the nearby human settlements. **Figure 7-3** shows the location map of Mari Sheikh Shijra landfill site.

- Cell locations of the proposed landfill site meet the buffer zone requirement to ensure that potential effects of the landfilling operation may not any unacceptable impact outside the site. The surroundings of the site are as follows:

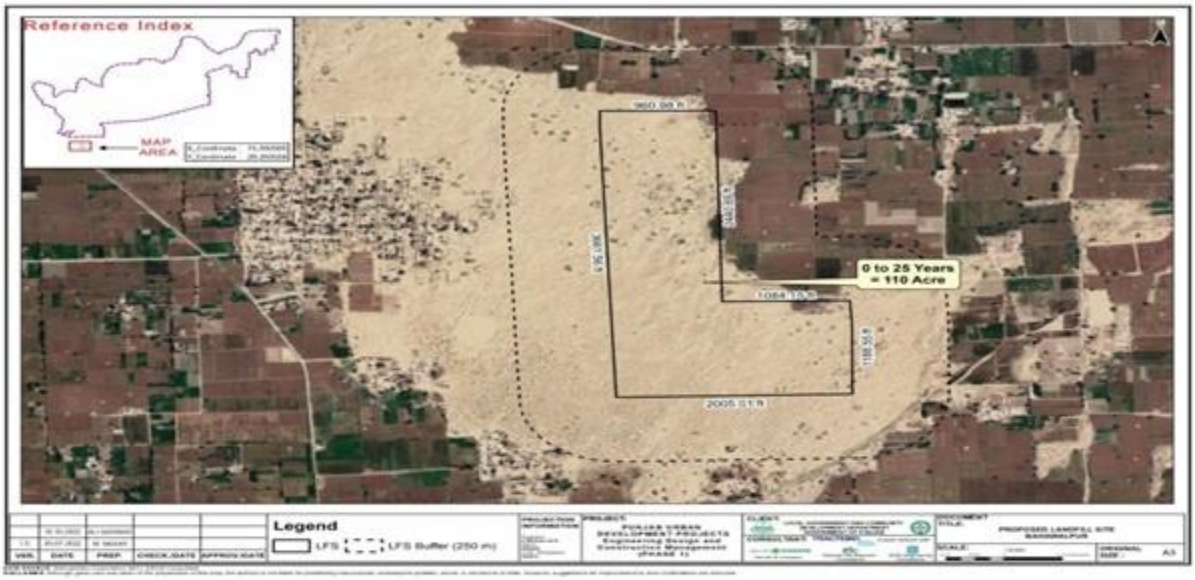
  East: Agricultural fields and human settlements

  West: Barren land, agricultural fields and human settlements

  North: Barren land and agricultural fields

  South: Barren land and agricultural fields

Figure 7-3: Mari Sheikh Shijra mouza Nouabad



577. These sites are collectively shown in the **Figure 7-4** below and the comparison of these different site alternatives is provided in **Table 7-1** below.

Figure 7-4: Location map of site alternatives

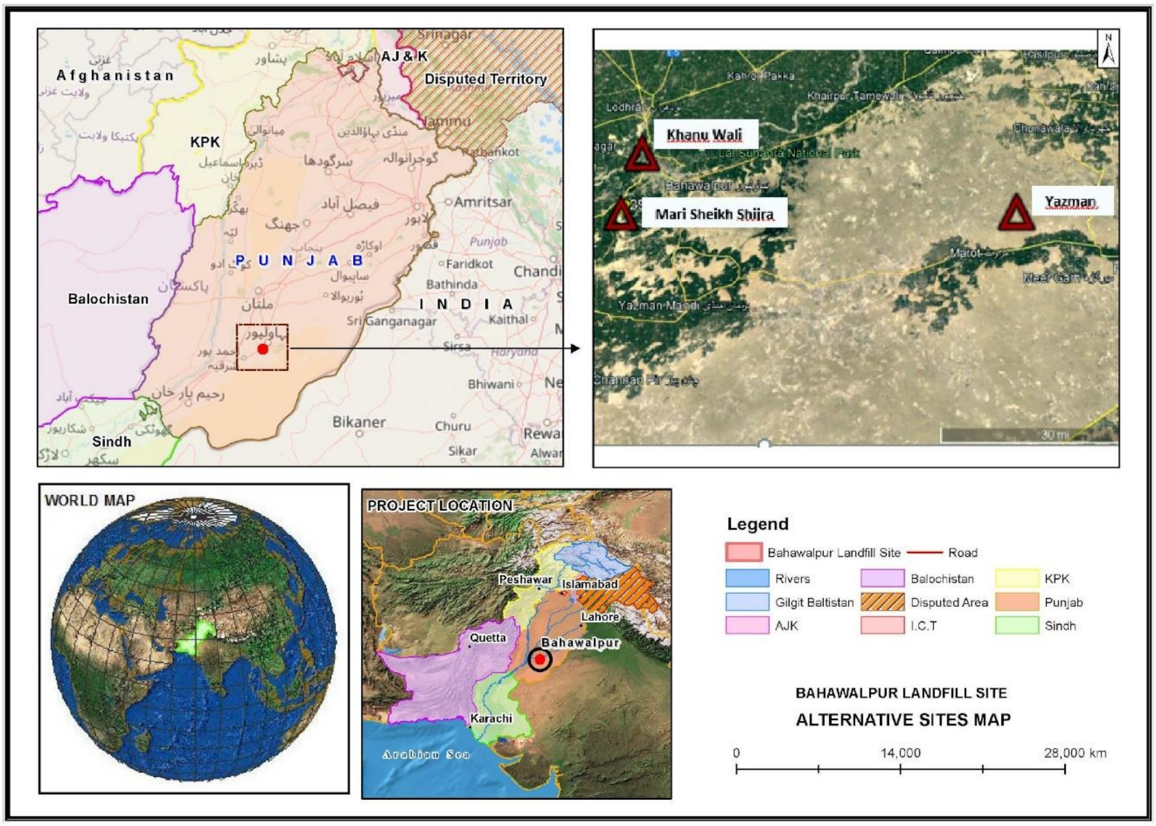


Table 7-1: Comparison of Site Alternatives

Parameters	Site Alternatives		
	Yazman	Khanu Wali	Mari Sheikh Shijra
Environmental Sensitivity	Very low due to less domestic, commercial and agricultural activity	Moderate to high as sparse agricultural activity in the outskirt of proposed site	Very low due to less domestic, and agricultural activity
Infrastructure	Accessible on Marot Yazman Road	Congested right of way for waste carrying transport	Accessible via main roads Mari Sheikh Sijra and Bhatti Dari Road
Site capacity	56 Acres will trigger the land acquisition and high social safeguard activities.	80 Acres	110 Acres
Land Acquisition	56 Acres owned by BWMC which is not sufficient for 25 years' period. Therefore, more	Existing dumpsite. Area already More land acquisition required and high social safeguard activities. Will	110 Acres area is sufficient already owned by BWMC. Hence no financial burden

Parameters	Site Alternatives		
	Yazman	**Khanu Wali**	**Mari Sheikh Shijra**
	land acquisition and high social safeguard activities will be required. This will cause additional financial burden to the total project	cause additional financial burden to the total project Could be problematic due to nearby agricultural and domestic activities	
Social Acceptability	Easily possible as present use of the location also deals with waste management	Not possible as the existing dumpsite is severely impacting agricultural activity	Easily possible due to safe distance from the nearby settlements and low agricultural, domestic and commercial activity
Distance from City Centre (km)	80	10	11

578. An alternative site at 13-solang at Yazman Road was also considered. This site was rejected based on some technical points related to the nearby locations of Bahawalpur airport in term of high chance of bird's strike with the flying aircrafts. The site area of 56 Acres is not adequate for the waste treatment till 25 years and more land acquisition will be required which will create financial burden to the project. Another reason of rejection was a clear more than three times distance of the alternative site which will entail comparatively huge cost of fuel and vehicles maintenance.

579. The site at Khanu Wali was immediately eliminated primarily due to its proximity to the city. The location lies very much within the urban built-up area. One option which this site provides is the setting up of a TS, a point of convergence for waste originating from various parts of the city, possibly coupled with a MRF and/or AD plant The site of Khanu wali is vacant but is in quite close to nearby settlements and agricultural fields. The site is also close to the city centre and its adverse impacts on the population will be comparatively greater than Yazman Landfill Site.

580. The site at Mari Sheikh Shijra fulfilled most of the criteria listed above. It is far enough away from the city. The population is sparse and although there are a few sensitive receptors, proper environmental assessments are being carried and resettlement plans are being prepared to minimize both environmental and socioeconomic impacts. Most of the surrounding area is barren and agricultural. Given the locations of other alternative sites, all were either agricultural or semi-urban areas, which at least places this site as the most ideal among the rest.

581. No land acquisition is required as land area of 110 acres is already owned by BWMC, and cell locations meet the buffer zone requirements which ensures that potential effects of the landfilling operation may not cause any unacceptable impact

outside the site. The social acceptability of the project is enhanced by educating the nearby population on the merits of a sanitary landfill.

582. The climatic and hydrological factors will have to be addressed by a sound technical plan, particularly during the operation phase where environmental monitoring.

7.5 Landfill Type Alternatives

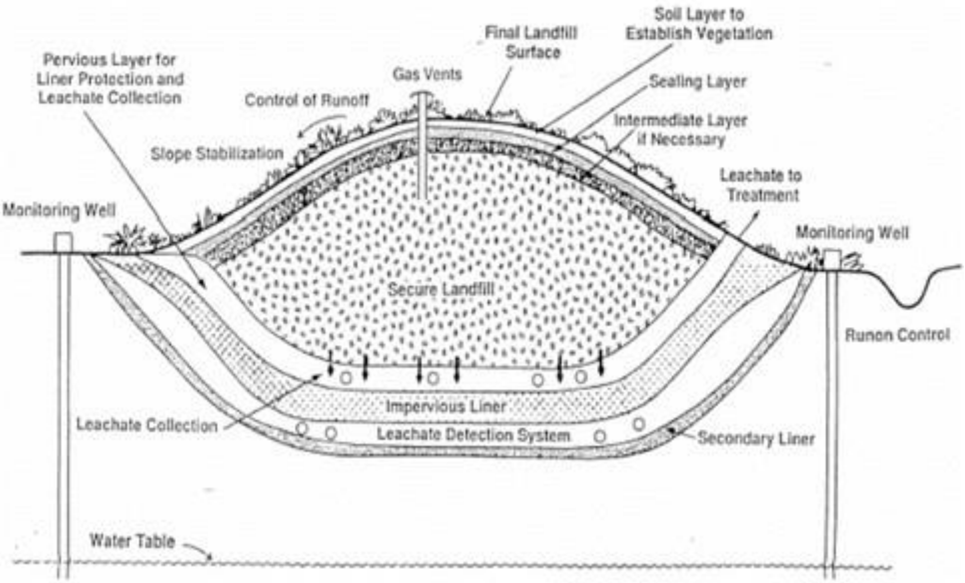
583. Landfills are vital components of any well designed MSW management system. They are ultimate repositories of a city's MSW after all other MSW management options have been exercised. In many cases, landfill is the only MSW management options available after the MSW is collected. The safe and effective operation of landfill depends on sound planning, administration, and management of the entire MSW management system.

584. There are three types of landfills viz, Sanitary landfill, Bioreactor landfill, Secured landfill (for inert waste). Various types of landfills are designed and constructed worldwide to manage MSW like sanitary landfill, bio-reactor landfill and secured landfill. The safe and effective operation of landfill depends on sound planning, administration, and management of the entire MSW management system and selection of appropriate landfill type.

7.5.1 Sanitary Landfill

Sanitary landfill is the process of dumping of solid waste in a scientifically designed land area spreading waste in thin layers, compacting to the smallest volume and covering with soil on daily basis. Sanitary landfill would be good option for disposal of existing/mixed waste which cannot be segregated. Landfill gas such as methane from the anaerobic conditions prevailing in the landfill due to the presence of organic material in mixed waste can be recovered. The facilities at the sanitary landfill include leachate collection and treatment system, storm water management system avoiding ground and surface water pollution. Since the project will be developed under a Design Build Operate (DBO) Contract, thus the exact equipment specifications are not available at present. However, a 'Typical' cross section of an engineered landfill is provided in the Figure below.

Figure 7-5: Typical Cross Section of an Engineering Landfill



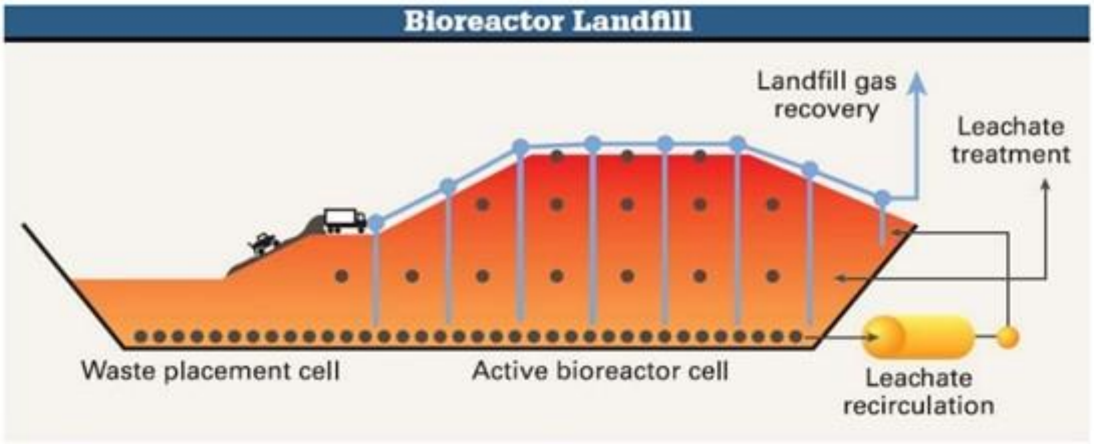
7.5.2 Bioreactor Landfill

585. Bioreactor landfill is one idea that has gained significant attention now days. This landfill uses enhanced microbiological processes to transform and stabilize the readily and moderately decomposable organic waste constituents within 5 to 10 years of bioreactor process implementation. The bioreactor landfill significantly increases the extent of organic waste decomposition, conversion rates and process effectiveness over what would otherwise occur within the landfill. The "bioreactor landfill" provides control and process optimization, primarily through the addition of leachate or other liquid amendments, the addition of sewage sludge or other amendments, temperature control, and nutrient supplementation. Beyond that, sanitary landfill operation may involve the addition of air. Based on waste biodegradation mechanisms, different kinds of "bioreactor landfills" including anaerobic, aerobic, and aerobic-anaerobic (hybrid) bioreactors have been constructed and operated.

586. The bioreactor landfill significantly increases the extent of organic waste decomposition, conversion rates and process effectiveness over what would otherwise occur within the landfill. Stabilization means that the environmental performance measurement parameters (landfill gas composition and generation rate and leachate constituent concentrations) remain at steady levels, and should not increase, in the event of any partial containment system failures beyond five (5) to ten (10) years of bioreactor process implementation.

587. The bioreactor landfill requires certain specific management activities and operational modifications to enhance microbial decomposition processes. The single most important and cost-effective method is liquid addition and management. Other strategies, including waste shredding, pH adjustment, nutrient addition, waste pre-disposal and post-disposal conditioning, and temperature management, may also serve to optimise the bioreactor process. Successful implementation also requires the development and implementation of focused operational and development plans. The schematic of a bioreactor landfill is show below.

Figure 7-6: Schematic of a Bioreactor Landfill



588. Through a Bioreactor Landfill As an alternative to conventional (“dry tomb”) landfills, bioreactor landfills are designed to promote the rapid decomposition of the organic portion. This is accomplished by maintaining optimal moisture conditions at or near field capacity (approximately 34% to 65 %). At a minimum, leachate is injected into the landfill to stimulate naturally occurring micro-organisms that can be either aerobic (with oxygen) or anaerobic (without oxygen). However, bioreactor landfills often need other liquids such as storm water, wastewater, and wastewater treatment plant sludges to supplement leachate for maintenance of optimal moisture levels. Liquids are added to the landfill through vertical wells, horizontal pipes, or trenches. The primary purpose of a bioreactor landfill is to accelerate decomposition of the organic fraction to less than ten (10) years (that is, rather than thirty (30) or more years). Another aim is that through the bioreactor technology (physical, chemical and biological process control with adequate leachate management) to recover energy within the waste in the form of landfill gas and, possibly, residues as manure. There are three basic configurations of a bioreactor landfill:

- Aerobic – leachate is collected from the bottom layer of the bioreactor landfill, stored in tanks and then re-circulated in the landfill body in a controlled manner. By using vertical or horizontal wells, air is injected into the waste to help aerobic activity and to accelerate waste stabilization. The degradation of waste occurs under conditions like compost operations. The by-products of aerobic degradation are carbon dioxide (CO_2) and water (H_2O);

- Anaerobic – some moisture is added to the waste (either re-circulated leachate or from other sources) to obtain an optimal moisture level in the landfill. Waste biodegradation will take place in the absence of oxygen (anaerobic process) and will produce landfill gas (LFG). Without air, methanogenic bacteria are promoted to accelerate waste degradation. Landfill gas is a composition of methane (CH_4) and carbon dioxide (CO_2) and can be extracted from the landfill body to minimise greenhouse gas emissions and to transform it to energy; and

- Hybrid (Aerobic – Anaerobic) – this bioreactor type accelerates waste biodegradation by employing a sequential aerobic-anaerobic treatment to achieve a rapid degradation of organic matter in the upper sections of the landfill and the collection of landfill gas from lower sections. Operation of a hybrid bioreactor results in an earlier production of landfill gas compared to aerobic bioreactor landfills.

7.5.3 Secured Landfill

589. Secured landfill is a carefully engineered depression in the ground (or built on top of the ground) into which wastes are dumped to avoid pollution to the surrounding environment. Secured MSW landfill should be restricted to non-biodegradable, inert waste and other waste not suitable for recycling or for biological processing. The important features that should be considered before designing a landfill are given in Schedule III - “Specifications for Landfill sites” of MSW rules 2000. These include:

- Site Selection
- Facilities at the site
- Specifications for land filling
- Pollution prevention
- Water quality monitoring
- Plantation at landfill site
- Closure of landfill site and post care
- Special provisions for hilly areas

590. Based on above information, the project design consultant suggested to construct a sanitary landfill for Bahawalpur as it is relatively low in cost and requires less technical and operational maintenance as compared to other options.

7.6 Landfill Construction Alternatives

7.6.1 Lining

591. The liner system's goal is to prevent migration of leachate from landfill and prevent contamination of groundwater and soil beneath the landfill. Leachate collecting facilities serve the following purposes: controlling and reducing leachate heads within the landfill; protecting the liner system; and removing leachate contained within the landfill by the liner system for treatment and disposal. The drainage layer is made up of granular soil with the right amount of permeability. Also, appropriate thickness of geomembrane and compacted clay layer is essential to safeguard the soil and water.

592. The alternative of concrete lining is not as favourable as the HDPE (high density polyethylene) geo-membrane due to its higher erosion factor, indirectly amounting to a higher maintenance cost and greater harm to the environment.

7.6.2 Leachate Collection and Treatment

593. The best option is to reapply the daily leachate to the surface of the solid waste dumped at the landfill. This is a cost-effective and environmentally friendly method of handling leachate. If the volume of leachate produced exceeds the spraying capacity, leachate treatment will be required.

594. The alternatives regarding leachate management itself are:

- Discharge to lined drains
- Discharge to wastewater treatment system

- Recirculation
- Evaporation of leachate
- Treatment of leachate

595. There are various benefits and drawbacks to each option being researched and tested, including one in which recirculation acts as a catalyst for increased gas production (Kumar et al. 2011) to aid in energy recovery.

596. A combination of leachate management options, including leachate spraying and leachate treatment, has been chosen for Bahawalpur. Leachate will be primarily used for waste spraying, with the remainder collected and sent to preliminary treatment in three stage open ponds and AD Plant for final treatment.

597. By integrating additional technology in the form of remote monitoring equipment into the leachate management system and the gas management system, it is possible to reduce the need for round-the-clock security to only being necessary in emergency situations. Remote sensors can be installed on pumps and storage tanks to transmit real-time data and alerts to an online system.

598. The use of control technologies within these systems will allow facility operators and supervisors to be able to remotely address routine or emergency issues, whenever notified, without physically being present at the site.

7.6.3 Gas collection and Treatment

599. Landfill gas can migrate laterally and potentially cause explosions. Landfills are therefore provided with gas collection and processing facilities. The rate of gas production varies depending on the operating procedure. The rate and quantity of gas generation with time, is difficult to predict. Typical generation rates reported in literature vary from 1.0 to 8.0 litres/kg/year. Gas production rates of 60 m3 per hour have been reported from landfill sites in India having an area of 8 hectares and a depth of 5 to 8 m (Dutta et al. 2012). The decision to use horizontal or vertical gas recovery wells depends on the design and capacity of the landfill. The decision to flare or to recover energy from the landfill gas is determined by the capacity of the landfill site and the opportunity to sell power produced.

600. Gas outputs of 10 to 20 m^3 per hour (corresponding to 50 to 100 KW of energy) have been recorded in wells of 15 to 20 cm diameter drilled 10 m into waste at spacing of 30 to 70 m. For 1 MW output from a landfill site, 15 to 20 such wells are required.

601. Alternative plans for gas management can be one of the following:

- Uncontrolled release
- Controlled passive venting
- Controlled collection and treatment/reuse.

602. Controlled passive venting is proposed for the first years of landfill operation in Bahawalpur, followed by flaring for landfill gas management. Initially a 1000 m^3 flaring system is proposed in the project plan.

603. The organic waste will be used as a resource in sanitary landfill to maximise and regulate the landfill gas recovery system and conversion of methane component of the gas into CNG. The conversion of organic waste into LFG and Methane

component conversion will generate a high revenue and contribute to the substantially of the project.

604. The organic waste will be beneficially utilised when it is deposited in the bio reactor landfill where it will generate regular and increased quantity of landfill gas which will contain 55-60 percent of Methane. The methane can be converted into electricity or CNG. The CNG option is a much better option as the electricity tariff for green energy is very low in Pakistan and the CNG rates are quite high.

7.7 Technological Alternatives for Anaerobic Digestion System (AD Plant)

605. The AD Plant is controlled biological conversion and treatment of organic material by bacteria and other microbes in the absence of oxygen. Oxygen is toxic to anaerobic bacteria and other micro-organisms (anaerobes). The AD process produces biogas (about 50-60% methane or natural gas, 40-45% carbon dioxide and traces of other gases), liquid effluent and a solid, partially stabilized organic material known as digestate which is generally sent for further aerobic composting to yield a stabilized product (compost).

606. Many AD plant designs are available in the marketplace. AD plant vendors/EPC contractors will choose between:

- Wet or dry AD
- Single or two stage ADS
- Thermophilic or mesophilic AD
- Continuous, plug flow or batch AD.

607. The design decisions would need to be combined with pre-treatment decisions to create an overall AD design which would best meets the needs of the Bahawalpur landfill depending upon the waste characterization. The project design consultant advised not to prescribe or limit the design options at the pre-feasibility stage of the assessment. AD vendors/EPC contractors may provide customized approaches to AD and pre-treatment options.

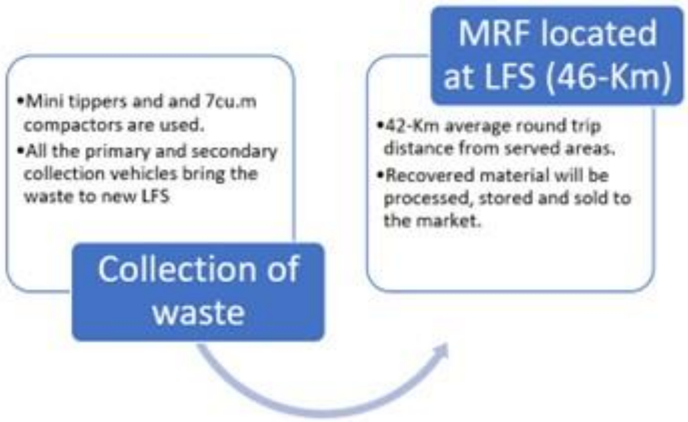
7.8 Location Alternatives of MRF

608. At the start of project feasibility, MRF was proposed to be installed at New LFS which is located away from the city at 46 km (round trip). Bases on cost benefit analysis of MRF at existing dump site vs. MRF at New LFS carried out at the time of feasibility study and keeping in view the inflation and increased fuel prices, this option is resulting in higher cost and increased financial burdens on the project. Further waste transport in small vehicles directly to landfill will result in increased emissions, waste littering and other public/road safety risks therefore in the updated FS installation of MRF at existing dump site which is near to the city is proposed.

609. The following options are considered with respect to location alternatives of the MRF:

Option - A: No material recovery system is installed, and all collected waste is directly transferred to LFS.

Option - B: Material recovery facility is installed at new LFS.



Option - C: A material recovery facility is installed at current dumpsite

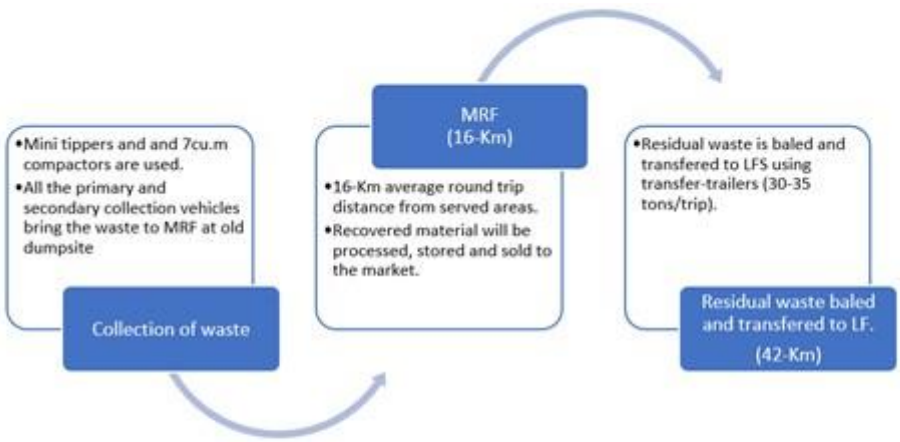


Table 7-2: Comparison of MRF Location Options

Comparison	Option A	Option B	Option C
Amount of waste being deposited at LFS (Assuming design horizon until 2050) (landfill life starting from 2028 till 2050, 22 years)	100% waste deposited at the LFS Reducing the life of LFS by 6-7 Years	84-86%	84-86%
Revenue from Recovery of recyclables.	NA	Treated, recovered recyclables are sold to the	Treated, recovered recyclables are sold to the

Comparison	Option A	Option B	Option C
		recycling industry, the revenue generated will add to sustainability of the project	recycling industry, the revenue generated will add to sustainability of the project
Transportation	Transportation of waste to LFS will be less efficient as lose waste will need to be transferred to New LFS which has an average distance of 46 Kms from served UCs	Transportation of waste to the will be less efficient as lose waste will need to be transferred to New LFS which has an average distance of 46 Kms from served UCs	Transportation of waste to MRF will be more efficient as lose waste will need to be transferred at an average distance of only 8 Kms from UCs

610. If MRF is situated at a reasonable distance from the city, it will reduce the transportation distance, time and cost required to collect and deliver generated waste. This can result in cost savings and energy efficiency by minimizing fuel consumption and emissions associated with long-distance transportation hence option-3 is considered most suitable.

7.9 Technological Alternatives for Material Recovery Facility (MRF)

611. Having already discussed their site selection criteria above, the analysis of technological specifications within MRF or composting facilities within the ISWMS will also determine how effectively they operate from both a financial as well an environmental point of view. The facilities for the proposed landfill can range from labour-intensive, lower initial costs but lower efficiencies, to machine-intensive, higher initial costs but greater efficiencies. Some technological alternatives that can be considered for a MRF are discussed below.

Automated Sorting Systems:

- Implement advanced sensor-based sorting technologies that use infrared sensors, optical scanners, and AI algorithms to automatically identify and separate different types of recyclable materials.

Advanced Optical Sorting:

- Utilize optical sorting equipment with high-resolution cameras to precisely identify and separate materials based on color, shape, and other characteristics.

Eddy Current Separators:

- Deploy eddy current separators to separate non-ferrous metals from other materials using electromagnetic induction.

Magnetic Separators:

- Employ magnetic separators to extract ferrous metals from the waste stream, contributing to more efficient material separation.

Air Classification Systems:

- Incorporate air classifiers that use air streams to segregate lighter materials from heavier ones, enabling effective separation of mixed materials.

Density Separation Technology:

- Utilize density separators that rely on differences in material densities to separate materials such as plastics and metals.

Screening and Trommels:

- Integrate rotating screens and trommels to classify and sort materials based on size, facilitating the segregation of larger items from smaller ones.

Waste-to-Energy Conversion:

- Consider technologies that convert non-recyclable waste into energy through incineration or gasification, contributing to waste reduction and energy generation.

Modular and Scalable Designs:

- Design the MRF with modular components that can be easily upgraded or expanded to accommodate changing waste streams and processing needs.

Waste Minimisation Technologies:

- Integrate technologies that focus on waste minimisation at the source, such as compaction systems that reduce the volume of waste before processing. Waste Disposal Alternatives

612. There are various technical methods for intermediate municipal waste treatment. However, some of them are only suitable for small-scale systems, while others are technically sophisticated. Considering the waste characteristics, the amount of waste for treatment, and the technologies that are practical for developing countries, the following technical options, including composting, MRF, and waste to energy (incineration & RDF), were selected for further investigation as potential intermediate treatment facilities for Bahawalpur, Punjab.

7.9.1 Waste as a Fuel

613. Waste collection is typically the most expensive aspect of solid waste management in cities and municipalities. As a result, municipal leaders are very interested in Waste to Energy (WtE) options to potentially (and partially) cover waste collection costs. Utilities typically view their solid waste as a resource that can be used to attract private-sector investment for waste-to-energy projects under the right institutional and financial conditions. However, caution should be exercised when applying off-the-shelf solutions to projects—each project should be evaluated on its own merits. These solutions should be sized to accommodate non-recyclable, non-recoverable, and non-upcyclable materials, as well as any landfill mining that may occur during the project's life cycle. It should not be assumed that all municipal waste can be used for waste to energy projects. The viability of any MSW incineration facility depends highly, and most importantly, on the quantity and calorific value of the waste. The economic state of the country/area is highly correlated to the calorific value of the waste. Following is waste to energy conversion techniques applicable to the waste available in Bahawalpur, Punjab:

Table 7-3: Conversion Techniques to utilise waste as fuel

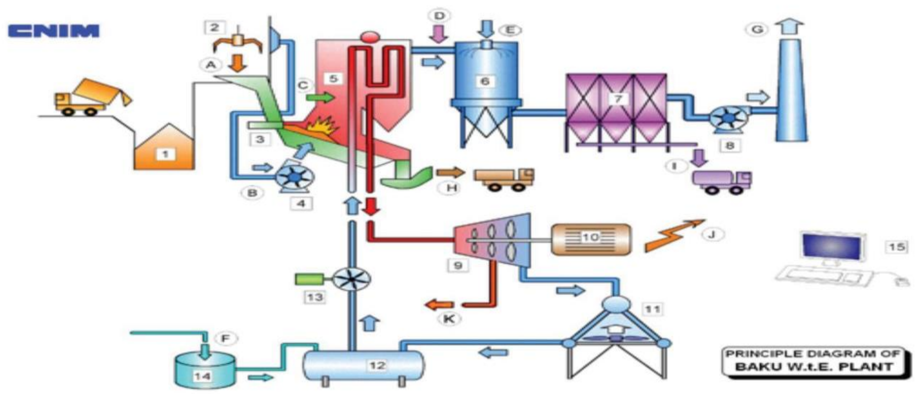
Item	Technology	Output
Thermal	Combustion	Heat, Electricity, Bottom Ash and Fly Ash
Mechanical-thermal	Mechanical Biological Treatment	Biogas, Electricity, RDF, compost like material
	Landfill gas capture	Biogas, heat, electricity,
Thermo-chemical	Gasification	Syn Gas, Bottom Ash
	Pyrolysis	Syngas, char, oil

7.9.2 Municipal Solid Waste Incineration/ Mass Burning Option:

614. Incineration is a process of controlled combustion for burning of waste and residue containing combustible material. The emissions from incineration of solid waste are of health concern, and the waste for incineration should be free from chlorinated plastics, hence this process is not proposed in the proposed project.

615. Direct combustion is the oldest technology for biomass conversion, especially for generating heat and steam. The combustion technologies to convert MSW to heat and electricity use similar processes if using fossil fuels. The MSW is burned in a boiler to produce high-pressure steam that flows through a series of turbine blades, causing the turbine to rotate. The turbine is connected to an electric generator that produces electricity. Dumping grate-type boilers are the preferred choice for MSW.

Figure 7-7: Principal Diagram for Waste to Energy Plant



Legend: EQUIPMENT: 1- Waste bunker, 2- Traveling crane and grab, 3- CNIM/MARTIN GmbH combustion grate, 4- Combustion air supply, 5- CNIM recovery boiler, 6- LAB Semi-dry type reactor, 7- Fabric filter, 8- Induced draft fan, 9- Steam turbine, 10-Alternator, 11-Air cooled condenser, 12-Deaerator and feed water tank, 13- Feed water pumps, 14- Feed water treatment and demineralized water tank, 15-Operation and control unit in control room.

INPUT: A- Waste; B- Air, C- Urea solution, D- Activated carbon, E- Lime slurry, F- Raw water.

OUTPUT: G-Clean flue gas, H- Coarse ash (clinker) to storage and maturation area, I- Fly ash and flue gas treatment by-products, J- Electricity, K- Steam to district heating network (future possibility).

Source: Constructions Industrielles de la Méditerranée (CNIM) Group.

- Mass burning aims to reduce MSW volume and mass and make it chemically inert in a combustion process without the need for additional fuel (autothermic combustion). There are always about 25% residues from incineration in slag (bottom ash) and fly ash. Bottom ash is made up of fine particulates that fall to the bottom of the incinerator during combustion, whilst fly ash refers to fine particulates in exhaust gases that must be removed in flue gas treatment. These residues need further attention and a secure place for final disposal in the case of hazardous fly ash. Incinerate the waste and convert the heat derived from the process to generate electricity. The energy recovered from incineration produces power and/or steam, depending on local infrastructure and needs. One ton of waste can be converted to approximately 2 MWh of heat and 2/3 MWh of electricity for combined heat and power plants.

- The energy content of Bahawalpur can be seen in **Table 7-4**. In general, the average (year- wide) and recommended lower calorific value of waste should be at least 7 MJ/kg or 1671 kcal/kg and must never fall below 6 MJ/kg or 1433 kcal/kg. Without this value, there would be a need to constantly supply auxiliary fuel, which would decrease the viability of an MSW incineration facility.
- The average energy content of Bahawalpur meets the minimum energy requirement. According to GIZ guidelines for Waste to Energy, the plant capacity should be preferably higher than 100,000 tons per year to achieve optimal economies of scale together with average collection distances (GIZ, 2017). Presently, Bahawalpur is generating 176,295 tons of solid waste per year, which fulfils GIZ criteria for waste to energy.

Table 7-4: Energy content of Bahawalpur

Waste Source		High-Income Area (kcal/kg)	Middle Income Area (kcal/kg)	Low Income Area (kcal/kg)	Average (kcal/kg)	Average (Collective)
Gross Calorific Value	Day 1	5300	4800	2302	4134	**4360.85**
	Day 2	5503	4660	3600	4588	
Net Calorific Value[34]	Day 1	4657.02	4081.15	1686.46	3474.88	**3708.39**
	Day 2	4868.2	3983.14	2974.42	3941.9	
Calorific Content		**Meets Requirement**				

Source: WACS Report,2022

7.9.3 Refuse Derived Fuel (RDF) via Mechanical Biological Treatment Option:

616. Pellets are formed from the combustible portion of MSW. Pelletization initially involves segregation of waste into high and low calorific value materials and then shredded and compacted into pellets with the required bulk density and later can be dried to get the appropriate heat value. These pellets so produced have a calorific value of 4000 Kcal/kg of the product which is quite close to that of coal and therefore is a good substitute for coal, wood, etc. to RDF plant. Comparatively, pellets have advantages over coal and are clean, energy efficient, eco-friendly fuel for coal-based industries, power generating industries. Additional advantage of Pellets is easy storage and transportation.

617. RDF consists largely of combustible components of municipal waste, such as plastics and biodegradable waste. Co-processing of RDF in cement plants has also become a widespread waste management system in several developing and emerging countries.

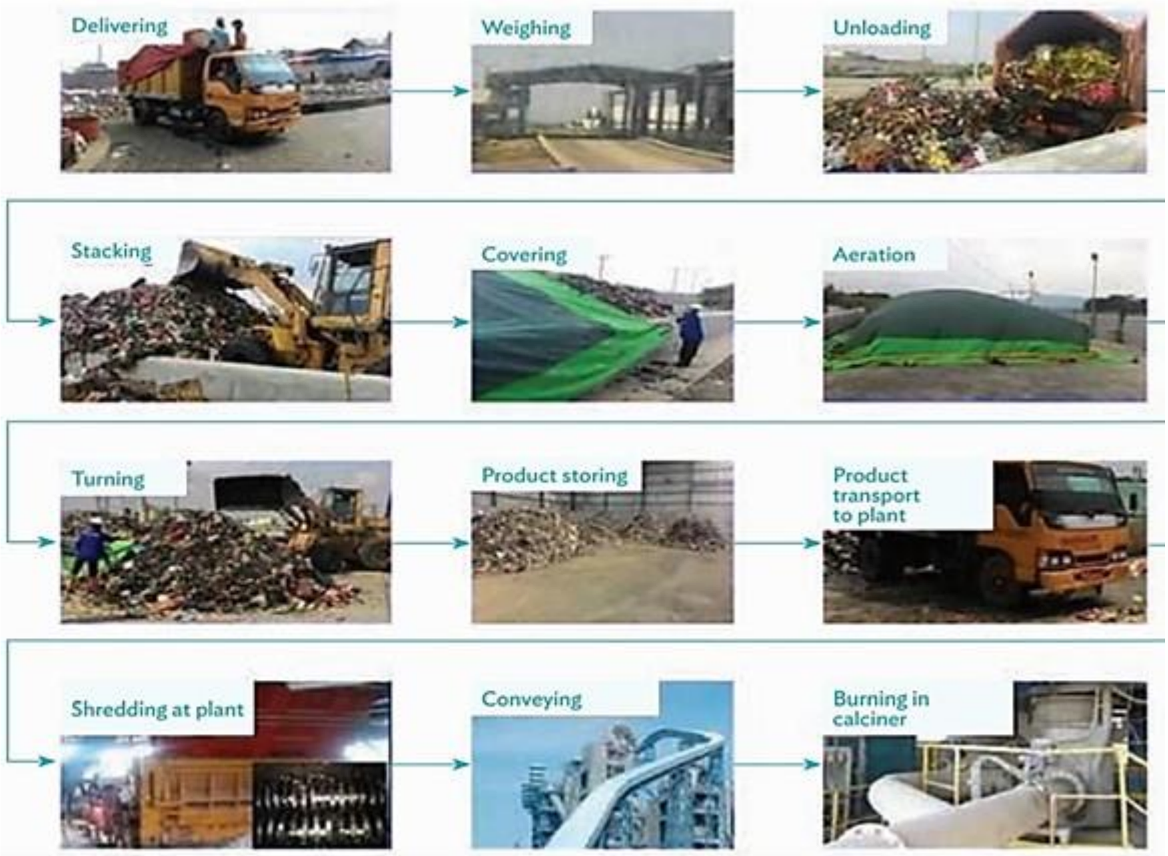
618. Mechanical biological treatment (MBT)[23] involves the combination of various processes such as mechanical (e.g., sorting, shredding, milling, separating, or

[23] F. Fe, Z. Wen, and S. Huang. 2018. Mechanical Biological Treatment of Municipal Solid Waste: Energy Efficiency, Environmental Impact and Economic Feasibility Analysis. https://doi.org/10.1016/j.jclepro.2018.01.060

screening) and biological components (drying, composting, or AD) to create solid recovered fuel or RDF and divert organic materials for fertilizer and energy. This fuel can be further processed as pellets or briquettes and can be used as feedstock in energy facilities as a replacement for fossil fuels. MBT consists of different treatment processes and has four types of outputs:

1. RDF – has a high calorific value due to its high paper and plastic content.
2. Stabilised organic waste – produced from the biological treatment of the organic portion of the waste.
3. Ferrous and non-ferrous metals – for potential recycling.
4. Inert wastes – scraps/residues that are disposed of in landfills.

Figure 7-8: RDF Via Mechanical biological treatment



619. For RDF to be successful, a high percentage of the waste streams needs to have a high calorific value. According to GIZ Waste-to-Energy Options in Municipal Solid Waste Management, the minimum pre-sorted waste required is 50,000 tons per year. Presently, Bahawalpur City generates a minimum of 176,295 tons of pre-sorted per year. Furthermore, GIZ calculates the net operating cost of using RDF to treat waste in developing countries as 19-40 Euro per ton.

620. Refuse Derived Fuel is suitable for Bahawalpur, Punjab, due to its high waste quantity. MSW of Bahawalpur has 24% material that can be used for RDF production. This option is not being explored due to its limited market potential for practical application.

7.9.4 Composting Option for Bahawalpur:

621. Composting is an organic method of producing compost manure by decomposition and stabilization of organic matter. Composting process is commonly used method and results in the production of stable compost product reduced in size (when compared to initial size) and free from offensive odours. Compost is particularly useful as organic manure which contains plant nutrients (nitrogen, phosphorous and potassium) as well as micronutrients which can be utilized for the growth of plants. Composting can be carried out in two ways - aerobically (with the presence of oxygen) or anaerobically (without the presence of oxygen) or vermin composting or by any other biological mechanism.

622. High moisture content suggests the applicability of wet treatment options, including composting and AD, which are more feasible options for the segregated organic stream of municipal waste. This could prove to be a feasible option because, during waste generation, a high amount of organic waste (more than 50%) with high moisture content (41.83%) was obtained that could be incorporated into compost successfully with the high percentage of biodegradable waste, at 52.69% of municipal waste in Bahawalpur, composting will be the most practical means for intermediate treatment.

623. Carbon and Nitrogen are of utmost importance for compost values as their correct ratio favours waste to be used as a fertilizer. The present study's average calculated C/N value of household waste is 16.81%, which is within the recommended range. GIZ guidelines indicate that a Carbon Nitrogen Ratio should be in the range of 16-25. High C/N ratios can lead to prolonged composting duration. The C/N ratio can be regulated by selecting the most suitable combination of compost materials and adding bulking agents to ensure a final ratio within the optimum range.

624. The composting plant is designed to handle 5 tons per day (tpd) of source-segregated waste, while the AD plant will manage an additional 25 tpd of waste. About 35 tpd source segregated waste contains organic matter (Cow dung & fruit waste) out of which 25 tpd will be diverted to AD plant while remaining 10 tpd will be directly landfilled. Similarly out of 29 tpd organic waste (green/wood waste) 5 tpd will be sent to compost plant while remaining 24 tpd will be directly landfilled. The feasibility of implementing 5-10% composting is applicable solely to source-segregated organic waste. Mixed organic waste will be disposed of directly in the landfill without undergoing composting**. Table 7-5** below shows the chemical characterisation of waste in Bahawalpur.

Table 7-5: Chemical characterization based composting potential of waste components in Bahawalpur, Punjab

City	Moisture (%)	Carbon (%)	Carbon/ Nitrogen
Bahawalpur, Punjab	41.83	26.50	16.81

Source: WACS Report,2022

625. Chemical characterisation of organic waste of Bahawalpur shows high moisture content (41.83%) and C/N ration (16.81) and highest percentage of waste type generated from the city. Although C/N ratio is within GIZ recommended guidelines for compositing however source segregated organic waste is required for compositing to maintain moisture and C/N ratio. Source segregation at pilot scale in UC-14 is underway and based on the results further compositing potential will be explored. Only limited source segregated organic waste will be sent to compost plant while remaining will be directly landfilled.

7.9.5 Material Recovery Facility (MRF) for Bahawalpur:

626. Suitable waste input for MRF includes sorted waste for recycling metal, glass, paper, plastics, and other valuables. The recyclables are stored in open spaces or small-scaled houses. Recyclables are sold to junkshops, recyclable shops, etc.

627. The waste characterisation study indicated a total of 24 % recyclable items in the waste stream. The potential of recycling in Bahawalpur is, therefore, 24%. Based on the waste characterisation survey, it is concluded that the Material Recovery Facility and the TS can be installed at the legacy landfill.

628. An example of the Philippines includes establishing a MRF, which is mandated to the local barangays (villages) under the Ecological Solid Waste Management Act of 2000 as the Centre for recovery of recyclable waste. Accordingly, the MRF shall have the role of a core facility of 3R activities operated by the villages with the participation of community residents. However, in most cases, the MRF facilities in the Philippines are operated mainly for the community-level composting of organic wastes since the recovery of valuable wastes by private junkshops is very active. The valuable wastes brought to the MRFs are very few.

629. Another example of MRF in Thailand includes waste banks establishing segregated recyclable wastes such as paper, glass, plastics, and metal recovered directly from the waste generation sources by the residents and/or community activities. The recovered recyclables are sold at the bank. The junk shops or the recyclers purchase the recovered waste from the bank. According to the report “Waste Minimization in Thailand: Experience and Trend” by Mr Rangsan Pinthong, Pollution Control Department, MONRE, Thailand, nowadays, more than 500 waste recyclable bank systems have been established in 30 provinces.

7.9.6 Biomethanation

630. Bio methanation is the process of conversion of organic matter in the waste (liquid or solid) to biomethane (biogas) and manure by microbial action in the absence of air, known as “anaerobic digestion”.

631. The solid waste and the slaughterhouse waste is first mixed with raw sewage and conveyed to the primary digester. Effluent waste from the primary digester is sent to the secondary digester after stabilization. The raw gas generated from the primary and the secondary digester is then sent to the gas storage/WTE plant. The excess effluent from the secondary digester will be re-circulated back to the primary digester for further generation of gas. The gas thus stored in the gas balloon is passed through a scrubber where gases like H_2S and SO_2 and moisture are removed from the gas. This clean gas is conveyed under pressure to the Power Plant to produce power. The excess sludge from the secondary digester is conveyed to the centrifuge to separate the liquid and solids for further disposal.

632. Biogas can be used as vehicle fuel or for generating electricity. It can also be burned directly for cooking, heating, lighting, process heat and absorption refrigeration.

633. In Pakistan, biomass is readily available in most areas of the country, particularly in rural areas. Biomass energy uses natural materials such as trees, plants, and wastes to make electricity and biofuel. It is also environmentally friendly. Since 1974, more than 1,700 biogas plants have been installed under a nationwide program funded by the Government of Pakistan.

634. NRSP provides the research to access the design, maintenance, usage and sustainability of biogas plants as an energy source at the household level. “Evaluation of Biogas Initiative in Punjab”, National Rural Support Program (NRSP), August 2011.

635. The full cost of biogas plants in Punjab, Pakistan, is in ranges from Rs. 40,000 to Rs. 80,000 and above, depending on the size.[24] Based on the economic analysis conducted in the US, the total cost for a biogas plant, including all essential installations but not including land, is between 50-75 US $ per m^3 capacity. 35 - 40% of the total costs are for the digester.[25]

Table 7-6: Daily requirements of biogas plant by size

Plant Size(m^3)	Daily dung requirements (kgs)	Livestock requirements (cow/bullocks)	Daily water requirements (litres)	Gas Production (M^3/day)
4	30	2-3	30	4
6	45	4-5	45	5-6
8	60	5-6	60	6-8
10	75	7+	75	8-10

7.10 Proposed Solution for Bahawalpur City

636. Engineered sanitary landfills store and compress the waste without neutralizing toxins or pathogens, but have in place stronger controls against soil, water and air pollution than dumpsites. Moreover, sanitary landfills allow the recovery of methane gas, a by-product of anaerobic decomposition of organic matter, which can be used for power generation. Well sited and operated sanitary landfills provide the best option in waste management in view of their relatively low construction and operating costs and the type of wastes they are expected to handle. SLF is the best option considering the environmental, social and economic circumstances. Further, this can be complemented and enhanced by waste minimisation and recycling strategies.

637. Based on the Qualitative Evaluation Matrix of Intermediate Waste Treatment Options for Bahawalpur given under **Table 7-7**, the most suitable technological option for handling the municipal waste generated in Bahawalpur, Punjab, is the combination of mechanical and biological treatment options enabling around 95% of the organics, recyclables and combustibles from the Landfill. A centralised waste management facility will be handling MSW in the following steps:

- Construction of New Engineered Sanitary Landfill site (04 landfill cells) and Compost plant (5 tpd), C&D Recycling Plant (5 tpd) at Mari Sheikh Shijra mouza Nouabad including new construction of 2.5 km access road and improvement of 10 km main road. This landfill site is located at 20.2 km from the existing dumpsite at Khanu Wali.

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24 http://www.nrsp.org.pk/publications/Evaluation-Assessment-Studies/Renewable-Energy-Evaluation-of-Biogas-Initiative-in-Punjab.pdf

25 https://energypedia.info/wiki/Costs_of_a_Biogas_Plant#Production_Costs

- Installation of a TS, AD Plant (25 tpd) and MRF of 60 tph at the land adjacent to the legacy landfill. Improvements to the access road for the TS and Material Recovery Facility (TS+MRF) will extend over 5 kilometres.
- Construction of mixed plastic processing facility of 10 tpd at MRF
- Construction of BWMC office building at Hasilpur Road.
- Solar system will be installed at MRF, Landfill and Office building. As per the capacity of the solar plant, required power will be utilised in the internal system/operations of facilities.

Table 7-7: Qualitative Evaluation Matrix of Intermediate Waste Treatment Options for Bahawalpur, Punjab

Evaluation Items	Option 1: No Treatment (Current condition)	Option 2: Composting	Option 3: MRF	Option 4: Incineration	Option 5: RDF		Option 6: Bio-gas
Waste Type	Mixed waste	Biodegradable waste	Sorted waste for recycling	Combustible	Combustible (plastic, paper)		Biodegradable
Cost of Facility	No cost due to no facility	Cheaper	Cheaper	Very expensive	Expensive		Moderate
	-	A	A	B	A		A
Environmental Aspect	Need to acquire 100% collection efficiency	Odour if mishandled	Odour if mishandled	Need removal of pollutants from combustion gas emission. However, Incineration has additional environmental benefits as well.	Need removal of pollutants from combustion gas emission		Odour if mishandled
	B	A	A	A	A		A
Applicability	-	Small towns to large cities	Small communities to middle cities	For Large Cities	Medium to large cities		Villages /small towns in rural areas
	A	A	A	A	A		A
Actual Practical Experiences in Pakistan	Present	There is the Lahore Compost Company.	Not present (Few projects are under processed)[41]	Not present	RDF as fuel in D.G. Khan Cement Company and Lafarge/Fauji Cement companies.		Present (Installed by NRSP)

Evaluation Items	Option 1: No Treatment (Current condition)	Option 2: Composting	Option 3: MRF	Option 4: Incineration	Option 5: RDF	Option 6: Bio-gas
	B	A	A	B	A	A
Recommendations for application to Bahawalpur solid waste intermediate treatment facilities	-	Highly Applicable	High potential/ proportion (27%), but if the compost plant is established, MRF is viable as both activities are interdependent.	Sufficient volume and adequate energy content but need seasonal data to decide	Not suitable as a sufficient amount of combustibles is not present.	Organic matter was comparatively less as compared to other Cities
	-	A	A	B	A	A
Recommendation as per solid waste policies applicable to Bahawalpur, Punjab	Recommended options for waste utilization and recovery are Option 2: Composting, Option 3: Material Recovery Facility in Bahawalpur, Punjab					
	-	A	A	B	A	A
Evaluation Results		A	A	B	A	A

Legend: A- Suitable; B- Not suitable

Source: JICA Project Team, GWMC

Note:* NRSP stands for National Rural Support Programme (NGO).

** NRSP, Monitoring, Evaluation & Research Section, “Renewable Energy: Evaluation of Biogas Initiative in Punjab” August 2011

7.11 Economic Aspect Analysis

638. Economic analyses of various waste treatment methods have been conducted, revealing that sanitary landfilling is the most economically viable option for low-income countries such as Pakistan. **Table 7-8** shows the estimated total waste cost per tonne for various waste treatment methods.

Table 7-8: Economic aspect analysis of waste treatment methods[26] (UNEP, 2015)

World Bank Project Data	Low Income Countries	Lower Middle Income	Upper Middle Income	High Income Countries
Total Cost in US$/ton				
Sanitary landfilling	10-30	15-40	25-65	40-100
Composting	5-30	10-40	20-75	35-90
Waste-to-energy incineration	NA	40-100	60-150	70-200
Anaerobic digestion	NA	20-80	50-100	65-150

Disclaimer: All estimates are for comparative purposes only and are not indicative of actual costs at any particular local site. Costs for reduction, reuse and recycling are not captured in this table.

26 Incineration of Municipal Solid Waste February 2013, DEFRA UK

8 Potential Environmental Impacts and Mitigation Measures

8.1 Introduction

639. This chapter provides screening of potential environmental impacts of the proposed project, discusses the stakeholders' views, assesses the significance of the potential impacts, and recommends mitigation measures to minimize if not eliminate the potentially adverse impacts of the proposed activities. These include effects on the physical, biological, and socioeconomic surroundings.

640. The section provides details on the impacts related to the design, construction, operation, and closure/post closure phases of landfill components such as landfill cells, leachate collection network and treatment system, landfill gas collection and flaring system, AD and composting plant, material recovery facility, admin building, BWMC office building and associated road network. The Punjab EPA Rules and Regulations-2020, the Punjab EPA-(Amendment Act, 2017), and the ADB SPS, 2009 were all followed in carrying out the impact assessment of the Bahawalpur landfill.

641. Impact-screening matrices during each of the landfill development phases i.e. project design, construction, operation and closure/post closure are presented below.

8.2 Methodology for impact screening

642. Determining the significance of potential environmental impacts and their effects enables the identification of necessary mitigation and benefit enhancement measures as well as an estimation of the related financial costs associated with the impacts of a project. An impact can be either beneficial or adverse and is assessed by comparing the quality of the baseline conditions with the predicted quality once the project is under implementation or in place.

643. The procedure for determining the level of risk associated with each potential impact is described below.

644. The likelihood that the activity will have an effect on the environment, as well as the consequence of the effect occurring, are used to assess risk. It is frequently described as follows:

Risk = Likelihood × Consequence

Table 8-1: Likelihood Scale

Likelihood	Definition	Scale
Certain	Will certainly occur during the activity at a frequency greater than every week if preventative measures are not applied	5
Likely	Will occur more than once or twice during the activity but less than weekly if preventive measures are not applied	3
Unlikely	May occur once or twice during the activity if preventive measures are not applied	2
Rare	Unlikely to occur during the project	1

Table 8-2: Consequence Scale

Consequence	Definition	Score
Catastrophic	The action will cause unprecedented damage or impacts on the environment or surrounding communities	5
Major	The action will cause major adverse damage on the environment or surrounding communities.	3
Moderate	No or minimal adverse environmental or social impacts	2
Minor	No or minimal adverse environmental or social impacts	1

Table 8-3: Risk Score Table

	Consequence				
		Catastrophic	Major	Moderate	Minor
Likelihood	Certain	**25**	**15**	**10**	5
	Likely	**15**	**9**	6	3
	Unlikely	**10**	**6**	4	2
	Rare	5	3	2	1

Risk: Significant: 15-25

Medium: 6-10

Low 1-5

645. Any ‘Medium’ to ‘Significant’ risk requires an environmental management measure to manage the potential environmental risk. Judgment will be required concerning the application of an environmental management measure to mitigate low risk situations.

8.3 Potential for Hazardous Air Strikes

8.3.1 General

646. With respect to air strike risks, although damage can occur from any wildlife, damage probability increases as the species struck become heavier or when many individuals (flocks of birds) are struck at the same time (multiple strikes). Civilian airliners and engines are designed to tolerate strikes with bird(s) up to a given weight and maintain sufficient thrust to return safely to an airport. For example, a modern 737 engine should (depending on air inlet size) be able to tolerate an impact on take-off with a single 1.8kg bird and maintain 50% thrust for at least 14 minutes after ingestion. Multiple strikes of smaller birds require similar tolerances for the same or greater overall weight ingested.

647. Many birds and other wildlife are, however, significantly heavier than these tolerances or flock in such a way that a strike involving multiple smaller birds (e.g. flock of Feral Pigeons) may result in sufficient mass being hit or ingested that the tolerances are not covered by engine or airframe certification standards. Catastrophic risk therefore remains a possibility whenever large and / or flocking birds are struck.

648. Local examples of hazardous birds that may transit the area or visit landfill sites include. These can be seen in the table below, but may not be limited to.

Table 8-4: Potentially Hazardous Bird Populations

Species	Approx mass	Approx severity
White Stork (or similar), *Ciconia ciconia*;	3.4kg	26.7%
Small gulls, e.g. *Larus ridibundus*	345g	4.0%
Black Kite, *Milvus migrans*	765g	10.7%
Feral Pigeon (Rock Dove), *Columba livia*	345g	4.8%
Common Myna, *Acridotheres tristis*	120g	1.7%
Cattle Egret, *Bubulcus ibis*	450g	6.3%

649. All of the above are capable of forming flocks and feeding en-masse at sites such as waste management facilities. Some landfills may attract over 10,000 birds at any one time and provide resources for several hundred thousand birds over the course of a year. Migratory birds can use such sites as stopovers to replenish lost resources whilst resident birds may target scavenging at such sites daily. Large flocks of birds that therefore have the potential to cause some form of damage to aircraft and are present in the vicinity of an aerodrome therefore require careful consideration.

650. The wetland corridors in the Bahawalpur Region support several species that are also hazardous to aviation but are unlikely to be attracted to foraging opportunities presented by a landfill. These are not, therefore, considered as part of this assessment. Species that are specifically attracted to forage on putrescible wastes represent those that are of interest to air safety in relation to landfills.

8.3.2 Potential Risks

651. The likelihood of a bird causing damage to an aircraft when struck is related to many factors. The speed of the aircraft, the tolerance of the aircraft to ingestions or airframe strikes and the size of the species or number of each species struck in any one incident. All other things being equal, the chance of some form of damage occurring with civil aircraft operating out of civil aerodromes has been evaluated and equates to around 1.4% of strikes with every 100g of bird resulting in some form of damage. The level of damage can range from a paint scratch or dent on a wing's

leading edge through to a (thankfully rare) catastrophic strike resulting in the loss of an aircraft or loss of life. The severity ratings listed in section 3.2, above, are therefore based on strikes with individual birds and can be used to indicate the likelihood of some form of damage occurring with each species. The greater the number of individuals struck, and the greater the size of any of those individuals struck, the higher the chances of one of those strikes resulting in damage.

652. Clearly as the presence of birds near aircraft (all other things being equal) rises, a higher probability of a strike occurring happens. As such, high severity species (generally those considered as large and / or flocking species), that occur in closer proximity to aerodromes results in the greatest probability of damaging strikes occurring. The behaviours of different species are important as some may be present in greater abundance than others but have a better ability to avoid aircraft and as such result in lower probabilities of being struck. Similarly, the movements of birds either towards or away from critical airspace (areas where aircraft are manoeuvring or in flight on approach or departure corridors), will also affect the likelihood of strikes with such species occurring. Knowledge of the likely transits of hazardous species through a local area, or the movements that occur during the migration periods, in combination with their behaviours, will generally enable an assessment of risk to be developed.

653. Increasing the presence of large and / or flocking species in the vicinity of an aerodrome merits assessment, and such an assessment should consider whether any increase in hazard (the number of large and / or flocking birds present) could result in risk to aircraft.

Location and Risk Species

654. The relative locations of the airport, existing landfill site and proposed new landfill site are indicated in **Figure 8-1**. In the figure below, the locations of the airport (green), existing landfill site (yellow) and proposed new landfill site (red) are shown in relation to the western approach corridor to the airport (red line).

Figure 8-1: Airport Approach Relative to Project Components

655. The likelihood of hazardous bird infringements from the landfill into critical airspace on and in the vicinity of Bahawalpur Airport will be dictated to by the behaviour of different species on and around the landfill.

Black Kite *Milvus migrans*

656. Black Kite is likely to be ubiquitous within the surrounding environment and is certainly a common species across the region despite not being reported from the data provided to date. Large numbers may aggregate at feeding sites hence landfill operations have the potential to increase their presence within the vicinity of any aerodrome. These, and other birds of prey or large soaring birds, may also thermal over a site to several thousand feet above ground level and therefore pose a direct threat to air safety when sites are located close to approach corridors. Aircraft on a direct approach to the Bahawalpur 08 runway will be at or around 2000’ A.G.L at this distance from the aerodrome hence there is likely to be the potential for increased strike risks should thermalling over the new landfill occur. Similarly, any movements of birds to the north or north-east of the new landfill could result in crossings of the approach corridor.

657. It is considered likely that management controls at the landfill site would be needed if Black Kites and other large soaring bird species were present. These management controls are discussed in Section 9.5.4 and may consist of avian deterrents, netting and waste covering, and active methods of flying falcons to deter the Kites.

Gull species *Laridae*

658. Smaller gulls such as Black-headed Gull (Chroicocephalus ridibundus), frequent the coastlines and wetland areas of Pakistan during the winter. It is unknown whether they are present at this distance inland, although they are known to visit landfills in the general region and can be present in groups of several thousand individuals in other areas. Depending on the distance gulls fly to their nocturnal roost sites, gulls may also thermal upwards prior to departure each evening before moving off in the direction of their roost. If nearby roost sites (wetland areas) are available to the north, it is possible that movements could influence air safety. The nearest wetland area that is likely to be large enough to support a gull roost appears, however, to be the Punjnad Barrage at the Chenab River approximately 50km due west of the landfill. This is well within commuting distance of these species. Should birds arrive and depart from this direction, it is unlikely they would significantly impact air safety.

659. Gulls can be easily prevented from using landfill sites hence, whether they may or may not result in risk, if they are present, control could be implemented to ensure risks are minimised.

Egrets and Ibis’ *Pelecaniformes*

660. Cattle Egret (Bubulcus ibis) appears to be a common resident species throughout the area and is likely to visit and forage at landfills should the opportunity arise. Their presence at this distance from the aerodrome is unlikely to influence their presence at the aerodrome as they are equally likely to forage in large numbers in agricultural areas and grasslands. A small number of birds foraging in grassland on an aerodrome is likely to result in far higher risk levels than a large number foraging on the distant landfill. Their movements between feeding and roosting sites could, however, impact air safety if they result in crossings of an approach corridor or the aerodrome itself at altitudes aircraft are operating at. Given the main agricultural areas are to the west of the city and aerodrome and the wetland areas are to the north and

west of the landfill it is unlikely that these species' presence on the landfill will directly impact air safety.

661. If actions to deter gulls or Black Kites and other soaring bird species are being implemented at the landfill site, it would be prudent to also minimise the presence of these species. It may not directly impact risks to aircraft but could reduce the likelihood of other species perceiving the landfill site as a feeding opportunity if Egrets and Ibis are not present.

662. **Passerines Passeriformes**

663. Corvids including House Crow Corvus splendens and Large-billed Crow Corvus macrorhynchos, and Mynas such as Common Myna, Acridotheres tristis are members of the passerine (perching birds) order and are resident scavenging birds across the region. They will utilise many natural and man-made habitats to feed, rest and breed and are likely to attempt to utilise any foraging opportunities provided by landfill sites. Such sites may result in large numbers of birds being present and can thus increase risks to air safety. Given the distance of the landfill from the aerodrome, and the relatively low altitude movements of these birds when moving through the environment however, it is unlikely that this group of species will directly influence air safety.

664. As with Egrets and Ibis species, if actions to deter gulls or Black Kites and other soaring bird species are being implemented at the landfill site it would be prudent to also minimise the presence of these species. It may not directly impact risks to aircraft but could reduce the likelihood of other species perceiving the landfill site as a feeding opportunity if Corvids and Mynas are not present.

Pigeon species Columbiformes

665. Feral Pigeons (Columba livia domestica) and various smaller ground dove species (e.g. Laughing Dove Streptopelia senegalensis), may be common residents in the region. There is no doubt that landfill facilities have the potential to increase their presence in the vicinity of an aerodrome although longer distance movements over 5km are unusual. Feral Pigeons are more likely to remain within a given range of their resident area hence the landfill is sufficiently distant from the aerodrome that it is unlikely to influence the level of hazard at the aerodrome. Feral Pigeons are also highly unlikely to thermal over a landfill site and thus those birds that are present at a landfill this distant from an aerodrome will not directly affect air safety.

Other bird species

666. The above species and species groups represent an indicative list of the types of bird species that may utilise a landfill site in this area. It does not provide an exhaustive list of those species that will use the site but covers the main groupings and behaviours likely to affect risk. Species such as White Storks (Ciconia ciconia), for example, are resident in the region and may forage on landfill sites or soar overhead. Many species of scavenging passerines may be present as might other species of birds of prey including vultures. The above groupings, however, represent the likely species and behavioural traits that could influence flight safety and thus may require controls. Any other large and or flocking bird species that influence risk as per the above groups, should be managed accordingly as discussed in Section 9.4.5 Mitigation Methods.

8.4 Design/Pre-Construction Phase Impacts

667. This section assesses all components of the project where design and pre-construction activities are universal, otherwise, impacts have been separated into each component and assessed individually.

668. The impacts associated with the project locations (siting) are those which relate to the location at the designated site. These impacts are different from those which are associated with the project's construction and operational phases. The construction and operational impacts are associated with the activities such as land clearing, waste disposal, whereas the sitting impacts relate to the mere presence of a facility at the given location.

669. For the proposed project and its components, the aspect of the project site, land use and design have been considered.

Impact Screening Matrix

670. The 'activity wise' screening of potential impacts during the design/pre-construction phase is provided in **Table 8-5** below.

Table 8-5: 'Activity Wise' screening of possible Impacts during Design/Pre-Construction phase

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual (Significant, Medium, Low)
1	1	Landfill Site Selection	Likely	Moderate	Medium	Low
All	2	Lack of integration of IEE/EMP requirements in construction bid documents	Likely	Moderate	Medium	Low
All	3	EMP Implementation	x	x	x	x
1	3	Land acquisition and resettlement impacts	Likely	Moderate	Medium	Low
All	4	Impacts due to natural hazards	Likely	Moderate	Medium	Low
1&2	5	Site Characterisation and Baseline monitoring	Likely	Moderate	Medium	Low

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual (Significant, Medium, Low)
1&2 (Legacy Landfill	6	Site Closure Planning	Likely	Major	Signficant	Low

Critical Risk Level
Significant Risk Level
Medium Risk Level
Low Risk Level

8.4.1 Landfill Site Selection – Component 1

Impacts

671. The IFC Guidelines contain specific criteria related to site selection for landfill sites that have been developed to ensure any potential Impacts resulting from landfill operation are minimized as far as possible. In case these Guidelines are not strictly implemented for the development of the proposed landfill, it could result in considerable irreversible, diverse or unprecedented impacts.

672. A proposed landfill site should be selected on the basis that it must comply basic Punjab government regulations, IFC EHS guidelines for waste management facilities and ADB SPS 2009.

673. Proposed selection of landfill site must take into accounts impacts from leachate, litter, dust, vector and odours on the surrounding environment.

Mitigation Measures

674. The following mitigation measures will be implemented:

- The proposed landfill site has been selected in accordance with international landfill development standards and guidelines, including but not limited to the IFC Guidelines on Waste Management Facilities for Landfills.
- All parameters including site capacity, accessibility, acceptability, stability, environmental sensitivity, land use, socioeconomic receptors, and climate hazards have been considered, and the site has been selected accordingly.
- The site for Bahawalpur Landfill has been selected keeping in view environmental and social sensitive receptors and necessary design considerations have been provided to manage impacts related to leachate, litter, dust, vector and odours on the surrounding environment.

8.4.2 Integration of IEE/EMP requirements in construction bid documents – All Components

Impacts

675. The bidding documents must reflect the requirement to select a qualified and experienced Contractor from the perspective of ensuring implementation of required safeguards during project development.

Mitigation Measures

- The proposed ‘Safeguards unit’ that will be developed at the PMU will be assigned the task to check that design and bid documents are responsive to key environmental, social and safety considerations, and that the proposed method of work reflects the boundaries defined in the EMP. The bid documents must include the EMP, and its implementation cost must be reflected in the BoQ.
- The IEE/EMP implementation and monitoring requirements must be part of bidding documents and necessary contractual binding must be agreed by project contractors before award of contract.
- Project contractors shall have qualified and experienced environmental staff to plan, arrange, implement, monitor and report IEE/EMP requirements.

8.4.3 EMP implementation – All Components

Impacts

676. Lack of contractor’s environmental safeguard capacity or selection of environment non-responsive contractors may result in failure of EMP implementation and may be a source of number of non-compliances.

677. The responsibility of the PMU Punjab LG &CDD in collaboration with the focal agencies is to review and finalize the bidding documents relating to environmental issues.

678. Contractors that do not possess the required capacity for safeguards management must not be pre-qualified and selected.

Mitigation Measures

679. PMU Punjab LG &CDD shall review the contractor’s capacity with respect to safeguard management and contracts shall be awarded accordingly.

680. The Contractor will be required to define an Occupational and Environmental Health and Safety and Environmental Management Plan and procedure for all work, including work camp operation, management of cement dust, and use of Personal Safety Equipment. These procedures should be developed and approved by the PMU in collaboration with the local agencies before the Contractor commences any physical works on ground.

681. PMU Punjab LG&CDD shall ensure the project contractors are selected on merit and necessary funds has been allocated in the contract documents for EMP implementation and monitoring.

8.4.4 Land Acquisition and Resettlement Impacts – Component 1 & Legacy Landfill

Impacts

682. The field visits for social safeguards assessment by PMU and EDCM team has been carried out in October and November to identify any sensitive receptors falling

within 250 meters distance from landfill cells to be constructed as part of **Component 1**. None of the receptors is falling within 250 metres from the project site. Although, clusters of settlements are located near the project site, the nearest settlement is located at 520 metres from the boundary of the project site.

683. No land acquisition and resettlement impacts are anticipated for **Component 2** as it will be constructed on state land already under possession by BWMC and being already used for dumping. A buffer of land around the legacy landfill may need to be secured to allow for long term monitoring and landfill gas venting.

684. No land acquisition is required for the construction of Component 2 – MRF or Component 3.

Mitigation Measures

685. The PMU Punjab LG&CDD shall ensure the following:

- Pending payment to all landowners must be paid before mobilization of construction contractors.
- Social safeguard unit shall ensure that project affected people has been paid following appropriate procedures and there are no grievances about land acquisition process of the site/s.

8.4.5 Impacts due to Natural hazards – All components

Impacts

686. The sites are located outside of seismically active areas falling within Zone 2A on seismic map of Pakistan with moderate seismic risk. No fault lines or significantly fractured geologic structure is present within 500 meters of the perimeter of the sites (Component 1 and 2) that may allow unpredictable movement of gas or leachate.

687. The site is located outside of a flood plain, however, in case of high precipitation, there are chances of urban flooding. Surface drainage network will be provided in detailed design of landfill site to avoid risk of surface runoff and contamination.

688. Furthermore, extreme rainfall events in Bahawalpur do not show changing trends and surface water drainage/diversion work is included in the project design to avoid percolation of rainwater into the landfill cells.

Mitigation Measures

689. The PMU Punjab LG&CDD shall ensure the following:

- Bahawalpur Landfill and MRF (Component 1 and 2) infrastructure shall be designed keeping in view the seismic zone 2A building considerations.
- Surface water diversion shall be included in the design to protect the Component 1 and Component 2 sites from urban/flash flooding.
- Extreme precipitation events analysis shall be performed for landfill life i.e. 25 years, to predict and manage impacts of flash flooding.
- On site waste storage at loading bays shall be kept to minimum during high precipitation events.

- An emergency response plan shall be prepared by construction, operation, closure and post closure phase contractors and will be submitted to PMU for approval to manage impacts of natural hazards such as earthquakes and floods.

8.4.6 Impacts due to Site Characterization & Baseline Monitoring

Impacts

690. The legacy landfill will generate gas and leachate for its lifetime (estimated to be 30-50 years) and further site characterisation of the geology, hydrology and hydrogeology will be required to ensure the site closure and monitoring plan mitigates the impacts to the environment and human health.

691. Residential houses are present within the vicinity of the landfill and could be impacted due to landfill gas migration (explosion risk) or contamination of local drinking water wells by leachate.

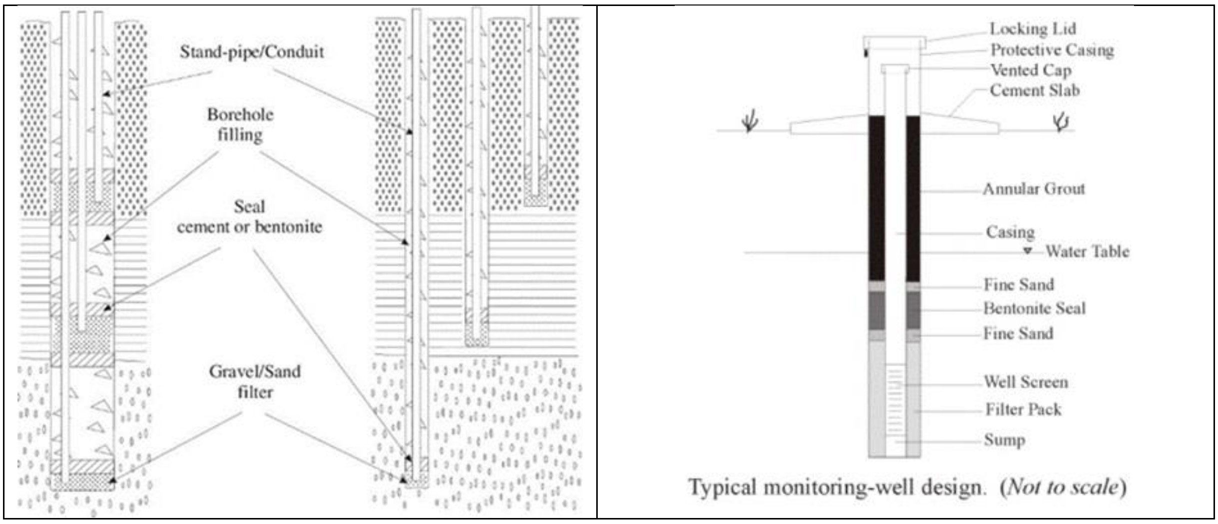
692. A detailed conceptual site model (CSM) will serve as a fundamental tool for understanding the potential impacts of the legacy landfill site and developing strategies to mitigate those impacts within the site closure timeframes. Failure to prepare a detailed conceptual model will result in risk being poorly understood and inappropriate or unnecessary site closure measures being designed.

Mitigation Measures

693. The PMU Punjab LG&CDD shall ensure the following:

- A full site characterisation of the geology, hydrogeology and hydrology in the surrounding area will be undertaken. This will include as a minimum:
    - Installation of c. 8 No. permanent perimeter boundary monitoring wells around the boundary of the landfill. These wells should be drilled to c.15m depth or 2m below resting groundwater whichever is deepest. The wells should be drilled using a rotary drilling rig capable of allowing logging of strata to BS5930 or similar. If perched water bodies are encountered these should be sealed with bentonite prior to extending drilling to prevent creation of a preferential pathway. Nested wells should be installed if necessary to allow monitoring of different water bodies (perched and groundwater). The image below indicates a suggested borehole construction. The contractor will agree the well design with the PMU before drilling commences. All wells should be completed with a metal, lockable covers and constructed and protected to minimise risk of damage and designed to enable monitoring during the lifetime of the landfill (c.25 years). If necessary, the contractor should budget to replace wells should they become damaged or inoperable. Care should be taken to construct wells so that they do not silt up.

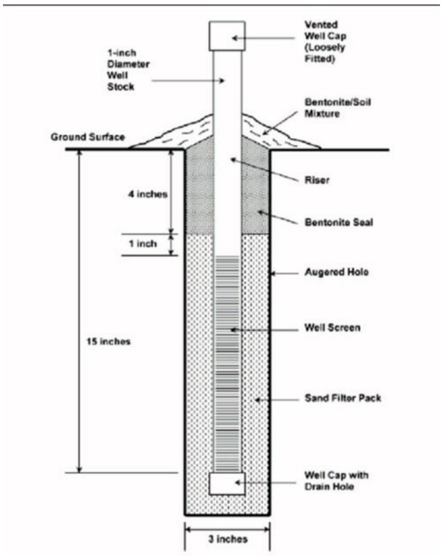
Figure 8-2: Recommended Groundwater Monitoring Well Design



Typical monitoring-well design. (*Not to scale*)

- o Installation of 16No. permanent gas monitoring wells (c.4 per boundary). These should be shallow wells installed to the depth of the landfill (c.3m) depth below natural ground level. They should include a 1m below ground bentonite seal and 2m of perforated well screen and fitted with gas monitoring taps. The contractor should agree the design specification of the wells with the PMU before construction.
- o The well should be a permanent monitoring feature protected with metal lockable covers and should be designed to last the lifetime of the landfill (c.25years). The contractor should allow budget for replacement of the wells as necessary.

Figure 8-3: Recommended Gas Monitoring Well Design



- The contractor should undertake monitoring of the above wells to ascertain the baseline conditions prior to restoration and to inform the site closure plan. Groundwater monitoring should be undertaken quarterly for two years, and gas monitoring should be undertaken weekly for a six-week period capturing periods of high and low atmospheric pressure and then be reduced to quarterly thereafter to tie in with groundwater monitoring. Consideration could be given to installation of permanent remote gas monitoring equipment such as GasClam ®.

- Once the site characterisation has been completed, the contractor will prepare a detailed conceptual site model detailing risks from leachate migration to hydrogeology, hydrology, ecology and human health and risks of landfill gas migration to residents, business and the proposed adjacent MRF facility operations.

- Once baseline conditions have been established the contractor will agree with the PMU the laboratory schedule and frequency of required further testing. This should be no less than monthly for groundwater and monthly for landfill gas unless four quarters of non-detectable concentrations are detected in which case a reduction in frequency can be agreed with PMU. At a minimum sampling and analysis will be conducted on a quarterly basis.

- The gas and groundwater monitoring schedule and frequency has been indicated in the Environmental Management Plan which should be provided to contractors prior to bidding.

- All monitoring data should be collated into an annual monitoring plan shared with the PMU. Any proposed adjustments to frequency or schedule of testing should be supported by monitoring evidence presented in the annual report.

- Following completion of the site characterisation, the site closure plan should be developed detailing how landfill gas and leachate will be collected and treated, if necessary, details of final capping construction and restoration plans for the landfill longer term (e.g. used for ground mounted solar or grazing land), and details of how surface water will be controlled. Any proposed end-use should preclude anything that will break ground beyond the capping layer.

- The baseline monitoring will also enable a cost benefit analysis to be undertaken regarding the feasibility of landfill gas to energy as a potential source of renewable energy for the site.

8.4.7 Impacts due to Site Closure Planning

Impacts

694. Poor site closure planning of the legacy landfill or in time the new landfill could lead to negative impacts on local communities and the environment from:

a. Uncontrolled migration of landfill gas posing a potentially explosive risk to the MRF, other businesses and residents. Landfill gas can become an explosion risk when it forms an explosive mixture with air in certain proportions and under low pressure. Methane, which is the primary component of landfill gas, is explosive between its lower explosive limit (LEL) of 5% by volume and its upper explosive limit (UEL) of 15% by volume. A site closure plan should assess the risk of fires and explosions to surrounding receptors and put in place measures to control these risks (e.g. landfill gas collection systems, natural venting and potentially flaring)

b. Contamination of groundwater drinking wells and surface water bodies impacting human health, livestock and the ecology.

c. Unsightly land use causing wind-blown litter, pests and disease vectors (rodents, insects, birds) and odours.

Mitigation Measures

695. The PMU Punjab LG&CDD shall ensure the following:

- A site closure plan will be developed for both the legacy landfill and the new landfill that details. This will be published prior to operation of the new landfill and closure of the legacy landfill. It will include details of:
    - How the site will be closed and restored and what its future land use will be.
    - Known details of the landfill, including the conceptual site model, construction details, likely types of waste and any known historical data.
    - Details of any local permit requirements.
    - Details of intermediate cover, final cover and post closure care. Timelines will be included.
    - The intermediate cover should control erosion, minimise water infiltration, reduce odours. The site closure plan will specify the materials, thickness and installation procedures to be used.
    - The final cover design will seal the landfill to prevent water infiltration and gas emissions. It should include specifications of the materials, slope and cap drainage system.
    - Details of how leachate will be managed, controlled and if necessary treated.
    - Details of how landfill gas will be collected and managed.
    - Details of the post closure monitoring plan including groundwater, surface water, and gas. It should outline the frequency and duration of the monitoring.
    - Details of the financial mechanisms in place to cover the closure and post closure costs ensuring funds are available to implement and maintain the closure plan.
    - Details of who will manage the landfill, and how they will liaise with local stakeholders to address any concerns.
    - Outline procedures for addressing emergencies, unforeseen or unexpected events during the closure process and landfill lifetime such as gas and leachate leaks and fires, regulation changes or land use changes (e.g. encroachment of significant residential development nearby).
    - Details of record keeping and who should be kept informed via annual reporting, and what information will be publicly shared.

8.5 Construction Phase Risks

696. This section assesses the impacts posed by the project and its components during the construction phase or implementation phase in the context of Component 3.

697. Impacts are considered universal unless otherwise specified and should therefore be applied to all parts of the project.

Impact Screening Matrix

698. The screening of potential impacts during the construction phase is provided in **Table 8-6** below.

Table 8-6: Screening of Possible Impacts during Construction Phase

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact (Significant, Medium, Low)
All	1	Water Contamination	Likely	Major	Medium	Low
All	2	Air Quality Degradation	Likely	Moderate	Medium	Low
1,2	3	Loss of Vegetation	Likely	Moderate	Medium	Low
1,2	4	Damage to Wildlife	Likely	Moderate	Medium	Low
All	5	Occupational and Community Health and Safety Hazard	Likely	Moderate	Medium	Low
1,2	6	Noise and Vibration	Likely	Moderate	Medium	Low
All	7	Hazardous and Non Hazardous Waste Disposal	Likely	Moderate	Medium	Low
1,2	8	Waste Effluent Disposal	Likely	Moderate	Medium	Low
1,2	9	Soil Erosion and Sedimentation	Likely	Moderate	Medium	Low
1,2,3	10	Soil Contamination	Likely	Moderate	Medium	Low
All	11	Employment Conflicts	Likely	Moderate	Medium	Low
All	12	Communicable diseases	Likely	Moderate	Medium	Low
All	13	Historical/Archaeological Sites	Unlikely	Moderate	Low	No Residual Impact
	14	Impacts associated with Construction of Administration and BWMC office Buildings and Other Infrastructure	Likely	Moderate	Medium	Low
1,2	15	Impacts associated with Construction/Widening of Access Road	Likely	Moderate	Medium	Low
2	16	Impacts associated with specific restoration of legacy landfill.				

Critical Risk Level
Significant Risk Level
Medium Risk Level
Low Risk Level

8.5.1 Soil Contamination (Component 1 and 2)

Impacts

699. During the project construction, spills of fuel, lubricants and chemicals can take place while transferring from one container to another or during refuelling. Also, during maintenance of equipment and vehicles, through leakages from equipment and containers and because of traffic accidents.

700. Landfill construction involve excavation of landfill cells. Excavated soil will be backfilled and remaining will be stored at site as it will be used as daily cover during landfill operation. Earthwork involving excavation and movement of machinery from which minor spills can occur and may be source of soil contamination.

701. MRF construction involves site preparation for construction of building in which MRF components will be installed. Site will be surveyed and cleared from bushes/vegetation followed by levelling, lean concrete, masonry works, flooring and roofing. Once MRF building is completed then base skids will be prepared for installation of MRF components. Minor spills of fuel, lubricants and construction waste may impact the project area soil; however, these impacts are of short duration and can be managed through implementation of mitigation measures.

702. Depending on the nature of the material, location of spill and quantity of spill, the soil can get contaminated.

703. Based on satellite imagery, uncontrolled tipping has also occurred within the MRF site boundary which may have resulted in soil contamination.

Mitigation measures

704. The following mitigation measures will be implemented:

- It will be ensured that spill prevention trays are provided and used during refueling. Also, on-site maintenance of construction vehicles and equipment will be avoided as far as possible. In case on-site maintenance is unavoidable, tarpaulin or other impermeable material will be spread on the ground to prevent contamination of soil.
- Regular inspections will be carried out to detect leakages in construction vehicles and equipment and all vehicles will be washed in external commercial facilities.
- Fuels, lubricants, and chemicals will be stored in covered bounded areas, underlain with impervious lining. Appropriate arrangements, including shovels, plastic bags and absorbent materials will be available near fuel and oil storage areas.
- Any uncontrolled tipped materials will be removed from site to the adjacent legacy landfill. The residual ground surface will be inspected for contamination and if suspected will be investigated and dealt with appropriately based on a risk assessment.

8.5.2 Water Quality (Surface and Groundwater)

Impacts

705. The project activities may also contaminate the surface water and groundwater, via:

- Solid waste disposal
- Sewerage disposal
- Equipment/ vehicles maintenance
- Spillage/ leakage of fuels, oils and chemicals
- Campsite sanitation facilities
- Erosion and run-off of soils during storm events.

706. Preparation of designated area of land for subsequent development activities involves levelling off of the ground surface, removal of vegetation, stockpiling and generation of construction waste. Construction of temporary infrastructure such as drainage culverts and haulage roads may be required.

707. The site formation may produce large quantities of run-off with high suspended solids in the absence of appropriate mitigation measures. This potential problem may be aggravated during the rainy season.

708. The used engine oil and lubricants, and their storage as waste materials as the potential to create impacts if spillage occurs.

709. Waste oil may infiltrate into the surface soil layers, or runoff into local watercourses, increasing hydrocarbon levels.

710. Proper precautionary measures should be taken to prevent any spillage of the above materials and their subsequent runoff into the water bodies

711. During construction, impacts from the workers include waste and wastewater generated from eating areas, and sewage from temporary sanitary facilities.

712. Sewage is characterized by high levels of BOD, ammonia and E. Coli. Significant water quality impact will happen only if the sewage is discharged directly into the receiving waters without any prior treatment.

Mitigation Measures

713. During site development of component 1 and component 2 sites necessary precautions will be taken, so that the runoff water from the site gets collected to a surface water drainage pit. The surface water collection should be designed with appropriate volume for the estimated surface water drainage.

714. During construction activity all the equipment's washed water will be diverted to oil water interceptor pits to collect the suspended solids and enable oils to be collected. The settled water will be reused for construction purposes, and for sprinkling on roads to control the dust emission, etc. The oil water interceptor pits should be designed to cope with sufficient volume of wash water and if construction lasts longer than 1 year should be cleaned annually with sludge and oils being disposed of to licensed facilities.

715. Sewage will be discharged into receiving water bodies after treatment. The design of the treatment plant will be agreed with the PMU before installation.

716. Within Component 1 there are no nearby existing irrigation channels near the project site which will be affected during project establishment. As such there is a low possibility that groundwater and surface water will be affected during the construction phase of the project.

717. Within Component 2 there is an irrigation channel located adjacent to the east of the site. Care should be taken to ensure no untreated discharge or uncontrolled surface water run-off impacts the channel.

718. Within Component 1 consideration shall be given to the stability of the sub-grade, the base liner system, the waste mass and the capping system. The sub-grade and the base liner will be sufficiently thick as per international standards and stable to prevent excessive settlement or slippage.

719. Within Component 1 the bottom and cap lining system for each landfill cell must be designed for the protection of soil, groundwater and surface runoff.

720. Within the Component 2 Legacy Landfill, the design should be followed to prevent soil and groundwater contamination.

721. An efficient leachate collection system must be provided for both the new landfill and legacy landfill to ensure leachate accumulation at the base of the landfill and keep it to a minimum. The lechate collection system for the legacy landfill will have to be designed retrospectively and should not create any preferential pathways to the underlying aquifer. This should be addressed during the design phase conceptual site model investigations.

8.5.3 Air Quality

Impacts

722. The impact to air and noise will be significant during the progress of the construction phase. The proposed landfill development in Component 1 will involve large scale earth works and transporting and dumping large quantities of dry material. This will likely lead to an increase in SPM (Suspended Particulate Matter) in and around the construction zones.

723. Significant earth movement will also be required during levelling of the MRF site and movement of the uncontrolled waste deposited in this area. This will likely lead to an increase in SPM (Suspended Particulate Matter) in and around the construction zones.

724. Potential sources of particulate matter emission during construction activities for both components include earthworks (dirt or debris pushing and grading), exposed surfaces, exposed storage piles, truck dumping, hauling, vehicle movement on unpaved roads, combustion of liquid fuel in equipment and vehicles, land excavation, and concrete mixing and batching.

725. Vehicles carrying construction material for both components are expected to result in increased Suspended Particulate Matter (SPM) levels near the haul roads. This can be of potential importance if the vehicles pass through the areas with a high concentration of sensitive receptors, such as residential areas, in this case.

726. The construction machinery and project vehicles for both components will release exhaust emissions containing Carbon Monoxide (CO), Oxides of Sulphur (SOx), Oxides of Nitrogen (NOx) and Particulate Matter (PM). These emissions can deteriorate the ambient air quality in the immediate vicinity of the project site.

727. Impacts of air emissions may be carried over long distances depending upon the wind speed, direction, temperature of the surrounding air and atmospheric stability.

728. At the construction yard, the dust levels are also expected to increase due to unloading of construction materials. It shall be ensured that most of the excavated material will be used within the project, with minimal cut and fill material to come from outside the site.

729. Poor air quality due to the release of contaminants into the workplace can result in possible respiratory irritation, discomfort, or illness to workers.

730. The quantity of dust that will be generated on a particular day will depend on the magnitude and nature of activity and the atmospheric conditions prevailing on the day. Due to the uncertainty in values of these parameters, it is not possible to calculate the quantity from a 'bottom-up' approach, that is, from adding PM_{10} emissions from every activity on the construction site separately. Typical and worst-case PM_{10} emissions from construction sites have been estimated[27] as 0.27 megagram per hectare per month of activity (Mg/ha-month) and 1.04 Mg/ha-month, respectively.

731. A dust management plan for the project that is applicable for components 1 and 2 is prepared and provided as **Appendix A.8.**

Mitigation Measures

732. The following mitigation measures will be adopted for preservation of the environment:

- During construction of both components and within the immediately adjoining areas, water will be sprinkled every three hours and at a higher frequency if felt necessary, at all construction sites to suppress dust emissions.
- For both components, site levelling and grading will be carried out, where ever possible to maintain the natural elevations
- For static areas of dust generation, consideration will be given to whether temporary tin sheets of sufficient height (3m) need to be erected around the site of dust generation. If necessary, a perimeter fence will be installed around the project site as barrier for dust control.
- Tree plantations will be erected around the boundary for both component sites (new landfill, MRF and legacy landfill site). This will be initiated at the early stages by plantation of 2 to 3 years old saplings, the contract will mandate regular watering to ensure survival of the saplings, so that the area will be moist for most part of the day. The species chosen should be resilient to local conditions. Tree Plantations can help improve air quality by:
    - Absorbing pollutants from the air (carbon dioxide, sulphur dioxide, nitrogen oxides and volatile organic compounds).

[27] Gaffney, G. and Shimp, D. 1997. *Improving PM_{10} Fugitive Dust Emission Inventories*. Sacramento, CA. California Air Resource Board. <www.arb.ca.gov/emisinv/pubs/pm10tmp.pdf>

- Increase oxygen levels in the vicinity of the landfill helping to dilute odours and improve air quality.
- Trees can help reduce temperature around the landfill, cooler air disperses odours less than warm air.
- Trees can help filter particulate matter from the air.
- Trees can act as a natural sound barrier.
- The plantation will create habitats for various birds and wildlife and help. maintain the ecological balance of the area.

- The contractor should calculate the greenhouse gas emissions generated by the construction phase and should communicate how many emissions can be offset via planting of these plantations during the lifetime of the construction phase.
- All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations.
- Stockpiled soil and sand shall be slightly wetted before loading, particularly in windy conditions.
- Fuel-efficient and well-maintained haulage trucks shall be employed to minimize exhaust emissions, and engines should be switched off during loading or standing.
- Vehicles transporting soil, sand and other construction materials shall be covered with tarpaulin.
- A strict speed limit should be deployed within the construction site boundaries for both sites of 5-15km per hour. Lower speed limits are important for safety, dust control, soil erosion and noise reduction.
- Concrete plants to be controlled in line with statutory requirements and shall not be close to sensitive receptors.
- Stack height of generators will be at least 3 meters above the ground.
- The contractor should prepare a site-specific risk assessment prior to siting any batching plants. This will assess risks to the environment and local community from air quality, dust, noise and water pollution. A distance of 0.5km will be ensured between batching plant(s) and the nearest community, however this could be reduced if best available technology is deployed to limit risks.
- The need for large stockpiles shall be minimized by careful planning of the supply of materials from controlled sources. Stockpiles should not be located within 50 m of schools, hospitals or other public amenities and shall be covered with tarpaulin when not in use and at the end of the working day to enclose dust. If large stockpiles (>25m^3) of crushed materials are necessary, they should be enclosed with side barriers and covered when not in use.
- Dust emissions due to road travel shall be minimised through good construction practices (such as keeping stockpiles down wind and away from communities) and sprinkling water over the access road.
- Maintaining levels of contaminant dusts, vapours and gases in the work environment at concentrations below those recommended as TWA-TLV's (threshold limit value)—concentrations to which most workers can be exposed

repeatedly (8 hours/day, 40 hrs/week, week-after week), without sustaining adverse health effects.

- Developing and implementing work practices to minimize release of contaminants into the work environment including:
  - Direct piping of liquid and gaseous materials
  - Minimized handling of dry powdered materials
  - Enclosed operations
  - Local exhaust ventilation at emission/release points
  - Vacuum transfer of dry material rather than mechanical or pneumatic conveyance
  - Indoor secure storage, and sealed containers rather than loose storage
- Where ambient air contains several materials that have similar effects on the same body organs (additive effects).

Fugitive *Dust Control*

733. The source wise fugitive control measures are provided in **Table 8-7** below.

Table 8-7: Control measures for Fugitive Dust Emissions

Source	Control Measures
Earth Moving	For any earth moving that is to take place in the immediate vicinity from the site boundary, watering must be conducted as required to prevent visible dust emissions
Disturbed Surface Areas	Apply dust suppression measures (clear vegetation only from areas where work is to commence, plant or mulch areas that will not receive traffic, construct artificial wind breaks or wind screens) frequently to maintain a stabilized surface. Areas that cannot be stabilised, such as wind driven dust, must have an application of water at least twice a day
Inactive Disturbed Surface Areas	Apply dust suppressants (clear vegetation only from areas where work is to commence, plant or mulch areas that will not receive traffic, construct artificial wind breaks or wind screens) in sufficient quantity and frequency to maintain a stabilized surface
Unpaved Roads	Periodic sprinkling on all roads used for any vehicular traffic at least twice per day during active operations and restrict vehicle speed to 20 kmph
Open Storage Piles	Apply water to at least 80 percent of the surface areas of all open storage piles daily when there is evidence of wind driven fugitive dust or install an enclosure all along the storage piles Tarpaulin sheet should be provided on the storage piles to avoid dust emissions
Track-out Control	Wash down of construction vehicles (particularly tyres) prior to departure from site.

Vehicular *& Equipment Emissions*

734. It shall be ensured that the following measures are taken to control emissions from vehicles being used in the construction activity:

- Periodically check and conduct maintenance of the construction machinery and haul vehicles. Generators, compressors and vehicles used during construction works will be maintained in a good condition to ensure that emissions are kept to a minimum level. Where feasible solar powered equipment and electric vehicles will be utilised as opposed to fossil fuels.
- Vehicles will be switched off during loading/unloading or stationary.
- Regularly change the engine oil and use new engines/machinery/equipment having good efficiency and fuel burning characteristics.
- Controlled technology generator and batching plants will be used to avoid excessive emissions.
- Burning of wastes at any site will not be allowed.
- The stack height of generators will be at least 3 meters above the ground.
- Training of the technicians and operators of the construction machinery and drivers of the vehicles.
- All type of machinery and generator must comply with the PEQS. Vehicles, which are not in compliance with PEQS are not allowed to use.
- Periodic emission monitoring of vehicles, generator and batching plants is proposed.
- Project activities should be planned to avoid harsh weather conditions.

8.5.4 Loss of vegetation

Impacts

735. The project sites for both components may necessitate the removal of the natural vegetation which will deteriorate the environmental quality. As landfill site is barren land comprised of sand dunes therefore no significant vegetation loss is anticipated from the project. Similarly, MRF site is also barren with urban undulation therefore limited vegetation clearance is anticipated. BWMC office building is situated on a vacant piece of land in urban settlement hence no significant impact on project area vegetations is expected however plantation will be carried put to improve the aesthetic appeal of the area.

736. There is no significant site preparation impacts are anticipated from construction of new landfill site including compost plant, C&D recycling plant at Mari Sheikh Shijra area. Further no sensitive receptors are present in close proximity of i.e. 250 m radius of the site. Similarly, MRF is located adjacent to existing dump site where there is limited vegetation to be cleared and no significant habitat or area of agriculture activity is present therefore no significant impact is anticipated.

Mitigation Measures

737. Endeavours will be made to enhance the environment through a plantation of trees.

738. All preventive measures will be adopted to control the spill-over of chemicals and other effluents on the ground to protect the soil.

739. Ornamental trees and bushes will be planted in the project area, which will improve the scenic and aesthetic value of the area.

740. A buffer zone of indigenous plantation will be maintained along the Landfill site and MRF through plantation along the boundary.

741. *Acacia modesta, Dalbergia sissoo, Albizia lebbek, Phoenix dactylifera, Prosopis juliflora and Tamarix aphylla* are indigenous species of the area and will be planted as buffer zone from the landfill site and MRF. Also, ornamental trees will be planted to improve the aesthetics of the area.

742. Inside the boundary wall, tree plantation will be conducted to create an environmental barrier between the external and internal environment. For the landfill and MRF to present a clean and aesthetically pleasing view, buffer zone with tree plantation and landscaped berms will be done. Plantation will start as one of the earliest activities of site development. Once the design of landfill is approved and necessary funds mobilized, plantation activity can be started by BWMC.

8.5.5 Damage to Wildlife

Impacts

743. The project site is small and inhibits no wildlife, while smoke, chemicals, dust particles, and noise generated by construction machinery during the construction period are the scary factor for biota. Rodents and insects would lose their abode.

744. The Project site falls outside of key biodiversity/ protected areas, and it is not habitat of key species. The project site is flat terrain piece of deserted land. The sand dunes are deposited all over the project area which comprises of mostly flat terrain with scattered vegetation consisting of bushes, grasses and some trees across the site. Due to limited vegetation and desert environment, no wildlife is permanent resident of the site however impacts on wildlife may arise from the following project activities:

- Noise generated from project activities,
- Movement of personnel and vehicles,
- Lights used at the project facilities,
- Clearing of vegetation, and
- Improper disposal of wastes
- Endeavours will be made to enhance the environment through a plantation of trees.

Mitigation Measures

745. Following mitigation measures will be adopted to reduce the impact on wildlife:

- Special measures will be adopted to minimize impacts on birds, such as avoiding noise-generating activities.
- The measures to enhance natural vegetation in the area will benefit the area's fauna as well.
- The project staff will not be allowed to indulge in any hunting or trapping activities.
- Appropriate diffusers will be used to restrict the illumination within the project site.
- Night time construction works will not be undertaken.
- No off tracking will be practiced. Work area will be minimized, and movement will be restricted to designated routes.

8.5.6 Health and Safety

Community Health and Safety

Impacts

746. Development of both components will involve the use of considerable heavy machinery at the project site along with posing the risk of community members falling into trenches. In addition, the risk to commuters on the road during the construction works will be significant and thus several precautionary measures will be necessary to minimize the risk of possible accidents. Community Health & Safety may be compromised during road travel particularly in night hours if adequate barriers and lighting is not provided at construction sites.

747. Land development and civil works can generate substantial number of dusts particularly from excavations and dirt roads. Air emissions from hauling trucks and heavy equipment can also be pervasive. These particulates (especially PM10) and emissions from exhausts vehicles may pose some levels of health hazards to workers at the site.

Mitigation Measures

748. The following mitigation measures will be implemented:

- Work areas outside the project site, especially where machinery is involved, will be barricaded and will be constantly monitored to ensure that residents, particularly children stay away while excavated areas being prepared for landfill related infrastructure will also be cordoned off. Also, no machinery will be left unattended, particularly in running condition.
- Local communities in the project area will be briefed on traffic safety, especially women who are the main care providers to children.
- Speed limit of 20 km/hr will be maintained by all project related vehicles and night-time driving of project vehicles will be limited where possible.
- Drivers will be educated on safe driving practices to minimize accidents and to prevent spill of hazardous substances and other construction materials during transport.
- The contractor will take appropriate safety measures to avoid people, especially children, accidentally falling into excavations. Excavations deeper than 0.5m will be protected by locked fencing, taped or covered with metal covers. If lockable

fencing cannot be provided the area should be manned with security whilst unattended.

- All the working platforms must be cordoned off with special care by well-trained skilled workers.
- The Contractor will prepare site specific environmental management plan (SSEMP) which will include the hazard prevention and safety plan, which will address the health and safety of the people in the project area.
- PMU Punjab LG&CDD should ensure the contractor staff working in the project are well trained and educated in the Health, Safety and Environment (HSE) hazards associated with their duties, and that of the public, in the project area.

Occupational Health and Safety (OHS)

Impacts

749. There is invariably an OHS risk when construction works for Components 1 and 2 are conducted, and precautions will be needed to ensure the safety of the workers.

750. The major OHS hazards expected during the proposed activities are as follows:[28]

Accident Hazards

- Falls from height, especially when standing/working on ladders;
- Slips, trips and falls, especially while carrying heavy or bulky loads;
- Cuts and injuries caused by sharp instruments and tools;
- Hazard of suffocation from asphyxiant gases released or from oxygen deficiency, during maintenance and cleaning operations;
- Burns caused by hot parts of equipment, steam lines etc, by release of hot water or steam;
- Electric traumas, caused by defective installations and equipment, especially portable;
- Musculoskeletal injury (especially of back), resulting from lifting and moving of heavy loads;

Physical Hazards

- Exposure to cold and/or heat stress, as a result of rapid movement between cold and hot areas;
- Exposure to UV radiation during welding operations;

Chemical Hazards

[28] https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_192256.pdf

- Exposure to various chemicals, such as: adhesives, caulking compounds, fluxes (solder), hydrochloric acid, zinc chloride, tar and solvents, various greases and inorganic lead;

Biological Hazards

751. Exposure to parasites, such as hookworm, ascaris, and various mites, chiggers and ticks;

Ergonomic, psychosocial and organizational factors

- Psychological stress due to dissatisfaction at work due to issues with peers, superiors etc.

- General ill feeling as a result of work in confined spaces and development of 'sick building syndrome'.

Mitigation Measures

General

752. The Contractor will be required to prepare and implement an effective OHS and ERP Plans that is supported by trained OHS personnel and emergency response facilities. Construction contracts will include standard OHS measures and contractors will be bound to implement these fully.

753. Monitoring will be required to ensure that the health and safety plan based on contract specifications is followed.

- Cement feed hopper areas will be inspected daily to ensure compliance with the requirement of dust masks.

- Surfaces (including flooring and work surfaces) in camps, kitchens, dining areas and workshops should be solid and easy to clean. Flooring for work camps must be float finished concrete or better. Camps and Kitchens should be provided with appropriate waste storage and collection to prevent and control vectors that spreading disease.

- All drivers engaged by Contractors must hold a valid license for the vehicle they are operating.

- Work in confined space shall be executed with available safety standards. Adequate monitoring and equipment shall be available to detect deficient oxygen levels.

- The Contractor shall submit to the Engineer for approval an emergency evacuation plan and practice the procedure annually.

- The Contractor shall submit to the Engineer for approval a site layout plan, identifying work areas, accommodation, kitchen, dining area, sanitary facilities, location of generators, plant and vehicle parking, transport routes through the camp, pedestrian routes through the camp, evacuation routes, emergency exits, batching plants, storage areas, waste facilities etc.

- Fire extinguishers should be provided throughout camps and work sites. Fire extinguishers should be inspected monthly and maintained as necessary.

- An adequate and reliable supply of safe drinking water shall be made available at readily accessible and suitable places including at all camps.

- The Contractor shall take samples from each supply of drinking water and arrange for analysis of these samples at EPA certified laboratory prior to its use by the Contractor's staff. The results of these tests for each supply must be submitted to the Engineer and must demonstrate that each water supply meets national and World Health Organization standards for drinking water.

- The Contractor shall provide and maintain adequate hygienic kitchens which are sheltered and separated from the living quarters. Kitchens shall include raised and washable surfaces suitable for food preparation.

- The Contractor shall provide and maintain adequate hygienic dining areas for staff. Workplaces and camps should be provided with both natural and artificial light. Artificial lighting should be powered by generator in the event of power cuts.

- Public sensitization training should be provided to workers to avoid social conflicts between residents and the construction contractor. Occurrence of any such impacts can be avoided by community sensitive project planning and implementation and through effective involvement of local administration.

- All OHS protocols should be implemented in true letter and spirit.

- Contractor must appoint an OHS resource to implement, monitor and report the HSE management plan to concerned authorities.

- Contractor must ensure the provision of first aid facility at construction site and camps through hiring medics and establishing a dispensary at the campsite.

- Reasonable number of first aid kits should be available on construction sites and within contractor camps.

- Site personnel will be provided appropriate type of personal protective equipment (PPEs). Contractor will ensure consistent use of PPEs.

- Worker welfare inspections should be undertaken regularly throughout the construction works and findings shared with the PMU.

754. Based on the type of hazard applicable during the proposed works at site, the mitigation measures as per IFC guidelines for Occupational Health and Safety (OH&S) must be implemented:[29]

755. Emergency response plan to provide measures and guidance for the establishment and implementation of emergency preparedness plans during project execution is provided as **Appendix A.6.**

756. Incident investigation form is attached as **Appendix A.10.**

Mitigation Measures for Phys*ical Hazards*

Rotating and Moving Equipment

757. Injury or death can occur from being trapped, entangled, or struck by machinery parts due to unexpected starting of equipment or unobvious movement during operations. Mitigation measures related to rotating and moving equipment on workers are provided below:

[29] https://www.ifc.org/wps/wcm/connect/1d19c1ab-3ef8-42d4-bd6b-cb79648af3fe/2%2BOccupational%2BHealth%2Band%2BSafety.pdf?MOD=AJPERES&CVID=ls62x8l

- Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions.
- Where a machine or equipment has an exposed moving part or exposed pinch point that may endanger the safety of any worker, the machine or equipment should be equipped with, and protected by, a guard or other device that prevents access to the moving part or pinch point. Guards should be designed and installed in conformance with appropriate machine safety standards.
- Turning off, disconnecting, isolating, and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored (e.g. compressed air, electrical components) during servicing or maintenance.
- Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms.

Vibration

758. Exposure to hand-arm vibration from equipment such as hand and power tools, or whole-body vibrations from surfaces on which the worker stands or sits, should be controlled through choice of equipment, installation of vibration dampening pads or devices, and limiting the duration of exposure. Limits for vibration and action values. Exposure levels should be checked based on daily exposure time and data provided by equipment manufacturers.

759. Other sources of vibration at construction site are rollers, compactors or any loose part of machinery exposure which may cause serious injury or workplace sickness. No equipment and machinery with loose or vibratory parts will be allowed to work. Such issues will be fixed through maintenance of the machinery on periodic basis. Use of rollers for land grading will be carried out during day times and with intermittent intervals to reduce the impacts of vibration on surrounding environment.

760. Considering the project setting, which is not in a congested urban environment and instead is a rural open setting, there is no potential risks with regards to vibration.

Electrical

761. Exposed or faulty electrical devices, such as circuit breakers, panels, cables, cords and hand tools, can pose a serious risk to workers. Overhead wires can be struck by metal devices, such as poles or ladders, and by vehicles with metal booms. Vehicles or grounded metal objects brought into close proximity with overhead wires can result in arcing between the wires and the object, without actual contact. Recommended actions include:

- Marking all energized electrical devices and lines with warning signs;
- Locking out (de-charging and leaving open with a controlled locking device) and tagging out (warning sign placed on the lock) devices during service or maintenance;
- Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools;
- Double insulating / grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits;

- Protecting power cords and extension cords against damage from traffic by shielding or suspending above traffic areas;

- Conducting detailed identification and marking of all buried electrical wiring prior to any excavation work.

Eye Hazards

762. Solid particles from a wide variety of industrial operations, and/or a liquid chemical spray may strike a worker in the eye causing an eye injury or permanent blindness. Recommended measures include:

- Use of machine guards or splash shields and/or face and eye protection devices, such as safety glasses with side shields, goggles, and/or a full-face shield. Specific Safe Operating Procedures (SOPs) may be required for use of sanding and grinding tools and/or when working around liquid chemicals. Frequent checks of these types of equipment prior to use to ensure mechanical integrity is also good practice. Machine and equipment guarding should conform to standards published by organizations such as CSA, ANSI and ISO.

Welding/Hot Work

763. Welding creates an extremely bright and intense light that may seriously injure a worker's eyesight. In extreme cases, blindness may result. Additionally, welding may produce noxious fumes to which prolonged exposure can cause serious chronic diseases. Recommended measures include: ·

- Provision of proper eye protection such as welder goggles and/or a full-face eye shield for all personnel involved in, or assisting, welding operations. Additional methods may include the use of welding barrier screens around the specific workstation (a solid piece of light metal, canvas, or plywood designed to block welding light from others). Devices to extract and remove noxious fumes at the source may also be required. ·

- Special hot work and fire prevention precautions and Standard Operating Procedures (SOPs) should be implemented if welding or hot cutting is undertaken outside established welding workstations, including 'Hot Work Permits, stand-by fire extinguishers, stand-by fire watch, and maintaining the fire watch for up to one hour after welding or hot cutting has terminated. Special procedures are required for hot work on tanks or vessels that have contained flammable materials.

Industrial Vehicle Driving and Site Traffic

764. Poorly trained or inexperienced industrial vehicle drivers have increased risk of accident with other vehicles, pedestrians, and equipment. Industrial vehicles and delivery vehicles, as well as private vehicles on-site, also represent potential collision scenarios. Industrial vehicle driving and site traffic safety practices include:

- Training and licensing industrial vehicle operators in the safe operation of specialized vehicles such as forklifts, including safe loading/unloading, load limits.

- Ensuring drivers undergo medical surveillance.

- Ensuring moving equipment with restricted rear visibility is outfitted with audible back-up alarms.

- Establishing rights-of-way, site speed limits, vehicle inspection requirements, operating rules and procedures (e.g. prohibiting operation of forklifts with forks in down position), and control of traffic patterns or direction.
- Restricting the circulation of delivery and private vehicles to defined routes and areas, giving preference to 'one-way' circulation, where appropriate.

Ergonomics, Repetitive Motion, Manual Handling

765. Injuries due to ergonomic factors, such as repetitive motion, overexertion, and manual handling, take prolonged and repeated exposures to develop, and typically require periods of weeks to months for recovery. These OHS problems should be minimized or eliminated to maintain a productive balance. Controls may include:

- Facility and workstation design with 5th to 95th percentile operational and maintenance workers in mind.
- Use of mechanical assists to eliminate or reduce exertions required to lift materials, hold tools and work objects, and requiring multi-person lifts if weights exceed thresholds.
- Selecting and designing tools that reduce force requirements and holding times and improve postures. ·
- Providing user adjustable workstations.
- Incorporating rest and stretch breaks into work processes and conducting job rotation.
- Implementing quality control and maintenance programs that reduce unnecessary forces and exertions.
- Taking into consideration additional special conditions such as left-handed persons.

Working at Heights

766. Fall prevention and protection measures should be implemented whenever a worker is exposed to the hazard of falling more than two meters; into operating machinery; into water or other liquid; into hazardous substances; or through an opening in a work surface. Fall prevention / protection measures may also be warranted on a case-specific basis when there are risks of falling from lesser heights. Fall prevention may include:

- Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard area. ·
- Proper use of ladders and scaffolds by trained employees. ·
- Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self-retracting inertial fall arrest devices attached to fixed anchor point or horizontal life-lines. ·
- Appropriate training in use, serviceability, and integrity of the necessary PPE. ·
- Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall.

767. These include:

Fire and Explosions

768. Fires and or explosions resulting from ignition of flammable materials or gases can lead to loss of property as well as possible injury or fatalities to project workers. Prevention and control strategies include:

- Fuel storage areas and generators will have secondary containment in the form of concrete or brick masonry bunds. The volume of the containment area should be equal to 120% of the total volume of fuel stored.
- Storing flammables away from ignition sources and oxidizing materials. Further, flammables storage area should be:
    - Remote from entry and exit points into camps
    - Away from facility ventilation intakes or vents
    - Have natural or passive floor and ceiling level ventilation and explosion venting
    - Use spark-proof fixtures
    - Be equipped with fire extinguishing devices and self-closing doors and constructed of materials made to withstand flame impingement for a moderate period of time.

769. Defining and labelling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment). ·

770. Providing specific worker training in handling of flammable materials, and in fire prevention or suppression.

Corrosive, oxidizing, and reactive chemicals

53. Corrosive, oxidizing, and reactive chemicals present similar hazards and require similar control measures as flammable materials. However, the added hazard of these chemicals is that inadvertent mixing or intermixing may cause serious adverse reactions. This can lead to the release of flammable or toxic materials and gases and may lead directly to fires and explosions. These types of substances have the additional hazard of causing significant personal injury upon direct contact, regardless of any intermixing issues. The following controls should be observed in the work environment when handling such chemicals:

- Corrosive, oxidizing and reactive chemicals should be segregated from flammable materials and from other chemicals of incompatible class (acids vs. bases, oxidizers vs. reducers, water sensitive vs. water based, etc.), stored in ventilated areas and in containers with appropriate secondary containment to minimize intermixing during spills.
- Workers who are required to handle corrosive, oxidizing, or reactive chemicals should be provided with specialized training and provided with, and wear, appropriate PPE (gloves, apron, splash suits, face shield or goggles, etc).
- Where corrosive, oxidizing, or reactive chemicals are used, handled, or stored, qualified first-aid should be always ensured. Appropriately equipped first-aid

stations should be easily accessible throughout the place of work, and eye-wash stations and/or emergency showers should be provided close to all workstations where the recommended first-aid response is immediate flushing with water.

Mitigation Measures for Biological Hazards

771. Biological agents represent potential for illness or injury due to single acute exposure or chronic repetitive exposure. Biological hazards can be prevented most effectively by implementing the following measures: ·

- The contractor should review and assess known and suspected presence of biological agents at the place of work and implement appropriate safety measures, monitoring, training, and training verification programs.
- Project contractor must provide good working and sanitation conditions at camp and wok sites. Disease surveillance should be carried out to identify any exposure to parasites, such as hookworm, ascaris, and various mites, chiggers, ticks and dengue.
- Measures to eliminate and control hazards from known and suspected biological agents at the place of work should be designed, implemented and maintained in close co-operation with the local health authorities and according to recognized international standards.

8.5.7 Noise and Vibration

Impacts

772. The impact of noise will be significant during the construction phase. The sources of impacts are mostly the vehicles and equipment that will be moving around the construction site, entering and leaving the project site.

773. Noise disturbance during the construction phase is inevitable due to the operation of typical construction equipment and machineries. This equipment typically has average noise levels of 70 – 105 dB at 15m.

774. The noise to be generated by these equipment and machines are expected to be confined within a radius of 500 meters up to 1 kilometre from the construction site. Any distance further than 1 kilometre will no longer experience the impact of the construction activities.

775. The detailed mapping of sensitive receptors has been conducted and the types of receptors and their respective distances from the work sites are provided earlier. However, any required mitigation measures that will be proposed will be to control potential impacts on noise to prevent any long-term impacts within the project area.

776. The assessment of the noise impacts on the sensitive receptors that have been identified at various locations in the project area depends upon:

- Characteristics of noise source (instantaneous, intermittent or continuous in nature)
- Time of day at which noise occurs, and
- Location of noise sources.

777. Each construction activity has its unique noise characteristics due to use of different equipment items. The potential sources of noise during the preparation,

construction, and worksite closure phases for the landfill works include equipment, machinery, and transportation used for the construction activities. The equipment used for construction will be the major source of noise.

778. The construction activities will include use of many trucks, generators, excavators etc., which can generate significant noise.

779. Since various modern machines are acoustically designed to generate low noise levels, any high noise levels that might be generated will only be for a short duration during the construction phase.

780. Depending on the construction equipment used and its distance from the receptors, the community and the workers may typically be exposed to intermittent and variable noise levels. During the day, such noise results in general annoyance and can interfere with sleep during the night. In general, human sound perception is such that a change in sound level of 3 dB is just noticeable, a change of 5 dB is clearly noticeable, and a change of 10 dB is perceived as a doubling or halving of sound level.

781. Due to the various construction activities, there will be temporary noise impacts in the immediate vicinity of the project site. The movement of heavy vehicles, loading, transportation and unloading of construction materials produces significant noise during the construction stage. However, these increased noise levels will prevail only for a short duration during the construction phase.

782. The **Table 8-8** below represents typical noise levels from various construction equipment items. It should be noted that the values indicated in the table may differ depending on the brand and age of machinery provided/used by construction contractors.

Table 8-8: Construction Equipment Noise Ranges, dB(A)

Equipment	Peak Noise Range at 15 m	Typical Peak Sound Level in a Work Cycle[a] at 15 m	Typical 'Quieted Equipment' Sound Level[b] at 15 m	Construction Phase		
				Earthworks	Structures	Installation
Batching plant	82-86	84	81		Y	
Concrete mixers	76-92	85	82		Y	
Cranes	70-94	83	80		Y	Y
Excavators	74-92	85	82	Y		
Front loader	77-94	85	82	Y	Y	Y
Water bowsers	85-93	88	85	Y	Y	Y
Graders	72-92	85	82	Y		
Bulldozers	65-95	85	80	Y		
Pavers	87-89	88	80	Y		
Pumps	68-72	76	75	Y	Y	Y

Equipment	Peak Noise Range at 15 m	Typical Peak Sound Level in a Work Cycle[a] at 15 m	Typical 'Quieted Equipment' Sound Level[b] at 15 m	Construction Phase		
				Earthworks	Structures	Installation
Diesel generators	72-82	81	77		Y	Y
Drilling machines	82-98	90	87		Y	Y
Compressors	74-88	81	71		Y	
Dumpers	77-96	88	83	Y	Y	
Dump/flatbed Truck	75-85	80	77	Y	Y	Y

Sources: USEPA, 1971; http://www.waterrights.ca.gov/EIRD/text/Ch11-Noise.pdf; http://www.lacsd.org/LWRP%202020%20Facilities%20Plan%20DEIR/4_6_Noise.pdf; http://newyorkbiz.com/DSEIS/CH18Construction.pdf

Notes:

a. Where typical value is not cited in literature, mean of the peak noise range is assumed

b. Quieted equipment can be designed with enclosures, mufflers, or other noise-reducing features. Where data is not available, a 3 dB reduction is assumed

783. Precise information on the type, quantity and location of equipment to be used during the construction phase is not available at this stage and will be dependent on the working methods of the selected contractors. However, preliminary calculations have been conducted to provide a general magnitude of the noise levels during various construction phases.

784. The mitigation measures listed below shall be implemented to minimise noise levels during the construction activity as far as possible.

Mitigation Measures

785. The following mitigation measures will be implemented:

- Equipment noise will be reduced at source by proper design, maintenance and repair of construction machinery and equipment. Noise from vehicles and power generators will be minimized by use of proper silencers and mufflers.
- Excessive noise emitting equipment will not be allowed to operate and will be replaced.
- Blowing of horns will be prohibited on access roads to work sites.
- As a rule, the operation of heavy equipment shall be conducted in daylight hours.
- Construction equipment, which generates excessive noise, shall be enclosed or fitted with effective silencing apparatus to minimize noise.
- Well-maintained haulage trucks will be used with speed controls.

- Use of ear plug and earmuffs must be ensured during construction. No employee should be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).

- Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible.

- Periodic medical hearing checks should be performed on workers exposed to high noise levels.

- All the equipment and machinery used during construction phase should be well maintained and in compliance with PEQS/WHO.

- Grievance redress mechanism to deal any public complaints related to noise is established.

8.5.8 Hazardous and Non-Hazardous Waste Disposal

Impacts

786. During construction/civil works, potential sources of waste will include spoils generated during landfill cells excavation, excavation waste for other civil works, domestic wastes (solid & wastewater), fuel or oil leakages or spills, onsite effluents from vehicle wash & cleaning, and cement spills.

787. Waste disposal of materials containing contents of both hazardous and non-hazardous nature such as scrap wood, bricks, concrete, asphalt, plumping fixtures, piping, insulation (asbestos and non-asbestos), metal scraps, oil, electrical wiring and components, chemicals, paints, solvents etc. can potentially become a serious environmental issue, particularly with the local contractors. To avoid any potential issue, the PMU in collaboration with focal agencies will need to impose adequate internal controls.

788. Domestic wastes generated during construction Bahawalpur SWF will include sewage, grey water (from kitchen, laundry, and showers), kitchen wastes, combustible wastes and recyclable wastes from contractor camps.

Mitigation measures

789. A waste management plan will be developed prior to the start of construction. This plan will cater to sorting of hazardous and non-hazardous materials prior to disposal, placing of waste bins at the project sites for waste disposal and an onsite hazardous waste storage facility i.e. designated area with secondary containment.

790. Licensed waste contractors will be engaged to dispose of all non-hazardous waste material that cannot be recycled or reused.

- Excavated material from landfill cells will be stored at site and it will be used as daily cover within landfill cells.

- All types of combustible and non-combustible waste including plastic or glass bottles and cans will be temporarily stored on site and later sold/handed over to a waste/recycling contractor who will utilize these wastes for recycling purposes.

- Waste management training for all site staff to be included in Contractor's training plan.
- Fuel storage areas and generators will have secondary containment in the form of concrete or brick masonry bunds. The volume of the containment area should be equal to 120% of the total volume of fuel stored.
- Fuel and hazardous material storage points must be included in a camp layout plan to be submitted for approval. Hazardous material storage areas shall include a concrete floor to prevent soil contamination in case of leaks or spills. Fuel tanks will be checked daily for leaks and all such leaks will be plugged immediately.
- Designated vehicles/plant wash down and refuelling points must be included in camp layout plan to be submitted for approval.
- Hazardous waste will be initially stored on site at designated area and then handed over to EPA certified contractor to final disposal.
- Record of waste generation and transfers shall be maintained by project contractors.
- Spill kits, including sand buckets (or other absorbent material) and shovels must be provided at each designated location.
- At the time of restoration, septic tanks will be dismantled and backfilled with at least 1m of soil cover keeping in view landscape of surrounding natural surface.
- It will be ensured that after restoration activities, the campsite is clean and that no refuse has been left behind.
- Clinical wastes will be temporarily stored onsite separately and will be handed over to approve waste contractor for final disposal.
- Training will be provided to personnel for identification, segregation and management of waste.
- The structure of a Framework waste management plan has been prepared for the project and attached as **Appendix A.13** and contractors will be required to prepare a waste management plan for the site in light of guidelines provided in the waste management plan and submit to PMU LG&CDD for approval.

8.5.9 Waste Effluent Disposal

Impacts

791. The staff and labour camps for the construction of the proposed landfill will be a source of wastewater generated from the toilets, washrooms and the kitchen. The wastewater will not meet the national environmental standards and will therefore need treatment prior to disposal.

792. The project sites where construction is being conducted must not be treated by the project staff and/or labour as a public toilet or for disposal of camp effluent.

Mitigation measures

- It will be ensured that no untreated effluent is released to the environment.

- A closed sewage treatment system including soak pits and septic tank will be constructed to treat the effluent from the construction/labour camps.
- Sewage treatment system will be installed at each respective labour camp based on the number of labourers residing at the respective camp.
- Wastewater from laundry, kitchen washings and showers will be disposed-off into soak pits or septic tank (where soak pit cannot be constructed) and after treatment it will disposed of in TMA provided drains in the project area.
- Soak pits will be built in absorbent soil and shall be located 300 m away from a water well, hand pump or surface water body. Soak pits in non-absorbent soil will not be constructed.
- Ensure that the soak pits remain covered all the time and measures are taken to prevent entry of rainwater into them.
- Sprinkling of grey water or sewage will not be allowed; in case the septic tank gets filled with sludge, septic tank shall be emptied through vacuum truck and material shall be transferred to treatment facility or approved municipal drain.
- Water being released from any batching plant(s) must be treated as per requirements of PEQS and WHO prior to release to sewerage system/any other water body.
- Sewage at the end of construction period to be disposed of in nearest municipal drains after getting approval from concerned municipal authorities.

8.5.10 Soil Erosion and Sedimentation

Impacts

793. Most of the works proposed for development of the landfill, MRF and BWMC office building may result in soil erosion and sedimentation. Spoils will be generated from the excavation activities, particularly during construction of landfill cells. Potential impacts from spoils and their disposal are (i) land for disposal of spoil, (ii) potential erosion from the spoil areas and spoil material reaching the waterways, and (iii) aesthetic impacts. Excavated soil will be stored at site and will be used as daily cover during landfill operations.

Mit*igation measures*

794. Any drainage structures, culverts or pipes crossing the project site may need to be modified or protected and the detailed designs must make provisions to protect or re-provision all infrastructure that may be affected by the construction works.

8.5.11 Employment Conflicts

Impacts

795. The proposed construction of Bahawalpur Landfill is not likely to create any significant permanent job opportunities. Even unskilled and semi-skilled employment opportunities that are likely to be created will be for a short period, while the landfill project is constructed. As persons with relevant skills may be available locally, people from the project area are likely to fill a significant number of the semi-skilled and skilled jobs.

796. This issue of provision of jobs can become particularly problematic if it is perceived by the local population that a significant number of construction-related jobs opportunities are not given to people from the local community. This can result in friction between residents and construction workers from outside of the community.

Mitigation measures

- The Construction Contractor will adopt a transparent hiring policy. Prior to the commencement of the construction activity, the local communities in the project area will be informed of the employment policy in place and number of people that can be employed for this project.
- It will be ensured that maximum number of unskilled and semi-skilled jobs will be provided to the residents of the project area.
- The PMU Punjab LG &CDD will ensure a balanced process of employment of the communities in the project area with preference given to those most directly affected by the project.

8.5.12 Historical/Archaeological Sites

Impacts

797. No historical/archaeological sites have been identified in the project area or project site.

Mitigation measure*s*

798. If evidence of any archaeological remains is found during the construction activities, the excavation work will be stopped immediately, and necessary next steps taken to identify the archaeological discovery based on the 'Chance Find' procedures provided as **Appendix A.7**.

8.5.13 Impacts associated with Construction of BWMC Office and Administration Buildings and other infrastructure including construction of roads, reception areas and security offices

Impacts

799. Bahawalpur LFS will have proper facilities like administration building, waste reception areas, weigh bridge, waste inspection area, wheel wash area, site services and security fencing and professionally trained workers to operate and supervise.

800. An Administration building will be constructed on the Component 1 site to house administration staff and manage the facility operations within Bahawalpur landfill. It is planned such that it can accommodate landfill operations team, has a laboratory for quality control and MIS monitoring room for data acquisition and transfer to head office. The building also contains a conference room for meetings at landfill, an inventory room for storing supplies for repair and maintenance of landfill machinery and vehicles. There are showers, prayer area, rest rooms and a kitchen in the building. A car park outside the building will be constructed for personnel's' vehicles. The area of the administrative building is surrounded by landscaping and greenery.

801. Roads inside the premises will be constructed. Road 10 m wide with two lanes each 4 m for two-way traffic of waste carrying vehicles will be constructed. Access roads within cells (8 meters wide) will be constructed at 1:10 longitudinal slope.

Vehicle parking shed for waste vehicles, a workshop for routine repair and maintenance work will be constructed.

802. BWMC office building will be constructed on already owned land (1.12 acres) of BWMC located at Hasilpur road. Building will comprise of ground floor plus 4 storeys. A building will be used for office of BWMC and other floors are rented out to commercial parties in order to generate revenue for the company.

803. Soil erosion is main impact during construction of admin and BWMC office buildings and associated infrastructure. Construction of roads or other facilities has also been historically perceived and in some cases has led to soil erosion. The possibility of soil erosion has been assessed in detail in the following paragraphs.

804. The possibility of soil erosion from a human activity increase when soil particles are detached from the soil mass. This is true for agricultural lands where a certain landscape is changed, and the area is left exposed to wind and water erosion and for dirt tracks which are developed through continual use by vehicles and the soil surface is subject to continual erosion for as long as the track is used. However, these cases are different from scenarios in which the soil surface initially disturbed is sealed or compacted by engineering means. For example, metalled roads are not subject to soil erosion, similarly neither would the gravel-topped roads which will be compacted to sustain loads.

805. Other environmental impacts from construction of administration and BWMC office buildings includes construction debris, unattended concrete and cement waste, brick waste, littering and empty cement bags which required to be disposed off as per waste management plan. Flooring works will add to slurry waste resulting from grinding activities. Noise from mixing plants, steel fixing works, wood works is another source of environmental nuisance which need to be managed. Use of generators, vehicles and machinery may be source of air pollution if not managed.

806. All the identified sensitive receptors are located at a safe distance from the administration building and BWMC office building and impacts associated with construction of buildings are limited to construction sites only and of short duration which can be managed through good construction management practices.

807. Based on the above, it can be assessed that on a macro level environmental impacts from construction of admin building within landfill site, BWMC office building at Hasilpur road and associated infrastructure will not be a significant issue as all these impacts will be managed through implementation of site specific EMP prepared by contractors and approved by CSC/PMU with consent of ADB within 28 days of contract award. No civil works will be allowed to start without approval of SSEMP.

Mit*igation measures*

808. The following are the mitigation measures that will be employed to manage impacts from construction of BWMC office building at Hasilpur road, administration building within landfill site and associated infrastructure.

- Water will be sprinkled regularly to suppress dust emissions. Off road travelling of vehicles will be prohibited.
- Stockpiles will be appropriately located and out of wind to avoid dust emissions. Dry dusty materials should be sprinkled with water and properly covered to avoid dust emissions.

- No cement and concrete waste will be left unattended. Construction debris will not be thrown from height to avoid dust emissions. Return unpaved areas to original or improved contours following construction.
- Solid waste generated from construction of admin and BWMC office buildings will be managed through site specific EMMP and no waste will be stored at site to improve housekeeping at site and to avoid environmental nuisance.
- Set protocols for proper and regular maintenance of construction machinery, vehicles and generators working at building sites. Generators that will be used will be placed at suitable locations to avoid nuisance.
- The contractor will not be allowed to store bulk quantities of fuel or hazardous material at building sites.
- Any fuel or chemicals stored at building sites (in small quantities) will be stored at designated site and containers/storage vessels be properly marked for their contents. Storage areas will be provided with hard impervious surface and secondary containment.
- Equipment and machinery with loose vibratory parts will not be allowed to use. Used equipment and machinery will comply to PEQS.
- Waste bins will be provided at appropriate places to manage waste. Daily housekeeping of the construction area will be carried out.

8.5.14 Impacts associated with Construction of Access Roads for Component 1 and 2.

Impacts

809. The following approach highlights the roads to be constructed as part of Bahawalpur ISWMS:

- The new landfill site (Component 1) will require a new 2.5km road from the main access road and improvement of the main access road for about 10km.
- Approximately 5 kilometres of road improvements will be necessary for the access road leading to Component 2.
- Road construction may impact physical and chemical soil conditions, water flow and air and water quality, as well as flora and fauna.
- Major activities of road works will include preparation of sub-grade, sub-base, base and wearing course. Major equipment to be involved in road widening works are tractor, bulldozer, roller, compactor, shovel, grader, dumper, aggregate distributor and spreader, asphalt mixer, bitumen boiler and sprayer, concrete mixer and paver, batching plant and finisher.
- The development of the access road will involve earth works and transporting and dumping large quantities of debris material. This will likely lead to an increase in SPM (Suspended Particulate Matter) at the road construction site. Construction of roads has been historically perceived and, in some cases, has led to soil erosion. The landfill development will involve the use of considerable heavy machinery at the project site along with posing the risk to commuters on the road during the construction works.

- Main impacts associated with road widening are noise, dust and vibrations and construction waste. Noise mainly occurs during road construction phases, but it can also occur to a lesser degree during maintenance operations. Dust is created during the construction of roads and unbound aggregate layers. Dust is an almost inevitable consequence of roadworks. Gravel and crushed gravel and hard rock aggregates always contain a proportion of fines, and if the material is dry, a heavy dust cloud can be raised when it is mobilised. The resulting dust can disturb both the population and the local environment.

- Excess dust production can be treated by a range of measures such as watering, use of alternative materials and by using dust binders near houses. Vibration can be caused by uneven road surfaces and can pose significant impacts and problems to houses close to the source. Vibrations disturb people close to roads, but they may also cause damage to buildings and sensitive equipment. Scarification, material cutting, formworks and foundation works, and poor material management are the sources of waste generation during widening of roads.

Mitigation Measures

810. The following mitigation measures will be implemented during construction of the proposed access roads and improvements to existing roads:

- The road widening will be to a standard that is suitable for movement of high-capacity waste carrying vehicles.

- BWMC/PMU will maintain close coordination with the residents living close to road widening works, project information leaflets will be distributed to them and awareness with respect to impacts (noise, dust and vibrations) associated with construction will be provided. If people are notified, their acceptance of the disturbance is usually higher.

- BWMC/PMU will arrange a community consultation session before commencement of construction works to make the public aware of the works which will facilitate smooth execution of project activities.

- Compaction with heavy vibration rollers should be avoided or minimized in built-up areas.

- Work areas outside the project site, especially where machinery is involved, will be barricaded and will be constantly monitored to ensure that residents, particularly children stay away.

- Local communities in the project area will be briefed on traffic safety, especially women who are the main care providers to children.

- Traffic diversions will be planned in such a way that it does not create traffic congestion during road widening works. Road closure for the works will be avoided.

- A proper drainage system will be provided to prevent excessive surface water run-off and impacts to local surface water bodies (e.g. irrigation channels).

- Off-road travel will be strictly prohibited and observance of this will be monitored during execution of the project.

- Vehicle speeds will be regulated and monitored to avoid excessive dust emissions.

- Blowing of horns will be prohibited on access roads to work sites.

- Vehicles engines will be switched off during loading/unloading or stationary periods.
- Periodic sprinkling on access road at least twice per day during construction phase and restrict vehicle speed to 20 kmph.
- Controls will be put in place to ensure access and egress to labour camps will not impact normal traffic flow.
- Contractors will prepare a construction management plan which will include the hazard prevention and safety plan, which will address health and safety of the people in the project area.
- The contractor will prepare an environmental management plan specific to the works being undertaken that incorporates the EMP of the IEE but is also site specific to their work specifications and local area. This will be shared and agreed with the PMU prior to works commencing.
- PMU Punjab LG&CDD should ensure the contractor staff working in the project are well trained and educated in the Health, Safety and Environment (HSE) hazards associated with their duties, and that of the public, in the project area.
- Record of waste generation and transfer shall be maintained by project contractor and all wastes will be deposited in appropriately licensed facilities.
- Periodic water sprinkling will be carried out during widening works to suppress dust.
- Fuel-efficient and well-maintained equipment and machinery shall be employed to minimize exhaust emissions. Where possible, electric and solar powered equipment will be utilized in preference to fossil fuels.
- The need for large stockpiles shall be minimised by careful planning of the supply of materials from controlled sources. Stockpiles should not be located within 50 m of schools, hospitals or other public amenities and shall be covered with tarpaulin when not in use and at the end of the working day to enclose dust. If large stockpiles (>25m^3) of crushed materials are necessary, they should be enclosed with side barriers and covered when not in use.
- The contractor should prepare a materials re-use plan to ensure any plans are re-used within the scheme.
- Prior to starting work, the contractor should prepare a method statement for water supply pipeline works. This should be simple and explain the contractor’s work process that is conducted on site, with safety and safeguard concerns.
- The contractor will prepare a detailed Methods Statement for each project and will be site specific to the project area. If necessary, different method statements will be prepared if project areas extend over 1km.

The method statement should cover the following:

- Work description
- No. of workers (skilled & unskilled)
- Details of plant, equipment & machinery, vehicles

    - Work duration (total, and activity-wise, for example for preparation of sub grade, sub-base, base and wearing coarse
    - PPE (helmet, gloves, boots, etc.) details for each type of work
    - Details of materials at each site (type & quantity)
    - Site and Work specific risks/hazards assessments associated with the work and location and how these will be mitigated
    - Construction waste/debris generated (details & quantity) and details of how project related waste will be minimised, re-used or recycled in accordance with circular economy principals
    - Detail the sequence of work process (step-by-step) including specific details of each work
    - Contractor's supervision & management arrangements for the work
    - Emergency: Designate (i) responsible person on site, and (ii) first aider
    - Emergency response plan – will cover what will happen during unforeseen events such as oil spills, extreme weather, accidents and incidents
    - Typical site layout plan including placement of material, excavated earth, barricading etc.
    - The following should be included in the site layout plan:
        - Provide barricading/security personnel at the site to prevent entry/trespassing of pedestrian/vehicles into the work zone
        - Location of temporary stockpiles and provision of bunds
        - Separation of stockpiles areas with workers/vehicle movement paths to avoid disturbing the stockpiled soil
        - Wetting of soil to arrest dust generation by sprinkling water
        - Waste/surplus soil utilisation and disposal plan – indicate expected duration of temporary stockpiling along the road and identify final surplus soil utilisation/disposal site in consultation with PMU.
- PMU Punjab will ensure the identification of appropriate disposal sites for unsuitable excavated material in consultation with BWMC.
- PMU will inspect and monitor the borrow material areas prior to procurement to ensure that it is being used in sustainable way and no significant disfiguration of landscape is going on at quarry site.
- Stock piling of excavated material at places that are congested will be avoided as these piles can create traffic issues and public nuisance.
- Already available quarry sites for additional backfill material will be utilized. Development of new quarry site will be discouraged.
- Record of borrow materials will be maintained including details of quarry site, agreement and necessary approvals from concerned government authorities.

8.6 Impacts Associated with Operation of Component 1 and 2 (Landfill & MRF)

811. The potential impacts from operation of the Landfill are provided as **Table 8-9** below.

Table 8-9: Screening of Possible Impacts during Operation Phase

Component	S/No.	Potential Impacts	Likelihood (Certain, Likely, Unlikely, Rare)	Consequence (Catastrophic, Major, Moderate, Minor)	Risk Level (Significant, Medium, Low)	Residual Impact
1 & 2	1	Leachate Generation	Likely	Major	Significant	Low
1&2	2	Soil and Groundwater Contamination	Likely	Major	Significant	Low
1&2	3	Landfill Gas Generation	Likely	Major	Significant	Low
1	4	Air Strikes	Likely	Major	Significant	Low
1&2	4	Air Quality Deterioration	Likely	Major	Medium	Low
1&2	5	Disease Vector Generation and Vermin Attraction	Likely	Major	Medium	Low
All	6	Occupational Health and Safety	Likely	Major	Medium	Low
3	7	Waste Collection and Hauling Impacts	Likely	Major	Medium	Low
All	8	Wind Blown Litter	Likely	Major	Medium	Low
All	9	Solid waste & health and sanitation	Positive impacts expected			Medium positive residual impact
All	10	Public Health	Positive impacts expected			Medium positive residual impact
All	11	Aesthetic aspects	Positive impacts expected			Medium positive residual impact
1	12	Construction and Demolition Waste Disposal	Positive impacts expected			Medium positive residual impact
2	13	Impacts associated with MRF operations	Likely	Major	Medium	Low
2	14	Impacts of operations of composting plant and AD plant	Likely	Medium	Medium	Low
2	15	Impacts associated with regeneration of legacy landfill.	Positive impacts expected			Medium positive residual impact
1,2	16	Lack of Site Closure Planning	Likely	Major	Significant	Low

Critical Risk Level
Significant Risk Level
Medium Risk Level
Low Risk Level
Positive Impacts

8.6.1 Leachate Generation

Impacts

812. Leachate generation risks relate to Component 1 and also to the legacy landfill of Component 2. Leachate is generated when water percolates through waste materials.

813. The general risks from leachate generated from wastes are due to its normally high organic contaminant concentrations and high ammoniacal nitrogen. Pathogenic microorganisms and hazardous substances that might be present in it are often cited as most dangerous, but pathogenic organism counts have been found to reduce rapidly with time in the landfill, so this only applies to fresh leachate.

814. The generation of leachate is inevitable in most landfill areas. Leachate generation rates are completely dependent on the amount of liquid the waste originally contains and the amount of rainfall in the area. Some factors that can influence leachate generation are the following:

- Climate;
- Site topography;
- Final landfill cover material;
- Vegetative cover;
- Site phasing and operating procedures;
- Type of waste materials in the landfill.

815. The climate at the site will significantly influence the rate of leachate generation in the landfill. Since the landfills are both located in an area of low precipitation, it can be expected that leachate generation will be relatively low, although plans to handle and treat even these minute quantities are incorporated in the design. This will be straightforward with Component 1 as cells will be lined and designed with appropriate collection systems in place.

816. For component 1 the quantity of leachate generated in a landfill is strongly dependent on the quantity of infiltrating water. This, in turn, is dependent on weather and operational practices. The amount of rain falling on a landfill largely controls the leachate quality generated. Precipitation depends on geographical location. A significant quantity of leachate is produced from a landfill's 'active' phases under operation during the monsoon season. The daily leachate amount generated from the proposed Bahawalpur Landfill site is calculated under the following conditions. **Table 8-10** below shows the average rainfall data of Bahawalpur.

- All the rainwater outside the landfill site is expelled and does not enter the disposal section.
- Daily precipitation is taken as 1.23 mm/day, based on August monthly precipitation, the highest throughout the year.

Table 8-10: Average rainfall data Bahawalpur

Month	Average Rainfall mm/Month	Average Daily mm/d
January	7.2	0.23
February	11.6	0.41
March	12.7	0.41
April	9.8	0.33
May	9.3	0.30
June	21.9	0.73
July	33.8	1.09
August	38.3	1.23
September	26.1	0.87
October	7.0	0.22
November	1.3	0.04
December	5.6	0.18

817. It is assumed that the peak leachate flow will generate during the activation of Phase 3. Hence till that time, two phases of 4,461 m^2 each will be filled and covered with the intermediate cover. So, the total covered area of phase one and two will be 8,922 $m^{2,}$ and the area of the operational phase will be 4,461 m^2. So, the coefficient of leachate generation for the landfilled area (8,922 m^2) will be 0.3, and for the active area (4,461 m^2) will be 0.5.

818. The following is the mathematical formula used to calculate the design leachate amount during master plan (2025-2050).

$$Qj = 1/1000 \times Ij \times (C1A1 + C2A2)$$

Qj: Design leachate generation amount (m3 /day) for the day (j) each year.

Ij: Rainfall amount (mm/day) for the day (j) each year.

C1: Leachate generation coefficient from the area of current landfill operation (0.5)

C2: Leachate generation coefficient from the landfilled area (0.3)

A1: Area of current landfill operation (m^2)

A2: Landfilled area (m^2)

$$Q = 1/1000 \times 1.23 \times (0.5*4461 + 0.3*8922)$$

Thus, the Peak Leachate flow for the new landfill was estimated to be 6.06 m^3/d for the purposes of the Master Plan (2025-2050)

819. In this case, fifty percent of the leachate that is circulated to the disposal site by the pump will evaporate, and the rest is assumed to return to the regulation pond from the disposal site as part of the design leachate generation amount.

820. Finally, it is a given that vegetation will, by evapotranspiration, re-direct a portion of the infiltrating precipitation back into the atmosphere. The presence of vegetation in the landfill can also influence the generation of leachate in the landfill.

821. The leachate situation for Component 2 is more complex given that the legacy landfill is unlined, and any leachate generated is dispersed to ground (known as a dilute and disperse model), the conceptual site model and site closure plan that will

be prepared prior to closing the landfill will fully assess the risks of the landfill remaining as a dilute and disperse model versus the implementation of a retrospective leachate collection system. Installing a retrospective collection system could pose greater environmental risks if the conceptual site model is not fully understood. Improving the management of the legacy landfill as part of the site closure planning will significantly improve the existing condition of this site.

822. An estimate of leachate flow for the Component 2 legacy landfill will be made within the site closure plan.

Component 1 - Mitigation measures

- Leachate generated during active phase of the landfill will be treated via a three-stage open leachate treatment system and portable anaerobic digestion (AD) treatment system for leachate. AD treatment system is portable arrangement for treatment of leachate and can be operationalized during monsoon for 24/7 basis. During monsoon season, recirculation of leachate will be increased to avoid operational constraints of leachate collection, storage and treatment system at landfill site.
- The landfill will be operated in accordance with applicable internationally recognized standards to minimise leachate generation, including the use of low-permeability landfill liners to prevent migration of leachate as well as landfill gas, a leachate drainage and collection system, and landfill cover (daily, intermediate, and final) to minimise infiltration.
- The daily exposed working face will be minimised, and perimeter drains will be used along with landfill cell compaction, slopes and daily cover materials to reduce infiltration of rainfall into the deposited waste.
- Leachate collection will be augmented by a leachate recirculation system in the landfill design.
- The operators of the landfill must ensure that an effective and efficient leachate control and monitoring system is maintained. This may be complimented by establishment of groundwater monitoring wells and regularly collecting samples for laboratory analysis. Results of the analysis could aid the operators to determine the final fate of the collected leachate and/detect any potential leakages. Final decision rests with the landfill operator on the final number of wells as well as the frequency of sampling for groundwater quality.
- The final vegetative cover plays an integral part in leachate production control. Its basic functions are to limit infiltration by intercepting precipitation directly, thereby improving evaporation from the surface, and to reduce percolation through the cover material by taking up soil moisture and transpiring it back to the atmosphere. Preferred plant species should be of those that do not have deep roots to protect the surface sealing. Further, these species should require minimal maintenance and human intervention.
- Landfill operators must be properly and adequately trained to operate and maintain the installed control system.
- A procedure for the rapid repair of leaks in the pipes, pumps and other equipment must be part of landfill operations.

- An inventory of spare parts and repair equipment must be continuously in place to ensure immediate remedial action against breakdowns.

- Strict quality assurance and construction guidelines during the installation of the HDPE liner should be strictly implemented.

Component 2 – Legacy Landfill Leachate Mitigation

- A conceptual site investigation and site closure plan will be prepared prior to closure of the landfill. This risk assessment will model transport times from landfill to local receptors and model direction of flow (likely anticipated to be west towards the Sutlej River). Once this information is known, appropriate decisions can be made on future leachate collection.

- The site closure plan will assess the risks of leachate generation to the environmental and human receptors and will assess whether installation of retrospective collection systems will significantly reduce environmental risks. It is possible that installation of retrospective measures could pose a greater environmental risk.

- The closure, capping and restoration of the landfill will reduce surface water ingress through the landfill and will reduce leachate generation and overall improve the environmental risks posed by the sites current condition.

8.6.2 Soil and Groundwater Contamination

General Impacts

823. Contamination of groundwater resources is among the most recognised impact of landfill development. In cases of leakages, the contaminated leachate will percolate into the ground and may find its way into existing groundwater resources.

824. Contamination of groundwater resources is among the most recognised impact of landfill development.

825. In the absence of mitigation measures, the contaminated leachate will typically percolate into the ground and may find its way into existing groundwater resources. This leachate can contain a mixture of pollutants, including organic compounds, heavy metals, hazardous chemicals, and pathogens. When landfill leachate infiltrates the ground and reaches the groundwater, it can have several significant impacts:

- Impact on Groundwater Quality:

    - The primary concern with landfill leachate is the contamination of groundwater. As leachate percolates through the waste, it can dissolve and carry contaminants with it. These contaminants can include toxic substances, heavy metals, volatile organic compounds (VOCs), and microorganisms.

    - Contaminated groundwater can render wells and aquifers unusable for human consumption or irrigation.

- Public Health Risks:

    - Contaminated groundwater poses a significant risk to public health if it is used for drinking or irrigation. Exposure to pollutants in groundwater can lead to various health problems, including gastrointestinal issues, skin disorders, and long-term health effects associated with the consumption of toxic substances.

- Environmental Damage:
    - Groundwater contamination can also have severe environmental consequences. It can harm aquatic ecosystems, affect the quality of surface water bodies that rely on groundwater discharge, and disrupt the balance of local ecosystems.
- Remediation and Clean-up Costs:
    - Addressing groundwater contamination due to landfill leachate is expensive and challenging. Remediation efforts may involve the extraction and treatment of contaminated groundwater, monitoring, and potentially, the installation of impermeable liners and containment systems at the landfill.
- Regulatory Compliance:
    - Proper disposal and management of landfill leachate are essential to comply with environmental regulations and minimize its impacts. Landfills are subject to strict requirements regarding leachate management to prevent groundwater contamination.
    - In many jurisdictions, groundwater is considered a sensitive receptor in itself, hence any pollution of groundwater is automatically a serious issue irrespective of other considerations.

826. In addition to the implicit risks associated with landfill leachate, construction and routine operational activities have potential to impact on groundwater. The principal risks during these phases relate to the handling and storage of hazardous materials, including fuel.

Component 1 Impacts

827. Four storage cells are proposed by the designer of LFS in Bahawalpur. A leachate leak from any of the storage cells may result in the contamination of the water table below the LFS. Efforts to mitigate the impacts of landfill leachate on groundwater centre around the development of modern, well-engineered landfills with advanced leachate collection and treatment systems, and low permeability liners. Additionally, monitoring, assessment, and remediation programs are crucial for identifying and addressing groundwater contamination issues associated with landfills. These elements are core to the design of the new Component 1 LFS. The potential for leachate losses do, however, still exist, either as a result of unforeseen ground conditions, inappropriate operation or failure of the landfill lining.

828. Multiple phases of site investigation have been undertaken for the new landfill. Depth to groundwater information from these investigations is summarised in **Table 8-11**. The finding that groundwater is approximately 15m below ground level is consistent with the local topography and surface water features. Although the data is limited, there is no indication of substantial seasonal fluctuation in the groundwater table at the Component 1 site. Again, this is consistent with what would be expected given the local environmental setting (e.g. low precipitation region relatively distant from surface water features).

829. In each of the investigations the soil types were consistently recorded as clayey or sandy silt, or similar variations, which would be expected to exhibit only low to moderate permeability. Falling head tests carried out during the June 2023 site investigation yielded coefficients of permeability in the region of 4 to 9 $x10^{-7}$ m/s, consistent with what would be expected for silts. High permeability formations were not encountered, although it must be recognised that such zones may be locally present given the nature of alluvial deposition.

Table 8-11: Summary of Depth to Groundwater Data at Component 1

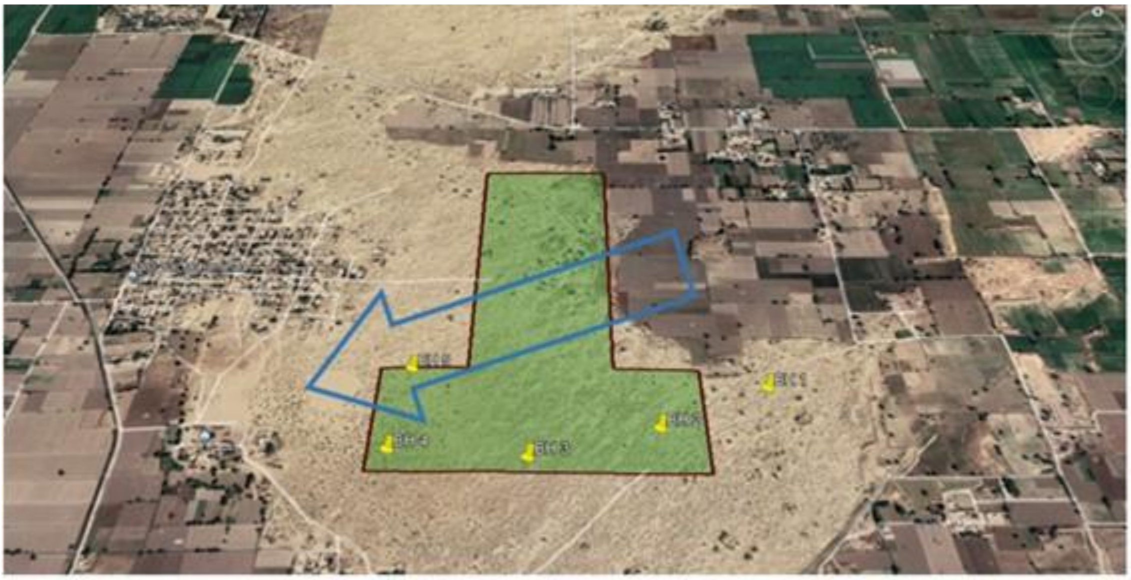
Date of Investigation	Number of Boreholes	Depth to Water
October 2022	5	14m, 16m, 14.8m, 16.5m, not encountered at terminal depth of 20m
January 2023	4	14m, 14.6m, 14.9m and not encountered at terminal depth of 16m
June 2023	1	Not encountered at terminal depth of 40ft (c. 12m)

830. This information supports a number of relevant conclusions with respect to the landfill:

- Groundwater is not likely to be encountered during the construction of the Component 1 landfill cells or associated infrastructure given the cell design depth of 9m below grade.
- After construction, the landfill cell liners will be located substantially above the standing groundwater level.
- In the event of leakage from the landfill, groundwater would only be impacted after leachate percolation through several metres of subsoil which appears to be of relatively modest permeability.

831. Based on the data collected during the October 2022 site investigation, the water table is sloping towards the South and West as illustrated in **Figure 8-4**: Location of tube wells and implied flow direction.

Figure 8-4: Location of tube wells and implied flow direction



832. The nearest communities with respect to the proposed LFS in the direction of the flow are residential houses (Distance 340m), and a Mosque (Distance 320m).

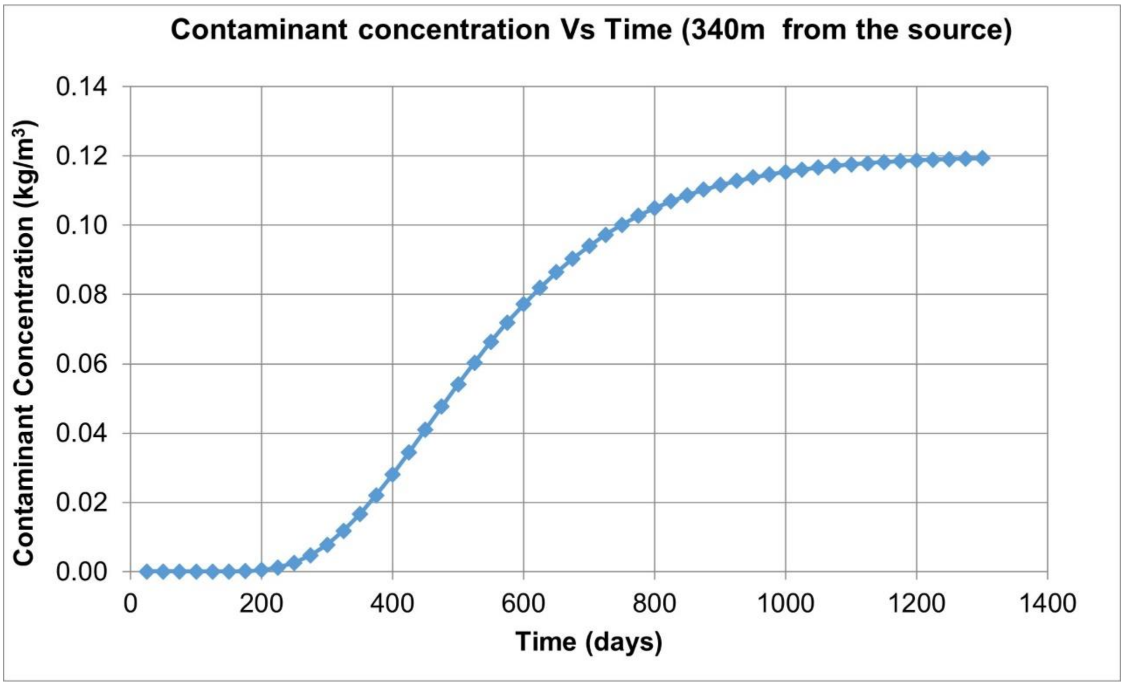
833. The project design consultant has estimated the leachate leaking effect on ground water quality of Bahawalpur LFS. A hydrogeological analysis was carried out for estimation of the effect of leachate on ground water quality as presented in **Appendix A19**. In order to provide a worst case scenario, the assessment was based on conservative assumptions and inputs to the numerical model, including:

- Leachate leakage from any of the storage cells may result in the contamination of the water table below the LFS.
- A risk analysis suggested that the contamination of groundwater from possible leakage of a storage cell may result in the uptake of contamination by the nearby community approximately 340m down gradient of the site. This was therefore set as the compliance point for the modelling.
- Relatively permeable strata both in the unsaturated and saturated zones.
    - The permeability value used for the soils below the landfill in the model was consistent with the assumption that that the strata comprise sandy silt but was approximately ten times larger than that suggested by the geotechnical testing done in June 2023.
    - The assumption for the hydraulic conductivity of the saturated migration zone was 30m/day which would be considered relatively high and typically associated with materials such as sand or gravel.
- No adjustments were included to allow for factors that might reduce the contaminant concentration over time. Specifically, it was assumed that there would be no biological decay, diffusion or retardation occurring.

834. Key findings of hydrological analysis are highlighted below:

- Based on analysis, it will take a total of **310 Days** for contamination to start appearing at the nearest tube. Time required to reach the full concentration of 0.12 kg/m^3 will be 1010 days
- Once the contamination starts appearing in the water supply from the tube well it will take about 700 more days to reach full concentration.
- Breakthrough curve of Contaminant concentration at local community location with time is shown in below figure.

Figure 8-5: Breakthrough Curve of Contaminant Concentration



835. The key recommendations of hydrological analysis team are highlighted below:

- The leachate discharge should be measured on regular basis and any indications of barrier breach through loss of leachate should be immediately investigated.
- There is a potential chance of harm if leachate leakage impacts the groundwater and migrates to abstraction points. Therefore, it was recommended to use observation boreholes to monitor groundwater quality and additional checks should be made on monthly basis by collecting water samples from the nearest tube wells for detection of any contamination.
- If any contamination is detected, then the necessary action to plug the breach should be completed as a matter of urgency.

836. Although some additional has been data gathered subsequent to the completion of the hydrogeological assessment, it is generally in keeping with the information available at the time and the outputs of the model remain a reasonable worst case scenario.

Component *1 Mitigation measures*

837. The following measures will be implemented for Component 1:

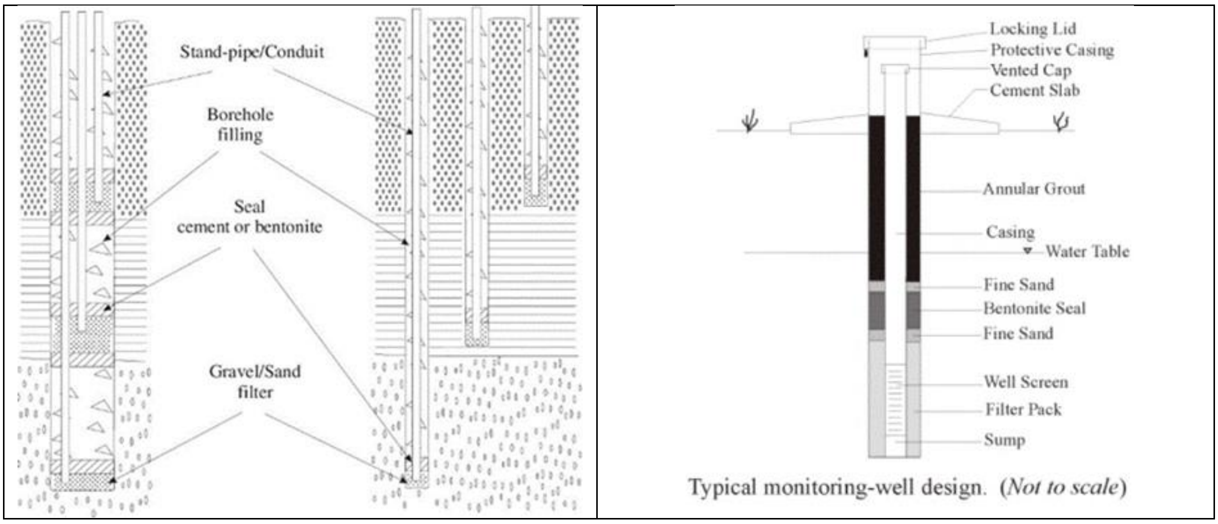
- Appropriate liner and collection systems in compliance with international guidelines/criteria are part of the design and will be installed.
- An efficient leachate collection and treatment system has been provided to ensure leachate accumulation at the base of the landfill and keep it to a minimum.
- The leachate system will consist of a leachate collection layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) with pipe network to convey the leachate to treatment facility.
- Leachate collection pond shall be in opposite direction from nearest surface water

- Bottom lining will be comprised of compacted sub-grade base, geo-synthetic clay liner (GCL) topped by 2 mm HDPE layer.
- Silty sand or geotextile (500 GSM) will be covered for the protection of the HDPE on the side slopes. Above geotextile gravel layer (30 cm thick) will be placed which will be topped up with sand layer (50 cm thick).
- Thick topsoil layer (6 inches) capable of supporting vegetation to protect the landfill surface from wind and water erosion.
- Drain Layer (18 inches) of at bottom to maximize runoff of precipitation while minimizing infiltration and preventing ponding of water on the landfill.
- Compacted soil layer or barrier of low permeability ($1x10^{-5}$ cm/sec) to limit and control the amount of precipitation that enters the waste.
- Vent layer of reasonable thickness comprised of sand and gravel
- The Leachate treatment system can comprise of a three-stage clarifier with aeration with diffusers or enclosed leachate treatment system utilizing anaerobic digestion system.
- Three Stage Clarifier with aeration and diffusers utilizing Anaerobic digestion will be used for leachate treatment. Slope of the landfill site shall be away from nearest surface water body.
- Cut-off drains around active landfill site and peripheral drains around landfill site should be provided.
- Permanent monitoring wells will be installed surrounding the boundary of the site (see **Figure 8-6**) with the aim of providing long term data on groundwater conditions both up-hydraulic gradient and down-hydraulic gradient. Baseline and long term groundwater monitoring will be carried out in accordance with the Groundwater Sampling Programme provided in **Appendix A-23**. Annual monitoring reports will be provided to the PMU.

Figure 8-6: Component 1 Indicative Groundwater Monitoring Well Locations

- The groundwater monitoring facilities will follow a similar approach for both Component 1 and Component 2– Legacy landfill, as follows:
  - Installation of c. 8 No. permanent perimeter boundary monitoring wells around the boundary of the landfill. These wells should be drilled to c.20m depth or 2m below resting groundwater whichever is deepest. The wells should be drilled using a rotary drilling rig capable of allowing logging of strata to BS5930 or similar. If perched water bodies are encountered these should be sealed with bentonite prior to extending drilling to prevent creation of a preferential pathway. Nested wells should be installed if necessary to allow monitoring of different water bodies (perched and groundwater). The image below indicates a suggested borehole construction. The contractor will agree the well design with the PMU before drilling commences. All wells should be completed with a metal, lockable covers and constructed and protected to minimise risk of damage and designed to enable monitoring during the lifetime of the landfill (c.25 years). If necessary, the contractor should budget to replace wells should they become damaged or inoperable. Care should be taken to construct wells so that they do not silt up.

Figure 8-7: Recommended Groundwater Monitoring Well Design



- As detailed in **Appendix A23**, detailed ground water quality baseline data will be collected during the construction phase. During the operational phase data will continue to be collected with the aim of early identification of any ground water contamination from landfill operations.
- In the worst-case scenario, if leachate contamination is detected during ground water monitoring after few years of landfill operation, detailed ground water modelling to determine possible contamination of leachate will be carried out and necessary design changes will be implemented.
- Waste hauling vehicles shall be covered during transport of waste to landfill site
- Any vehicle maintenance undertaken onsite shall be undertaken in dedicated areas on hard surfacing and in an area provided with surface water drainage and oil water interceptor. Spill kits will be provided to address any localised spills.
- Any vehicular wheel washes will be provided with dedicated storage of water preventing any discharge to ground and will be desilted on a weekly basis or more frequently if necessary.
- Hauling vehicles shall not wash at the surface water bodies along the route as the wash water shall drain into the canal and will pollute the surface water source which is used by the animals of the nearby communities and for agriculture purpose.
- Domestic sewerage of Bahawalpur facility shall not be discharged untreated in open area and drains.
- Wastewater generated from vehicle wash area shall be contained and treated before final discharge.
- To augment this system, regular quality control checks on the equipment /accessories of landfill site will be implemented and incorporated during operations.
- Site speed limits will be kept between 5-15km.hr to prevent dust generation potentially impacting surrounding land quality.

Component 2 Impacts

- Component 2 includes the MRF and the Legacy Landfill operations.

- Risks posed during the MRF operations include leachate generated via rainwater percolating through stockpiled waste, oils and heavy metals from vehicle maintenance and washing and sanitary waste from work and residential areas. No refuelling of vehicles will be undertaken onsite.

- Dust from operations if uncontrolled may settle onto local soil potentially causing soil and groundwater contamination.

- The legacy landfill within Component 2 will already be generating leachate given it has been operating in an uncontrolled manner. Given that disposal at the site only started in 2016, it is unlikely that the waste has reached a steady state of degradation. As such, it may be expected that the potential for leachate generation will continue to increase for some time. Introducing appropriate capping and a monitoring regime is expected to significantly improve the existing conditions whilst also supporting any future interventions which may be required.

- Based on historical photographs and the location of the site, it is possible that the base of the landfill is in direct contact with the groundwater at times. If that is the case, leachate generated from the waste will have direct impact on groundwater quality. The periodic presence of groundwater within the waste may also promote the generation of further leachate.

Component 2 Mitigation

- Once operational, the MRF site will be operated on hard standing (concrete, tarmacadam or similar) along with appropriately designed surface water collection systems. This is significantly reducing the risk of soil and groundwater contamination impacts from site operations.

- The MRF will be designed to avoid leachate generation. All surfacing where wastes are handled / stockpiled will be covered to prevent rainwater ingress/dust generation and located on hard standing with appropriate surface water drainage installed.

- Any vehicular wash bays or maintenance areas will be provided with dedicated surface water drainage that will be treated prior to discharge offsite.

- All wastes that are baled and stored onsite will be located on hard standing and will be covered prior to dispatch.

- The contractor operating the plant will prepare detailed standard operating procedures that will detail the control of leachate and other contaminants that may impact soil and groundwater. This will include details of how risks from any unforeseen events e.g. spills, extreme weather) will be managed. Spill kits and containment systems should be in place to prevent leaks and spills impacting soil and groundwater.

- The closure of the legacy landfill will be undertaken in accordance with the site closure plan and a programme of monitoring groundwater will be undertaken to monitor trends. The site closure plan will include procedures for further remedial works if conditions are declining or posing a risk to surrounding receptors.

- The project designer is yet to undertake a detailed conceptual site model and risk assessment to determine the most appropriate restoration and site closure plan. However, it is likely that as a minimum this will require covering and capping to prevent surface water ingress.

- As with the new Landfill, permanent monitoring wells will be installed surrounding the boundary of the site (see **Figure 8-8)** with the aim of providing long term data on groundwater conditions both up-hydraulic gradient and down-hydraulic gradient. Baseline and long term groundwater monitoring will be carried out in accordance with the Groundwater Sampling Programme provided in **Appendix A23**. Annual monitoring reports will be provided to the PMU.

Figure 8-8: Indicative Locations for Component 2 Groundwater Monitoring Wells

- Future residential development should be prevented within 0.5km of the site boundary.

8.6.3 Landfill Gas Generation

Component 1 and 2 Impacts

838. Studies and research indicate that landfill gas is approximately 40-60% methane (CH4) and the remaining being mostly carbon dioxide (CO2). There is another group of chemicals, called non-methane organic compounds (NMOCs), which may be present in the air near a landfill, although they are not likely to reach harmful levels. They are nitrogen, oxygen, water vapor, sulphur and hundreds of other contaminants. NMOCs may occur naturally or be formed by chemical processes. There is concern that long-term exposure to high levels of NMOCs could lead to health problems, but health studies have been largely inconclusive. Since the project will be developed under a Design Build Operate (DBO) Contract, thus the exact equipment specifications are not available at present. However, **Table 8-12** below provides a list of the various components of a 'typical' landfill gas.

839. Though NMOCs usually make up only less than 1% of landfill gas, many of these are hazardous chemicals like benzene, toluene, chloroform, vinyl chloride,

carbon tetrachloride and 1,1,1 trichloroethane. At least 41 of these are halogenated compounds. Many others are non-halogenated toxic chemicals. More exhaustive test for contaminants in landfill gas has found hundreds of different NMOC contaminants.

Table 8-12: 'Typical' Landfill Gas Components

Component	Percent by Volume	Characteristics
Methane	45-60	Methane is a naturally occurring gas. It is colourless and odourless and lighter than air. Landfills are the single largest source of U.S. man-made methane emissions. The explosive limit of methane is between 5 and 15% by volume.
Carbon Dioxide	40-60	Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colourless, odourless, and slightly acidic.
Nitrogen	2-5	Nitrogen comprises approximately 79% of the atmosphere. It is odourless, tasteless, and colourless.
Oxygen	0.1-1	Oxygen comprises approximately 21% of the atmosphere. It is odourless, tasteless, and colourless
Ammonia	0.1-1	Ammonia is a colourless gas with a pungent odour
NMOCs (non-methane organic compounds)	0.01-0.6	NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most found in landfills include acrylonitrile, benzene, 1, 1-dichloroethane, 1, 2-cis dichloroethylene, dichloromethane, carbonyl sulphide, ethylbenzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes
Sulphides	0-1	Sulphides (e.g., hydrogen sulphide, dimethyl sulphide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten egg smell. Sulphides can cause unpleasant odours even at very low concentrations
Hydrogen	0-0.2	Hydrogen is an odourless, colourless gas
Carbon Monoxide	0-0.2	Carbon monoxide is an odourless, colourless gas

Source: *Tchobanoglous, Theisen, and Vigil; EPA 2015*

840. These landfill gases are released into the atmosphere. Whenever unabated, these gases might affect the general environment, including the welfare of its employees and host community in general.

841. Landfill gas is the main carrier of landfill generated odour, which is classified to be objectionable. Odours are caused by the release of volatile organic compounds and hydrogen sulphide and can travel significant distances from landfills.

842. Landfill gas may release accidently due to uncontrolled emissions that can impact air quality, release odours and trigger landfill fires. Continuous surveillance is required to monitor landfill gas generation and its collection.

843. Landfill gas may cause temporary discomfort, but it is not likely to cause permanent health effects. At extremely high concentrations, persons exposed may

experience eye irritation, headaches, nausea, and soreness of the nose and throat. People with respiratory ailments such as asthma are especially sensitive to these effects. However, these temporary conditions are reversed as soon as the gases are reduced or eliminated. Engineered Sanitary Landfills normally have landfill gas capture systems.

844. The project design consultant has initially proposed flaring of landfill gas management. A 1000 m^3 flaring system is proposed for landfill site for initial years. Keeping in view the volume of gas generated after a few years of operations LFG will be converted to CNG for final reuse/disposal.

845. Landfill gas is lighter than air and will naturally vent to atmosphere, however where landfills are capped, and the gas is under pressure the gas will migrate laterally via the path of least resistance. This means that gas can migrate offsite and get trapped in confined spaces posing a potentially explosion risk if methane is between 5-15%. Landfills typically generate gas for 25-50years depending on composition and as such gas collection systems should be designed for the lifetime of the landfill.

846. Landfill gas comprises methane which is a potent greenhouse gas.

Component 1 Mitigation Measures

- The DBO will prepare a detailed risk assessment following final design but prior to groundworks commencing. The detailed risk assessment should be in line with local and international guidelines, such as Landfill operators: environmental permits - Design and build your landfill site - Guidance - GOV.UK (www.gov.uk). This document will detail how landfill gas will be controlled and monitored throughout the lifetime of the landfill and how risks to onsite and offsite receptors will be minimised.
- The landfill location is located c.250m away from the residential developments of Basti Yar Muhammad. The DBO should ensure that a minimum 250m buffer can be maintained between the face of landfill cells and residential development areas. This buffer will allow for off-site monitoring and allow for natural venting and or machinery access in the event of remedial measures being required.
- The DBO will install a gas collection and control system (GCCS). The GCCS and 1000m^3 flaring systems will be in place as part of the landfill design and thus no significant impacts on occupational or community health and safety are envisaged from landfill gas exposure.
- Landfill gas will be collected through installation of perforated pipes within the cells. This gas will initially flare through 1000 m3 flaring system at start of landfill operations. Keeping in view the volume of gas generated after few years of operations feasibility for gas reuse including conversion into CNG will be carried out and accordingly design changes will be executed. Both Horizontal and Vertical gas collection systems will be implemented in the landfill. The gabion of the gas collection wells will be filled with gravel, and these will be constructed with iron mesh. There will be a perforated HDPE pipe with pressure class in the centre of the gas collection wells. The gap between the iron mesh and the perforated pipe will be filled with pebble stone.
- The estimates based on the daily waste generation and disposal rates indicates that the following will be estimated emissions rates of potent gases:

  Sulphur Dioxide (SO2) = 4.9 kg/day (0.0491 m^3/s)

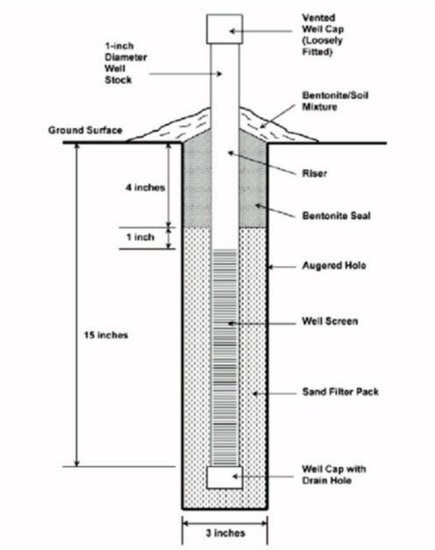
  Methane (CH4) = 406.98 m3/day (0.004m^3/s)

Carbon Dioxide = 103.87 m3/day (0.0001m^3/s)

All the gases are compliant with the stringent emission standards. Keeping in view the amount of gas production after few years of landfill operation, feasibility for gas reuse has been recommended in the project feasibly.

- The organic waste will be used as a resource in sanitary landfill to maximise and regulate the landfill gas recovery system and conversion of methane component of the gas into CNG. The conversion of organic waste into LFG and Methane component conversion will generate a high revenue and contribute to the substantially of the project.
- The organic waste will be beneficially utilised when it is deposited in the bio reactor landfill where it will generate regular and increased quantity of landfill gas which will contain 55-60 percent of Methane. The methane can be converted into electricity or CNG. The CNG option is a much better option as the electricity tariff for green energy is very low in Pakistan and the CNG rates are quite high.
- The landfill gas recovery must be designed from bottom up to avoid emission during landfill operation and drilling through the garbage when the cell is filled with waste. When two meters of waste layer will deposit in the first cell, a 30m x 30m or 50m x 50m grid of perforated gas recovery pipes will be installed over a 15cm layer of gravel under the pipe and another layer of 15cm gravel will be placed on top of the gas grid. The 30m length of the pipe will be joined with the second pipe with a ‘’T’’ joint and vertical gas well is installed. When desired height 20-30m of the fill achieved the ring main will be installed and connected to final LFG to power generation.
- A series of gas monitoring wells will be installed both on and off site and the risk assessment prepared by the DBO should propose the frequency of GHG monitoring that will be carried out during construction and operational phase of the project and accordingly, necessary design changes will be incorporated, if required. The frequency of monitoring should be more frequent until gas emission trends are established and if emissions are stable and well controlled less frequent monitoring may be proposed. Monitoring should also consider any seasonal variations such as temperature and atmospheric pressure.
- For the purposes of this IEE, the gas monitoring wells have been assumed to have the following specifications:
    - Installation of 16No. permanent gas monitoring wells (c.4 per boundary). These should be shallow wells installed to the depth of the landfill depth below natural ground level. They should include a 1m below ground bentonite seal, at least 2m of perforated well screen and fitted with gas monitoring taps. The contractor should agree the design specification of the wells with the PMU before construction.
    - The well should be a permanent monitoring feature protected with metal lockable covers and should be designed to last the lifetime of the landfill (c.25years). The contractor should allow budget for replacement of the wells as necessary.

Figure 8-9: Indicative Landfill Gas Monitoring Well Specification



- Landfill gas/fire emergency response plan (**Appendix A-21**) will be implemented.
- Landfill operator will train its staff on landfill gas/fire emergency plan.
- Landfill operator will allocate budget and necessary resources to manage landfill fire emergencies.
- A site closure plan will be prepared, and the operator will ensure necessary funds are available to deliver the site closure plan and manage the landfill post closure during its active life (c.25-50years).

Component 2 Mitigation Measures

- Given the temporary waste storage at the MRF, significant landfill gas is not anticipated that will require mitigation.
- With regards to Component 2, the legacy landfill will already be producing landfill gas. It is likely that this is currently venting naturally to atmosphere.
- The project designer is yet to undertake a detailed conceptual site model and risk assessment to determine the most appropriate restoration and site closure plan. However, it is likely that this will require covering and capping to prevent surface water ingress. A landfill gas capture and collection system should be installed beneath the cap of the landfill to ensure landfill gas can vent or be flared. The operator should establish whether it is financially feasible to capture landfill gas for energy generation.
- As with Component 1, a buffer should be established and protected around the perimeter of the landfill site. The distance of the buffer (typically 250m or more) should be established by the risk assessment and will depend on the volume and pressure of landfill gas generated. If necessary, retrospective gas venting should be installed around sensitive receptors already within the buffer zone.
- Again as with Component 1, permanent monitoring wells should be established around the perimeter of the landfill and monitored on a frequency to be determined by the site closure plan and risk assessment. The frequency of monitoring will depend on receptor location, landfill gas flow and pressure and concentration mix of the gas. If landfill gas is detected migrating off-site within the buffer, consideration should be given to the installation of passive or active gas venting measure within the land buffer. Measures may include:

   - Passive Gas Venting – Vertical Gas Venting Wells. Horizontal gas collection system, Leachate control, landfill gas permitter trenches.
   - Active Gas Venting – Gas blowers or compressors, gas extraction wells, flaring, installation of gas to energy system.
- Consideration may need to be given to odour control. Landfill gas is the primary cause of odours therefore if odours are objectionable, mitigation may need to include chemical scrubbers, biofilters or activated carbon to mitigate foul odours.

8.6.4 Air Strike Hazards (Component 1)

Impacts

847. The new landfill site may have little or no effect on air safety at Bahawalpur Airport. Equally, without understanding the likelihood of its attraction to species that may be hazardous to aircrafts, it is difficult to confirm whether this will be the case, or whether risks may arise that could result in a reduction in the levels of air safety. It will be important, therefore, to confirm the existing levels of attraction the current landfill results in, whether this attraction changes by time of day or time of year and whether any other species are present in the local environment that could use the new landfill site and impact air safety.

848. It is recommended that the bird species, their abundance, timing, and movements to and from the existing Legacy Landfill site are recorded for a period prior to the construction of the new Landfill.

849. In an ideal world this would involve regular monitoring over several years to account for any natural variations that may arise, however, it may be possible to review daily and seasonal variations using significantly less observations whilst still gathering enough data to determine outline risks.

850. An outline program involving two randomly selected days for one week per month over a number of months between either dawn and midday, or midday and dusk (or a single full day of observations) would provide strong indicative information. All hazardous bird species, their arrival times and directions and hourly counts on, around or over the existing landfill site should be recorded.

851. The numbers and species of birds recorded in relation to their location and behavior would be as follows:

Table 8-13: Bird Location and Behaviour Monitoring

1.	Birds feeding on the active face
2.	Birds feeding on any covered waste
3.	Birds loafing on the site (resting anywhere on site but not feeding)
4.	Birds loafing off site but clearly associating with the landfill (e.g. whilst awaiting feeding opportunities whilst sat in open space 1km distant)
5.	Birds circling over the site
6.	Birds flying in to / out from the site (including directions)

852. It is recommended that this is done via a suitable vantage point, or a standard walked route around the site for approximately 30 minutes every hour (depending on the numbers of birds present as to how long a count takes). Clearly if no birds are present this would need confirming for the day but would require far less time to record. Standard methods for counting should be followed and, where possible, altitudes of birds over the site should be recorded.

853. The directions of birds arriving or departing the site should be recorded to ascertain where they may be heading to/from at different times of year.

854. One morning and one afternoon of monitoring during the same week for one week each month would provide sufficient information to evaluate the use of the existing site over the course of a day and over the course of the year. If very few or no birds are recorded, it may be acceptable to reduce this further to seasonal checks provided the results are consistently showing no or very few birds seen.

855. If large numbers of hazardous birds use the existing landfill and are roosting / breeding to the south and east of the landfill (in the city or beyond), it is highly likely that they may then start to move to the new landfill and result in flightlines of birds that either progress along or fly across the western approaches to the airport. Significant mitigation measures may then be needed to minimize the presence of hazardous birds using the landfill and to therefore minimize or eliminate the risks to air safety.

856. Consideration of the precise location of the new landfill would then be beneficial. It is possible that a movement of the proposed location just a few km's north (e.g. to the north of the approach corridor) could result in virtually no risk arising. Without data and monitoring information to assess this hypothesis, however, the situation cannot be accurately described hence a potentially worst-case scenario should be assumed whereby birds attracted are hazardous, thermal over the site and fly along the western approach corridor towards the aerodrome.

857. It is also possible that very few birds use the existing landfill in which case it will be likely that this will remain the case with the new development. In these circumstances it is recommended that a monitoring brief be applied so that any changes in the presence of hazardous birds could be highlighted over time and management actions applied to minimize future risks if required. In these circumstances it is likely that the development of the new site could proceed without concern over increasing risks to air safety. As the data provided to date suggests the site has very few hazardous scavenging species present, it is not out of the question that such a finding may arise. Overall, the risk of bird strike is low, though monitoring of the strike rate is recommended in case this increases.

Mitigation Measures

858. On the assumption that monitoring and recording identifies some hazardous species using the existing landfill and the potential for movements that could increase risks to air safety, however, and despite the distance of the proposed site from the aerodrome, a plan may need to be developed to deter or prevent species using the site.

859. The project proponent and delivery team will liaise with the Air Traffic Control team at the Airport to ensure that pilot reports of near misses and air strikes are fully recorded. This information will be reviewed on a regular basis by the project team and, in the event that indications of significant risks are identified, additional monitoring or mitigation efforts will be implemented.

860. Further monitoring methods may require a baseline survey to be completed, followed by regular surveys as necessary. These surveys may be conducted annually, seasonally, or quarterly, depending on the specific identified needs and regulatory requirements.

Waste Treatment

861. Open discarding of food wastes is the key attractant to scavenging species hence any removal or prevention methods that stop such wastes being accessible to birds can minimise the attractiveness of a landfill site. Separation and management of waste either via sorting to remove putrescible wastes (edible waste), incineration of putrescible wastes or bio digestion of putrescible wastes can significantly reduce the attractiveness of a site to scavenging birds. Should no food wastes (inert landfill) be developed, little if any bird presence will occur. Management of putrescible wastes undercover or in a separated building will also prevent access to such species and remove the attraction of the site and thus risks to air safety.

Netting

862. The potential methods and techniques that may be needed could range from full netting enclosures to prevent any hazardous birds from accessing waste (exclusion of birds) or the site in general to netting that prevents access to the active tipping area only.

Figure 8-10: Example of a bird netting enclosure at an active tipping face on a landfill site

863. Active preventative methods may then include regular covering of the tipped and compacted waste with sufficient depths of inert material to prevent scavenging birds gaining access to food and ensuring the tipping face remains small and all other areas of the site are fully covered to prevent access.

Active Methods

864. There are many different tools available to disperse and control the presence of hazardous birds on landfill sites. Automated systems tend to only be viable at sites that have very low bird pressure on them (e.g. very few birds of species that are easily scared). This is because habituation (the process by which birds learn that a method does not result in any real threat and begin to ignore its use), occurs more easily with

a randomly timed single system than a specifically targeted process that uses a variety of different methods.

865. Techniques such as the flying of falcons or hawks can be good for dispersing gulls, passerines, pigeons and egrets but may have little or no influence on birds of prey. They may also only work during the periods the birds are being flown and can therefore fail to disperse target species over the long term. Hawk and falcon use therefore always requires back-up methods for use when birds are not being flown or during periods of poor weather conditions when birds cannot be flown. As a method used within a suite of systems, the use of falcons or hawks at landfill sites can, however, be beneficial.

866. Distress calls can be used to disperse some passerines and potentially egrets but may also result in habituation and will need to be used as part of a suite of systems. They will not work against all species likely to frequent landfill sites in this region.

867. Pyrotechnics can have a very positive output but need to be carefully used to avoid potential fire risks in dry regions and, with their loud bangs, can result in nuisance to nearby neighborhoods if overused. If available, pyrotechnics can provide a valuable tool for dispersing overhead birds and preventing birds accessing the tipping areas in the first place. Habituation may again occur hence their use should be within a multiple system approach.

868. Lasers are effective during poor light or low visibility conditions but may have little or no effect on some species during daylight hours. Given that most species will feed by day, lasers may not prove to be an effective system for deployment at a landfill site in this region.

869. Visual and other acoustic deterrents such as kites and wailers may have an initial impact via neophobia but are unlikely to provide a long-term solution to hazardous bird species at landfill sites. The can, however, be used to indicate actual threat such as shooting or lethal falconry.

870. Combinations of the above methods with, where feasible, the addition of lethal control via a shotgun to reinforce the threat from non-lethal methods being deployed can be highly advantageous. Such combinations are generally capable of reducing the presence of hazardous birds at landfill sites by over 90% and thus making even attractive landfill sites potentially compatible with aerodrome operations when located this distance from an airport.

8.6.5 Air Quality

Component 1 & 2 Impacts

871. Objectionable odour is expected at the landfill site from landfill cells, compositing facility, legacy landfill and material recovery facility depending on various factors. Some of which are the types of wastes being handled, humidity, temperature and moisture content, among others. Uncontrolled composting and poor housekeeping at site will be the source of objectionable odour. Furthermore, ambient dust may be generated from sorting lines of MRF which need to be managed through proper ventilation and necessary arrangements for dust collection/suppression. Haphazard waste tipping at the unloading bay and weighbridge will create nuisance and objectionable odours, if not attended at frequent intervals.

872. At the composting plant, odours originate with the incoming ingredients, which may have been stored anaerobically (without oxygen) for a week or more before transport to the site. Once these ingredients are incorporated into the composting

system, subsequent odour problems are usually a result of low oxygen or anaerobic conditions. Anaerobic odours include a wide range of compounds, most notoriously the reduced sulphur compounds (e.g. hydrogen sulphide, dimethyl sulphide, dimethyl disulphide, and methane thiol), volatile fatty acids, aromatic compounds and amines. Ammonia is the most common odour that can be formed aerobically as well as anaerobically, and thus has its own set of management options.

873. The closest receptors will be the personnel who will be onsite, monitoring the status of the facility. Some of the anticipated problems that may be raised during the operations of Components 1 and 2 are as follows:

- Discomfort of working with offensive odours; and
- Concerns for the mental or psychological welfare of exposed communities
- Concentrations of VOCs and Landfill Gas

874. Site specific risk assessments should be undertaken for any existing residents located within 500m of the landfill – both for components 1 and 2.

875. The Wind Rose for Bahawalpur City shows that dominant wind direction of Bahawalpur is from North to South with an average speed of 6 km/hr. As a result, the potential impact on the households from any airborne related impacts, particularly during landfill operations. Since most of the houses which are being used for residential purposes are located at a minimum distance of 500 meters from the proposed landfill, therefore, no significant impacts from objectionable odour are anticipated.

876. Daily cover will be provided at end of each day to avoid risk of fire, wind littering, odour, vector breeding and dust hazards in the landfill. Working surface of waste will be covered with a soil layer called “daily cover” at the end of each working day. Amount of soil to be used in daily cover will be about 10% of the waste volume. Suitable quality of excavated material will be used as daily cover material.

877. The special dispersion of the pollution levels around the Component 1 project site was modelled for ground level concentration through Lakes Environmental Software AERMOD. Dispersion of maximum pollutants is found in the northeast direction driven by the south-westerly wind.

Key Inputs:

878. The key inputs required by the model were: number, height, inner diameter, velocity, emission rate of pollutants and temperature of stack, displayed in **Table 8-14** below. The pollutant concentrations and other related data obtained from the designer of landfill Project.

Table 8-14: Inputs data of Flare

Sr.No.	Stack Parameter	Values
Technical Inputs / Specification of Stacks		
1	Stack height	42.50 m
2	Stack diameter	0.85 m
3	∆h (Gas Enthalpy)	1.94 j
4	Stack Gas exit Velocity or Gas Flow Rate	1.15 m

5	Down wind speed (u)	1.27m/s
6	Stability class	D (Neutral)
7	Ambient Temperature	24.5°C
8	Stack Temperature	24.5°C
9	Urban /Rural Class Option	Rural
10	Total number of stacks	01
11	Gas Emission rate	0.0561g/s
Pollutants Specifications		
The concentration of pollutants as percentage ratio of the total pollutant concentration was estimated at "15% oxygen normalization" as below: **Exhaust Analysis % Vol.** Nitrogen 74.51% Oxygen 13.15 % Carbon Dioxide 3.47% Water 6.99% Particulates 1.88 %		

Modeling Outputs

879. Downwind model summaries of overall 24-hourly levels at receptors distanced at 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1500, 2000, 2500, 3000, 4000 and 5000 meters from the stack along 16 radial directions 22.5 ° apart from each. The stack was treated as point source for modeling the plume dispersion.

880. Modeling levels have been compared to verify compliance with the allowable ambient levels. Comparison of levels has been made with WHO and PEQS allowable atmospheric (ambient) concentration for CO, NO2, & PM_{10} for 24-hours $\mu g/m^3$.

Air shed classification at monitored locations based on modelled incremental values and cumulative values are provided in **Table 8-15**.

881. The results of modelling show that the 24-hour average highest ground level concentration of CO from the flare remains 0.347$\mu g/m^3$ at 1000 meters (75'14''63.19N, 3244037.28E) NOx from the flare remains 0.417$\mu g/m^3$ at 1000 meters (75'14''63.19N, 3244037.28E) and PM_{10} from the plant remains 0.00463$\mu g/m^3$ at 1000 meters (75'14''63.19N, 3244037.28E) when flare operating at its normal conditions.

882. Airshed classification results of monitored locations based on modelled incremental values shows that cumulative values of CO and NO_2 are well within the stringent WHO guidelines, however PM_{10} values are exceeding WHO guidelines' Cumulative values of CO, NO_2 and PM_{10} are well within PEQS which shows that air quality impact will be low when flare operating at its normal conditions provided good air to landfill gas ratio is maintained during combustion.

883. The colour contours maps plotted by the model for the proposed emissions effect of the flare shows the extent of dispersion of the pollutants. The dispersion plumes shown in above figures show that the plant is located at 1000 meters from the origin set at top left corner of the map. Contours maps expand to 5000 meters from the flare site. The contours show that the emissions disperse in north-east-north direction.

Table 8-15: Airshed Classification with Model Outputs

Pollutants	WHO		Pak. NEQS		Modelling Out Put (ug/m^3) Incremental	Modelling Out Put (ug/m^3) Cumulative at Location near to Landfill Flare					
	Avg. Time	Standard	Avg. Time	Standard		Basti Rama	Basti Yar Muhamamd	Basti Karim Bux	Basti Meriwala	Basti Rasheed Abad	Basti Chachran
CO	24hr	04 mg/m^3	8 hrs	5 mg/m^3	0.347	0.617	0.837	1.077	0.737	0.727	0.647
NO_2	24hr	25 ug/m^3	24 hrs	80 ug/m^3	0.417	7.947	12.817	14.757	8.857	10.657	10.837
PM_{10}	24hr	45 ug/m^3	24 hrs	150 ug/m^3	0.00463	64.03463	59.37463	68.36463	52.93463	57.95463	54.49463

884. Models for dispersion of NO_x, and PM based 24-Hour Averages for proposed facilities have been recorded. Contour maps of average concentration are shown in below figures.

Figure 8-11: Contour Map of Average NOX Concentration

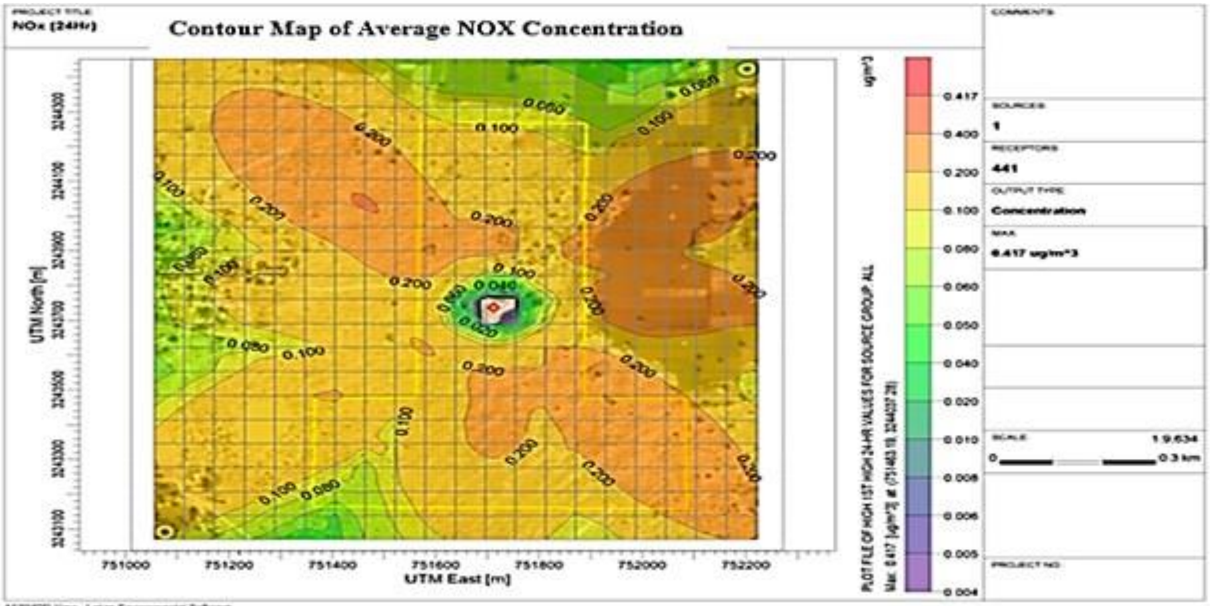


Figure 8-12: Contour Map of Average CO Concentration

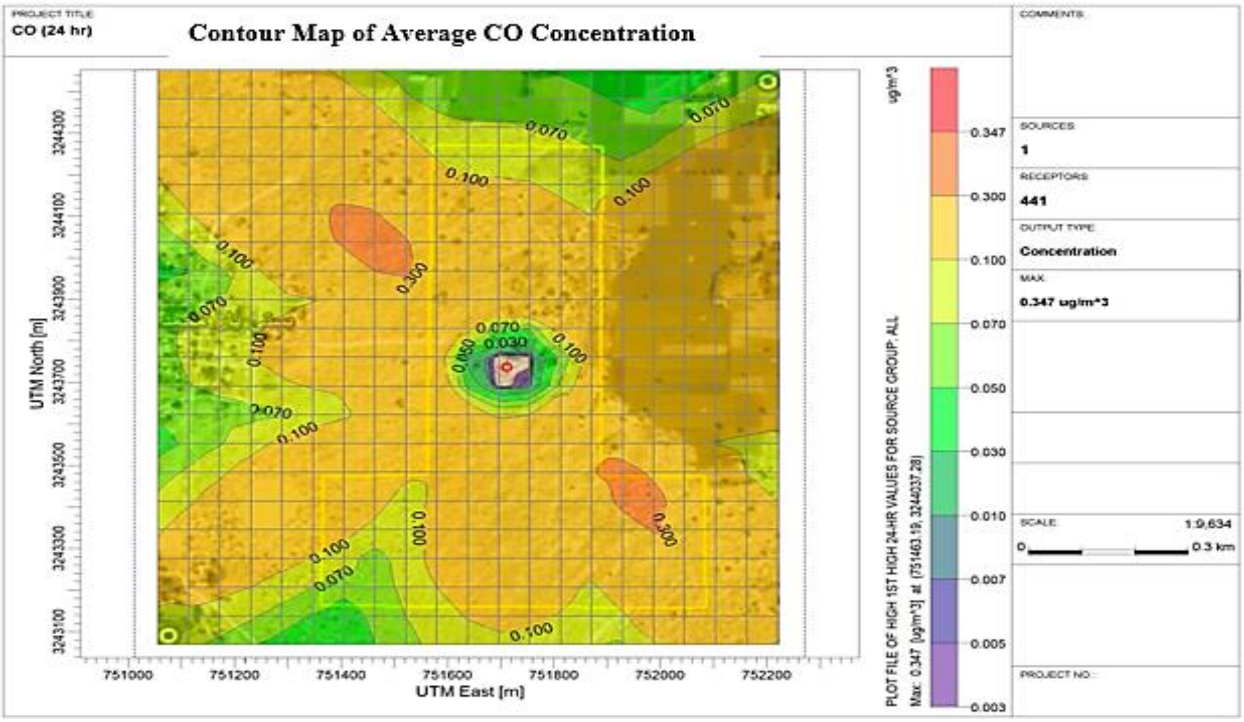
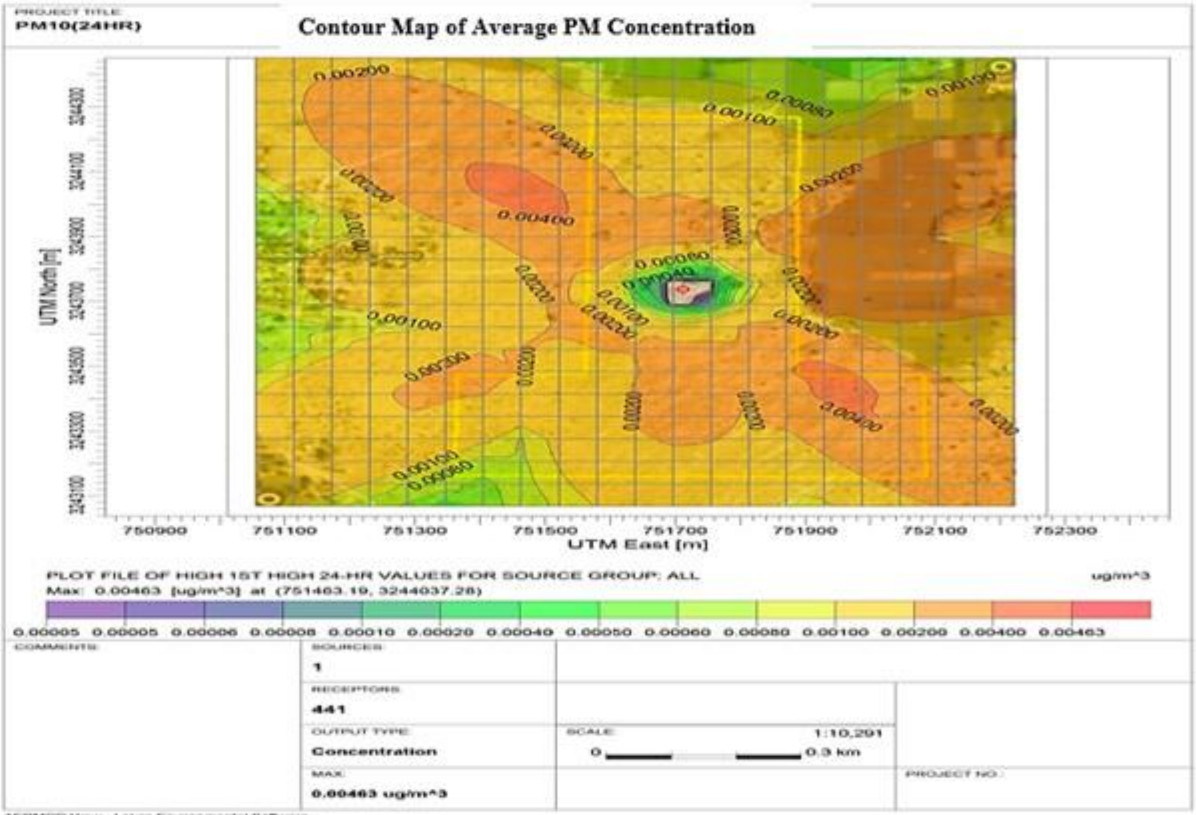


Figure 8-13: Contour Map of Average PM Concentration



885. This modelling analysis demonstrates that operation of the Component 1 facility described in this report neither causes nor contributes to any exceedance of applicable air quality standards outside proposed flare. The limits set by NEQS/WHO also suggest that the quality of air shed would not be altered to hazardous state by the emissions from the flare. Establishment of proposed flare would therefore be an environmentally safe proposition.

886. The requirement for a flare is unknown for the **Component 2 Legacy Landfill**. After completion of the detailed conceptual site model and as part of the site closure design, landfill gas generation should be calculated and if a flare is required similar modelling should be undertaken to establish air quality risks.

887. Air dispersion modelling report is attached as **Appendix A 20** of the report.

Mitigation measures

888. Best management practices and good housekeeping measures will be implemented to minimise the release of objectionable odours. Potential odours impacts can be minimised or eliminated by adopting the following measures:

- Daily cover will be placed on working surface of waste in component 1 and the legacy landfill site to reduce the risk of fire, wind littering, odour, vector breeding and dust hazards in the landfill. Temporary wastes at the MRF will be stored internally within the buildings prior to being sorted.
- Suitable amount of daily cover will be stocked at the landfill site.
- Final capping of landfill cells will be carried out in order to limit and control the amount of precipitation that enter the waste and to limit wind and water erosion and

‘from escaping from the landfill but also protect the site against intrusion of vermin and pests.

889. A detailed site closure plan will be prepared for both the new landfill and legacy landfill at Component 2. This will detail how the landfill cells will be covered. The list below provides an indication of the likely arrangements.

- Thick topsoil layer (6 inches) capable of supporting vegetation to protect the landfill surface from wind and water erosion.
- Drain Layer (18 inches) of at bottom to maximize runoff of precipitation while minimizing infiltration and preventing ponding of water on the landfill.
- Compacted soil layer or barrier of low permeability ($1x10^{-5}$ cm/sec) to limit and control the amount of precipitation that enters the waste.
- Vent layer of reasonable thickness comprised of sand and gravel
- Appropriate and regular housekeeping (i.e. cleaning) will be done in all areas
- Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh Bridge, MRFs, material handler and waste compactor operators) must be ensured.
- All the incoming ingredients that are anaerobic will be converted to aerobic state through combining them with a coarse, dry bulking amendment to increase the porosity and allow oxygen penetration.
- Air should be thoroughly dispersed throughout the organic waste. This is done by frequently turning and mixing the wastes within the composting plant.
- Oxidizing chemicals like hydrogen peroxide, potassium permanganate, and chlorine will be used by the wastewater treatment industry for odour control.
- Any organic waste lot which is creating objectionable odours will be attended immediately and introduced in the composing system on a priority basis.
- Controlled compositing conditions will be maintained throughout the operation.
- Mandatory health and medical check-ups for all employees especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m3 as an 8-hr TWA). This should ideally be complimented by obtaining an Insurance Policy for Workmen especially engaged in the daily activities of the landfill.
- Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE).
- Where solid waste will be processed (i.e. weigh bridge area). This will prevent the reproduction of flies, generation of obnoxious odours, scattering of plastic and papers, etc.

8.6.6 Disease Vector Generation

Impacts

890. The operation of the landfill, MRF and Legacy Landfill may attract pests such as rats, cockroaches, flies, ants and other pests in the immediate area along with

various other vectors such as foxes, feral cats and dogs, birds and other animals. These pests can freely move around the area and may find their way to buildings and areas adjacent to the landfill. Since these pests are known to be carriers of diseases, they may trigger the sudden occurrence of illnesses and unacceptable conditions among people of weak resistance and children.

891. Each type of vector can live and multiply at a landfill and is potentially of concern to site operators, regulators, public health professionals and the public. Fortunately, vectors are controllable and should rarely, and even then, only intermittently, be present on a well-controlled landfill.

Mitigation measures

892. The most important control measure used to minimize vector problems at landfills is the application of daily cover. Cover should be present on all solid waste at all times, except the tipping face while it is being worked. Daily cover of at least 150mm of compacted soil or similar material or an effective layer of alternate daily cover (ADC) should be applied on finished portions of the daily cell during operation and at the conclusion of daily operations, and not less frequently than once per day. Alternative daily cover materials such as tarpaulins, foams, granular waste, etc, can be effective as vector control after careful site-specific evaluation.

893. Intermediate cover of 300mm (minimum) compacted soil should be used on all areas not at finished levels, but not to be further landfilled for a period of 30 days or more.

894. Final cover is typically applied as each area is brought to finished level through the operational life of the landfill.

895. There should be no uncontrolled or uncovered (stockpiled) waste, including litter, tyres, brush, appliances, construction/demolition waste or even inert industrial waste on the landfill property. The only exception is compactable soil-like inert wastes, such as ash, but even this waste must be graded and compacted to avoid ponding water.

896. There should be no ponding water on the landfill property except as designed for runoff storage or leachate treatment ponds. Such storage ponds can, however, aid vector reproduction if not designed and controlled properly to minimise stagnant water, nutrient build-up and plant growth.

897. Finally, the waste must be compacted and graded at reasonable maximum slopes (see the Working Face Guideline) to minimise voids within the waste that can harbour rodents. Rodents and foxes can readily dig into cover soil but have much more difficulty digging into compacted solid waste.

898. On-site landfill site personnel must be trained and must monitor the levels of key vectors daily as part of daily management. A simple monthly site walk-over can provide a baseline of vector activity so changes can be noted and translated into action. Observations of various droppings, sightings, tracks, insect counts, etc are useful indicators of activity. Written reports from regular walk-over assessments should be kept on file so changes that occur over time and in response to control measures can be assessed.

899. Whilst these mitigation measures are easy to put establish for Component 1, consideration should be given to implementing these measures at the legacy landfill whilst still operational. Any control measures implemented will significantly improve conditions for the local area.

8.6.7 Occupational Health and Safety

Impacts

900. There are considerable risks associated with the operation of the proposed landfill and MRF site (Component 1 and 2) from an occupational health and safety perspective, keeping in view the scope of work to be conducted daily and the use of heavy machinery to be involved in the daily operations. Moreover, organic dust which may lead to exposure to airborne microorganisms and their toxic by-products exposure cause work-related symptoms and effects among waste recycling workers in MRFs are also a concern.

901. The equipment in a MRF is likely to expose employees to excessive noise levels. Unless suitable precautionary protocols in accordance with international good practices are put in place, there is a high risk of injury and accidents taking place at the landfill site during its day-to-day operations. Draft Occupational Health and Safety Plan has been attached as **Appendix A.5.**

Mitigation Measures

902. To ensure a safe and healthy working environment for the employees of the landfill and all its auxiliary facilities, the following measures must be strictly enforced, implemented and monitored:

- OHS management system will be prepared and implemented prior to commencement of operation of the Landfill. The OHS system should be accessible, and consideration given to different levels of literacy and languages. To ensure accessibility information in the management system should be communicated via numerous means – written, visual, audio, video and hands-on.

- Designation of an Environment, Health and Safety (EHS) officer dedicated to the site and ensuring the OHS Management System is adhered to.

- All employees must be able to reach their workstations safely. All path, walkways, staircases, ladders and platforms must be stable and suitable for the tasks to be undertaken.

- Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh Bridge, material handler and waste compactor operators) must be ensured.

- Mandatory health and medical check-ups for all employees, especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m^3 as an 8-hr TWA). This should ideally be complimented by obtaining an Insurance Policy for Workmen especially engaged in the daily activities of the landfill.

- Develop a written program (i.e. health information, instruction and training) which sets forth procedures, equipment, personal protective equipment, and work practices that are capable of protecting employees from the health hazards of working in a landfill and its auxiliary facilities.

- Mandatory monitoring of air quality and noise levels in the working stations i.e MRFs, compactors and bailer etc to maintain the same within local standards and whenever possible near ambient levels.

- Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE).
- Accidental fires must be addressed immediately. Appropriate operational procedures involving the spreading and smothering of burning waste, rather than the use of water, must be implemented.
- Emergency plan (including fire management) must be developed and implemented.
- Availability of first-aid kits and vehicles that can be used to bring any injured employee to the nearest doctor in cases of accidents.
- Mandatory reporting of all accidents or incident of near misses of accidents and immediate adoption of corrective measures.
- Management must provide all the necessary financial and manpower resources for the implementation and enforcement of all health and safety programs and activities of the project.
- Regular training and orientation on safety practices will be implemented to impart knowledge of safe and efficient working environment. Furthermore, regular health check-ups of all employees including contract workers will be conducted. Effective and proper housekeeping is recommended to reduce dust exposures to its direct vicinity. Heat levels must be monitored as well. Spot checks should be done to ensure that workers' welfare is addressed especially during summer months.

8.6.8 Waste Collection and Hauling Impacts – All Components

Impacts

903. The operation of the proposed landfill and MRF will result in the movement of a higher/medium volume of trucks and heavy vehicles in general, transporting solid waste between Bahawalpur city and the proposed MRF and then landfill site. The movement of these vehicles could result in a higher risk of accidents along with the risk of increased congestion events taking place along the route of these vehicles, particularly during the times of peak traffic, such as during the morning and evening times of the day.

904. Increased traffic volume of waste carrying vehicles at MRF and LFS will result in increased air emissions, noise levels and dust issues if such impacts are not managed properly. Waste hauling through mechanically unfit vehicles will result in increased noise levels in the project area. Waste transport without purpose-built vehicles or waste transport on dirt roads will result in increased dust levels.

905. There is general practice by citizens to throw waste on streets instead of communal bins. BWMC workers needs to collect all scattered waste manually. There are multiple transactions of waste till disposal site resulting in poor waste management.

906. Communal storage constraints include shortage of containers, lack of financial resources leading to broken and ill maintained bins; Lack of planning for waste storage depots or temporary storage locations and Inaccessible areas and narrow lanes that do not allow sufficient space for container. If such constraints are not addressed, it will result in poor waste management and environmental/public nuisance.

907. Currently BWMC is under capacity with respect to daily manual sweeping and waste collection on Sunday and public holiday resulting in poor waste collection and environmental nuisance.

908. There is lack of public/civic sense with respect to waste management at source, segregation of recyclables and waste collection system. Public don't practice responsible behaviour and throw litter outside their premises in open streets, along roads, canals and other places which is resulting in operational constraints for BWMC towards solid waste management.

Mitigation measures

909. The following measures will be implemented to ensure that no traffic related issues take place due to the MRF and landfill operation:

- Capacity of BWMC will be increased though increase in its collection fleet. It will be done through procurement of both solid waste and non-solid waste carrying machinery under this project.
- Door to Door collection of waste will be enhanced through media campaigns. Communication programs would be developed to encourage better management of waste. Proper PPEs will be provided to waste handlers. Key performance indicators will be developed to monitor improvements in the system.
- All type of waste hauling at MRF and LFS will be carried out in purpose-built vehicles to avoid scattering of waste at hauling routes. Drivers of waste carrying vehicles will be trained with respect to environmental sensitization. Drivers are allowed to commute only on designated routes through purpose-built vehicles for waste hauling.
- Multiple transactions of waste will be avoided through use of main and mobile TSs. Improved segregation practices will be introducing once door to door collection desired efficiency achieved. Necessary legal bindings with respect to waste storage by Public will be introduced.
- A comprehensive traffic management plan (TMP) must be developed and implemented. Traffic management plan is provided as **Appendix A.11.**
- As part of the TMP, it will be ensured that the movement of heavy vehicles related to landfill operations is minimized during the peak traffic hours of the day to prevent congestion and accidents as far as possible.
- Furthermore, the movement of heavy vehicles within Bahawalpur city related to landfill operations must be restricted to specific routes containing least number of sensitive receptors and low traffic volumes.
- Waste hauling through dirt tracks will be strictly prohibited. Waste hauling though mechanically unfit vehicles or noisy vehicles will not be allowed.
- Waste transporters will be directed to use designated routes and follow recommended speed limit for waste hauling and such routes will be metaled roads instead of dirt tracks.
- Waste carrying vehicle shall be maintained with respect to vibratory parts, oil change and emissions.
- Vehicles which are not in compliance to PEQS shall not be allowed to transport waste to MRF and LFS.

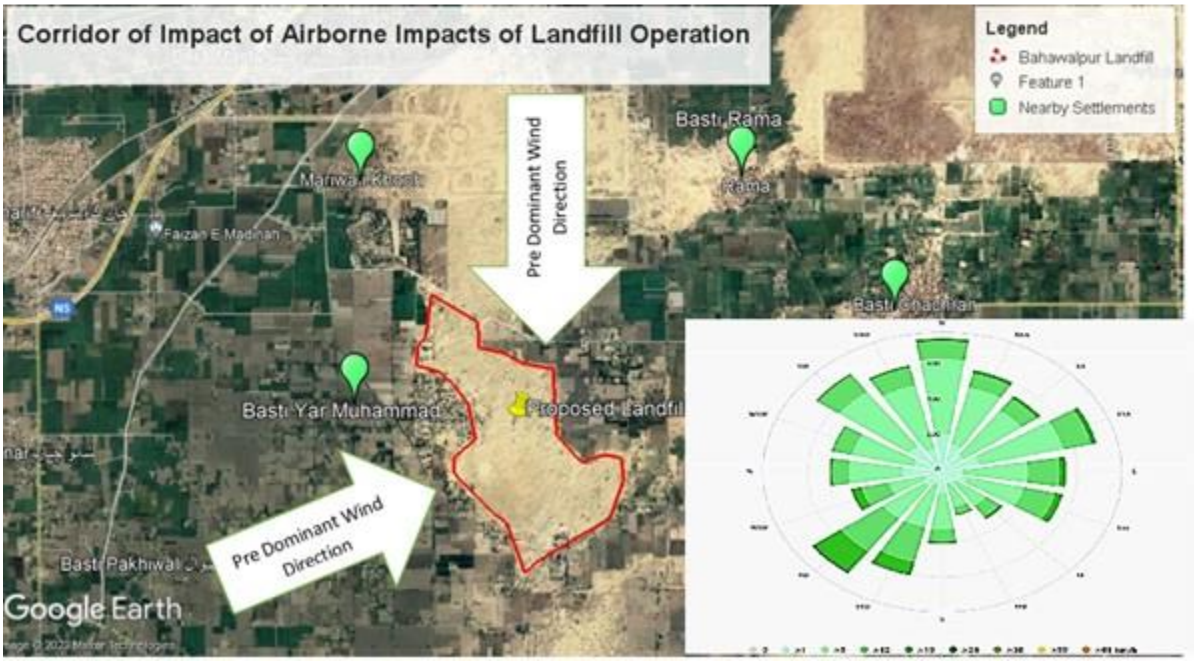
- Vehicle drivers will be trained on safe driving practices,
- Use of horns and waste scattering during waste transport to MRF and LFS shall be not allowed.
- Consultation with communities falling along the route of waste transport will be conducted on periodic basis and their response/concerns shall be promptly addressed by landfill/MRF operator.

8.6.9 Wind Blown Litter

Impacts

910. The Wind Rose for Bahawalpur City shows that dominant wind direction of Bahawalpur is from North to South with an average speed of 6 km/hr. The nearest residential area is Basti Yar Muhammad located c.520m upgradient of the landfill to the east. Since most of the houses which are being used for residential purposes are located at a minimum distance of 500 m from the proposed landfill of Component 1, no significant impacts from objectionable odour, disease vectors and litter are anticipated. Wind rose diagram is shown in below figure 9.6

Figure 8-14: Corridor of Impact of Airborne Impacts of Landfill Operation



911. One of many operational concerns in the management of a landfill is the control and management of litter. Litter includes blowing papers and other solid materials that may become airborne and carried by the wind away from the working face where solid waste is being deposited. The prominent wind direction at site is north to south and southwest to northeast. No downwind community is falling in the south and northeast of the site. The community which may be impacted from windblown litter is Basti Chachran however it is located at reasonable distance from the site and no significant impact of wind blow litter is anticipated from landfill operations.

912. The control of litter is an integral part of the daily operations of the facility. The goal of the facility operations is to implement best management practices and have all blowing litter contained at the working face. However, due to the type of facility operation and waste materials received, total containment of litter at the working face

may be difficult to achieve. The secondary goal of the facility is to strive to pick up all blowing litter that has escaped the working face at the end of each operating day.

Mitigation measures

913. The facility operator, as necessary, will implement the following procedures and techniques to control litter:

- All trucks must be tarped upon entering and exiting the facility. They should only untarp and tarp at the active area. This policy will be strictly enforced.
- Daily waste entering the landfill site will be subject to immediate compaction to minimize the area and debris subject to the impacts of wind.
- If possible, on windy days, the daily fill face tipper locations shall be selected for its protection to minimize effects of wind.
- Waste that is more susceptible to windblown distribution may, on windy days, be worked immediately into the fill face and covered with a layer of daily cover, as needed, or the waste may be excluded from the site.
- Portable skid-mounted litter fences may be provided for deployment downwind as close as practical to the working area, as needed.
- Semi-permanent fencing may be provided around the fill area as an additional barrier to the migration of litter off-site when litter has not been contained by the portable litter fences. (Examples of additional barriers include but not limited to, a four-foot minimum temporary construction fence and/or a ten-foot or higher semi-permanent fence.) The utilization will be continually evaluated, and the fence will be relocated or added as needed.
- Permanent fencing (ten-foot high with an additional three-foot kicker) may be constructed with possibility of placement on an eight-foot-high berm.
- On very windy days, when all other procedures are not successful in controlling blowing litter, the operator may apply cover material more frequently or immediately to the incoming waste load.
- Buffer zones resulting from required facility setbacks along the site's perimeter should provide some protection of adjacent properties.
- As a final control measure, personnel will be dispatched, as needed or daily if conditions require, to collect any litter that has escaped the above control measures.
- Portable litter vacuums may be used to collect litter that has accumulated on litter fences. If fences are positioned properly, this can be a very efficient method of collecting litter.
- The main highway leading to the site will be routinely inspected for litter. If the highway has litter associated with the trucks entering the facility, then the litter will be picked up on a routine basis. All necessary safety precautions must be followed.
- Before and after photos of any litter removal effort may be taken in the event anyone questions the level of effort spent on litter collection.
- Site management's cell phone numbers may be provided to community/neighbours.

- The management of litter at the landfill is a daily activity. In most instances the above procedures and techniques should properly manage litter effectively. However, there will be occasions and situations when litter will be distributed by the wind in such a manner that the above procedures will not totally manage the litter and contain the litter on-site. In these situations, the facility operator may not be able to collect all litter within the day the litter problem occurred. However, the facility operator should proceed with collecting the litter off site and complete the retrieval of wind-blown litter at the earliest practicable time.

8.6.10 Solid Waste Disposal & Health and Sanitation

Impacts

914. The landfill development will greatly improve solid waste management system in Bahawalpur city and the project area and improve overall aesthetic value and quality of urban area of Bahawalpur city.

915. Community development programs that may be undertaken, including health and hygiene education, reduction, reuse and recycling of solid waste, skill training of low-income people would be of great benefit to local community. The magnitude of the impact shall be high, local, long term and impact is very significant.

Mitigation measures

No measures required.

8.6.11 Public Health

Impacts

916. The operation of the proposed landfill will result in solid waste management in a way resulting in fixing issues like odour, vector borne diseases from open dumped waste, poor sanitation and ground water contamination in the area.

917. The operation of the proposed landfill will limit risk of vector spread, fire and explosion of dump site gas.

918. It will result in an overall positive impact on the public health by preventing issues such as infectious diseases, disease vector generation, groundwater aquifer contamination etc.

919. Specifically, successful operation of Bahawalpur landfill site will limit the child scavenging activity who are directly at risk as they are not using any PPEs.

920. Further, it will provide promising opportunities to people involved in scavenging activity in terms of jobs and other economic incentives to accelerate recycling potential at the facility.

Mitigation measures

No measures required.

8.6.12 Aesthetic Aspects – All Components

Impacts

921. Open dumping of solid waste creates poor aesthetics in the project area. However, landfill and MRF site shall be walled, and the aesthetic impacts will be far less as compared to open dumping. However, due to the movement of the waste truck on the streets will create a little aesthetic nuisance.

Mitigation measures

- The boundary walls shall be constructed alongside the facility.
- The indigenous plants shall be planted alongside the access road and around the landfill site, MRF and legacy landfill which will act as buffer zone.
- The waste transfer vehicles shall be covered.
- Reasonable area will be allocated for plantation within and at boundary of facility to improve aesthetic appeal of the area. This plantation can also act as the buffer zone.
- The plantation will start as one of the earliest activities of site development. Once the design of landfill is approved and necessary funds mobilized, plantation activity can be started in collaboration with Bahawalpur Development Authority or BWMC can outsource the activity separately.

8.6.13 Construction and Demolition Waste Disposal

Impacts

922. Dumping of construction wastes/excavated material in Bahawalpur City create poor aesthetics and may limit the use of land in the project area. The solid waste may be generated due to different construction activities, and it will mainly include surplus excavated and construction material.

923. The indiscriminate disposal of solid waste may cause dust emissions due to the wind blowing, thereby affecting the health of the community.

Mitigation measures

- All components of construction & Demolition Waste shall be processed, recycled, and reused.
- All Concrete, PCC and RCC will be processed to Produce Class II and Class III recycled Sub-Base and Base materials.
- Recovered Asphalt Concrete will be mixed in Recycled concrete or reused by mixing with fresh Asphalt concrete.
- All metal will be recovered and recycled.
- Wood component will be Processed and used as Mulch or raw materials for compost.
- Processed waste will be used as Cover material for landfills.

8.6.14 Impacts associated with Operations of Compost and AD plant

Impacts

At the composting plant, odours originate with the incoming organic waste, which may have been stored anaerobically (without oxygen) for a week or more before transport to the site. Once these ingredients are incorporated into the composting system, subsequent odour problems are usually a result of low oxygen or anaerobic conditions. Other impact from composting plant will include leachate generation which will be collected through provision of drains at site. Improper compositing can result increased CH4 and N_2O emissions which are GHGs. Compositing may attract rodents such snakes, rats and bugs to the site. Composting requires continuous supply of good quality organic waste and bulking agents and required controlled conditions; in case such requirements are not met the quality of compost will be compromised. Since the AD plant is closed system therefore no significant impacts associated with the operation of AD plant are envisaged.

Mitigation measures

- Inventory and quality of organic waste reaching the composting facility shall be maintained.
- No mixed waste shall be introduced in the compositing facility.
- pH, C/N and C/P ratio shall be maintained as per design recommendations.
- Air should be thoroughly dispersed throughout the organic waste. This is done by frequently turning and mixing the wastes.
- Temperature should be maintained between 50 to 60oC for active composting period.
- Incoming organic waste shall not be stored for longer time without processing at the facility as it will create odour.
- Leachate drains shall be provided at compositing pads. Collected leachate shall be sprayed to the landfill site.
- Adequate stock of bulking agents shall be available at the facility.
- Facility shall be secured and fenced to avoid rodents such as snakes and rats.
- Fumigation shall be carried out on periodic basis to kill pathogens.
- Housekeeping of the facility shall be ensured through dedicated staff to remove chances of vectors breeding.
- Proper PPEs shall be provided to workers involved in compositing operation.
- Local exhaust ventilation system shall be operational all the time to limit impacts of objectionable odour.

8.6.15 Impacts associated with MRF Operations

Impacts

924. MRF operations can generate fugitive dust, noise hazards, ergonomics problems and occupational hygienic implications. If MRF is operated without improper ventilation, then it will result in increased dust which can pose health hazards to workers. IF MRFs conveyor belt workstations (picking-stations) are not well constructed to ensure that operators do not excessively lean, stoop, twist, or over-reach, these repetitive movements can themselves lead to musculoskeletal injury. Most MRFs have processes which emit high noise levels which need to be managed through enclosures and use of PPEs. The MRF processes involved during recycling can generate organic dust, which may lead to exposure to airborne microorganisms and their toxic by-products. This may cause health problems in workers who are involved in the handling waste. There is also the potential for exposure to agents which are known to have harmful effects on human health such as fungi, bacteria and endotoxins. Other risks include collision among vehicles, machinery failures and maintenance issues, slips and trips and work at height hazards.

Mitigation measures

- Conduct risk assessment for MRF operations and prepare method statement in line with risks and suggested mitigation measures
- Procure MRF machinery or plant with designed noise data from the supplier.
- Move noisy machinery/plant into areas where there are no workers, or few i.e. dedicated area.

- Provided enclosure if machinery/plant must remain in the working area, enclose it within a sound-insulating enclosure if possible.
- Where enclosure is not possible, reduce noise by other engineering means such as:

  - lining guards/panels with noise dampening material
  - providing acoustic screens
  - lining the inside of hoppers with impact-deadening material
  - fitting anti-vibration mountings
  - fitting silencers to exhaust systems

  ensuring good maintenance to stop rattles and prevent noise from wear.

- Provide job rotation to reduce exposure of noise.
- Provide hearing protection to workers.
- Where noise levels still exceed 85dB(A) ensure workers wear hearing protection (earplugs or earmuffs) within the designated and clearly marked zones.
- Conveyor belts shall not be too high or low (making the person stoop and/or stretch)
- Conveyor belts shall not be too wide (making the person reach too far)
- Provide adequate foot clearance under conveyor
- Provide proper access to belt surface
- Provided adequate illumination at work area for clear visibility
- Speed of belt shall be controlled
- Emergency arrangements shall be in place to stop to the belt in case of break or fatigue
- Provide adequate working space of workers engaged at conveyor belts
- Provide sufficient job rotation
- Provision of adequate welfare and hygiene facilities
- Provision of a risk-based health surveillance programme
- Control of inhalation exposure to hazardous substances by the effective use of general ventilation, Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE)
- Provision of training and supervision
- Periodic inspection of MRF machinery to ensure its integrity and cleanliness
- Haphazard material stocking shall be avoided to reduce slip and trips hazards
- Work at height will be supervised and work platform shall be inspected prior to start of work
- Necessary PPEs shall be provided to workers for noise, airborne dust and work at height.

8.6.16 Impacts associated with closure of Legacy Landfill at Khanu Wali

Impacts

925. The current legacy landfill at KhanuWali will continue to operate until the new landfill has been constructed and is accepting waste. This landfill is currently accepting waste in an uncontrolled and un-engineered manner with no mitigation measures in place.

926. The current condition will currently be resulting in uncontrolled generation of landfill gas, leachate and windblown litter. There are no security measures in place and the site is open to scavenging presenting health and safety risks.

927. The plan to close and remediate this landfill will itself have significant benefits for the environment and human health.

Mitigation

- As part of this project, a detailed site investigation and development of conceptual site model will be established to enable modelling of the landfill gas and leachate risks presented from the site both now and projected to 2028 when the site will close fully. Details of this have been recommended in the design stage impacts and mitigation.
- Once the conceptual site model and risks to the environment and human health are understood, and effective site closure plan will be developed for the site. This will assess the risks of allowing the landfill to continue as a dilute and disperse model versus the deployment of engineered control systems to control landfill gas and leachate.
- Whilst the site is operational, simple measures will be taken to reduce ongoing impacts to the environment, such as:
    - Limiting tipping to within the landfill boundary and should cease on the MRF site.
    - Installation of daily cover to reduce wind-blown litter, odours and vectors.
    - Establishment and maintenance of a buffer zone (c.250m) surrounding the landfill to enable passive gas venting measures to be installed,
    - Installation of boundary fencing and planting of trees around the permitter of the site to prevent windblown litter, spread of odours, reduction in greenhouse gas emissions, and improvement of the site aesthetics.
    - Installation of permanent perimeter gas monitoring wells with frequent gas monitoring to understand the risks from off-site landfill gas migration.
    - Installation of permanent groundwater monitoring wells to establish the site baseline and assess whether offsite migration of leachate is occurring.
    - Regular monitoring of surface water and any nearby drinking water wells to establish baseline quality.
    - Monitoring results should be collated into an annual report shared with the PMU prior to closure and should feed into the design of the final site closure plan and restoration options for the site.

8.6.17 Landfill – Site Closure Planning

This section details the impacts from a lack of site closure planning and applies to both the new landfill (Component 1) and the legacy landfill (Component 2)

Impacts

928. Even after closure, landfills require long-term care, including maintenance of the cap system, collection and treatment of leachate, collection and flaring or utilization of landfill gas, and monitoring of groundwater so that the waste remains isolated.

929. Impacts associated with closure and post closure phase of the landfill include poor aesthetics of the area, runoff issues, leachate/odours issues, uncontrolled gases and long-term environmental nuisance.

930. There is a need of routine inspection of the facility infrastructure particularly landfill cells and gas/leachate collection system to avoid and monitor any contamination released to environment.

931. There is need to manage leachate and gas continues after landfill closure, which should be an integral component of the total landfill management together with restoration and surveillance.

932. As moisture enters the landfill through an ineffectively maintained cover after the landfill has been closed, leachate will also again be generated. If the leachate collection and removal system is no longer functioning to collect and remove from the landfill all the leachate generated, and/or the landfill operator is no longer operating/maintaining the system, the leachate will accumulate in the landfill, leading to increased potential for leachate to penetrate through the liner and potentially begin to pollute groundwater.

933. The result will be landfill gas and leachate migration off-site posing a risk to the environment and human health.

Mitigation measures

- Appropriate selection of soil type for final cover will be ensured to prevent water infiltration and minimize infiltration of precipitation into the waste and the subsequent generation of leachate; control landfill gas migration; and minimize long term maintenance needs.
- Appropriate selection of soil type for final cover will be ensured to prevent direct or indirect contact of living organisms with the waste materials and their constituents.
- Application of final cover components that are consistent with post closure use and local climatic conditions.
- Necessary environmental objectives and controls (including technical specifications) will be defined and implemented.
- Necessary surveillance protocols for final capping, leachate and gas monitoring will be established and implemented.
- Future Land use of the site will be defined in consultation with local communities and government agencies. Future land use should not break ground cover damaging the integrity of the capping layer.

- It will be ensured that financial resources, and monitoring arrangements are in place for closure and post closure activities.
- PMU Punjab LG&CDD will ensure that financial instruments are in place to cover the costs of closure and post-closure care and monitoring.
- Long term integrity and security of the site will be maintained.
- Continuous monitoring of gas and groundwater quality will be undertaken. The frequency of which will be determined by the regular monitoring during operation. If conditions are stable, the monitoring frequency can be reduced.

8.6.18 Cumulative Impacts

934. Based on the scoping exercise of the site and based on discussions with the public sector agencies responsible for development in the project area, no other infrastructure works are planned to be conducted in the landfill project area while these project works shall be conducted. Thus, no cumulative impacts are expected.

8.6.19 Indirect and Induced Impacts

935. The potential impact of development of the landfill in the project area has been examined, which indicated that the existing and planned infrastructure such as water supply, wastewater collection and treatment, municipal solid waste collection and disposal would be adequate to accommodate any potential population intake because of the proposed landfill development. Impacts on the environment from air emissions, traffic and community noise have also been assessed and have found to be acceptable and within the carrying capacities of the environmental media.

936. Thus, negative indirect and induced impacts from the proposed landfill works are not expected.

9 Environmental Management Plan

9.1 Introduction

937. The IEE has identified potential impacts that are likely to arise during development of the project, both negative and positive impacts at each stage of the project. To minimize the effects of adverse impacts the IEE has recommended mitigation measures in the EMP. The proposed mitigation measures have been based on the understanding of the sensitivity and behaviour of environmental receptors in the project area, the legislative controls that apply to the project and a review of good industry practices for projects of similar nature. For residual impacts (impacts remaining after applying the recommended mitigation measures) and for impacts in which there can be a level of uncertainty in prediction at the IEE stage, monitoring measures have been recommended to ascertain these impacts during the project activities.

938. The Environmental Management Plan (EMP) is developed to eliminate and/or mitigate the impacts envisaged at the design, construction, and operation stages.

939. The detailed EMP provided in this document as **Table 9-1** ensures that development of all project components (landfill, MRF and Legacy Landfill) have no detrimental effect on the surrounding environment.

940. The Plan shall act as a guideline for incorporating environmental measures to be carried out by the contractors engaged for the proposed project. It shall also be used for other parties concerned for mitigating possible impacts associated with each project and will form part of the Contract documents to be considered alongside the specifications. This Plan shall act as the Environmental Management and Monitoring Plan during the construction and operation phase of the project and will allow for prompt implementation of effective corrective measures.

9.2 Environmental Management Plan (EMP)

941. The EMP attached with this report ensures the following:

- Delivery of the prescribed environmental outcomes during all phases of this sub-project.
- Formulating a system for compliance with applicable legislative requirements and obligations and commitments for this sub-project.
- Ensure that project design process incorporates best practice environmental design and sustainability principles to minimize potential impacts of construction on the environment and community.
- Ensure that the construction work procedures minimize potential impacts on the environment and community.
- Develop, implement and monitor measures that minimize pollution and optimize resource use.

9.3 Objectives of EMP

942. The EMP provides a delivery mechanism to address potential impacts of the project activities, to enhance project benefits and to outline standardized good practice to be adopted for all project works. The EMP has been prepared with the objectives of:

- Defining the roles and responsibilities of the project proponent for the implementation of EMP and identifying areas where these roles and responsibilities can be shared with other parties involved in the execution and monitoring of the project.
- Outlining mitigation measures required for avoiding or minimizing potential negative impacts assessed by environmental study.
- Developing a monitoring mechanism and identifying requisite monitoring parameters to confirm effectiveness of the mitigation measures recommended in the study.
- Defining the requirements for communication, documentation, training, monitoring, management and implementation of the mitigation measures.

9.4 Environmental Management/Monitoring and Reporting

943. During the construction phase, the overall responsibility for the implementation and monitoring of the EMP rests with the Project Director (PD), Project Management Unit (PMU), LG&CDD, Punjab. The PD at the PMU, using the Construction Supervision Consultant (CSC), will supervise the implementation of the proposed mitigation measures and monitor the implementation progress in the field.

944. During the operation phase, the overall responsibility for the implementation and monitoring of the EMP rests with Managing Director, BWMC. For initial two years of LFS operation, relevant Contractor will be responsible for running of relevant plant (e.g. AD compositing vendor, MRF Vendor, Leachate treatment plant vendor etc.) and also responsible for implementation of EMP. This requirement will be reflected in the bidding document of such Contractors/Suppliers. Furthermore, these Contractors will train designated staff of BWMC with respect to technical matters as well as EMP requirements.

945. The specific roles and responsibilities for environmental management and monitoring are provided in **Table 9-1** below.

9.4.1 Inclusion of EMP in Contract documents

946. To make Contractors fully aware and responsible of the implications of the EMP and to ensure compliance, it is recommended that mitigation measures be treated separately in the tender documentation and that payment milestones should be linked to performance, measured by execution of the prescribed mitigation measures. Such a procedure would help ensure adequate management of project impacts is carried out during the construction and operation phases, where a consistent approach will be expected on behalf of the Contractor and its sub-contractors so that data and information collected from monitoring programs is comparable with baseline monitoring data.

947. The Contractor shall be made accountable through contract documents and/or other agreements for fulfilling the environmental safeguard obligations and delivering on the environmental safeguard components of the Project. Contractors shall be prepared to co-operate with the executing agency and supervising consultants and local population for the mitigation of adverse impacts. After the EMP's inclusion in the contract documents, the Contractor will be bound to implement the EMP and will engage appropriately trained environmental and social management staff to ensure the implementation and effectiveness of the mitigation measures.

948. The Contractor is required to bid for executing the EMP, including the recommended mitigation measures and monitoring programs, as part of its Bill of Quantities (BoQ).

9.5 Institutional Arrangements

949. The environmental management plan will require involvement of the following organizations for its implementation during construction and operation phases of the project:

9.5.1 Role of PMU/CIU, PUNJAB LG &CDD

950. PMU will:

- Provide support to ADB missions.
- Coordinate activities with all stakeholders, review consultants, proposals, and provide overall guidance during various stages of project preparation.
- Manage and ensure safeguard due diligence and disclosure requirements including resettlement and environmental safeguards in accordance with ADB's Safeguard Policy Statement (2009) and PUNJAB government requirements.
- Manage and ensure effective implementation of the gender action plan.
- Ensure submission of all IEE requirements as per law by responsible entities.
- Monitoring of activities of the entire project.

9.5.2 Role of the ADB

951. ADB will:

- Support the coordination and administration of the project.
- Provide guidance to PMU and BWMC on implementation issues and project design.
- Disclose all safeguards documents and monitor safeguards implementation.
- Monitor and report project performance.
- Conduct periodic review of the project.

9.5.3 Role of Construction Supervision Consultant (CSC)

952. The CSC will be responsible for the following items:

- Incorporates into the project design the environmental protection and mitigation measures identified in the EMP for the design stage.
- Assists PMU to ensure that all environmental requirements and mitigation measures from the IEE and EMP are incorporated in the bidding and contracts documents.
- Ensure monitoring and compliance with EMP and its requirements.
- Preparation of SAEMR and submission to PMU for review.
- Ensure staffing of Environment and OHS resources for the project.
- Prior to construction, reviews the updated SSEMPs prepared by the contractor.
- Undertakes environmental management capacity building activities for relevant project focal staff.

9.5.4 Role of PUNJAB EPA

953. The Punjab EPA will have the following responsibilities with regards to this landfill project:

- Provides regulatory compliance works for the project.
- Reviews and approves environmental assessment report of landfill, submitted by PMU.
- Issues environmental clearance certification for the project based on their mandate and regulations.
- Undertakes monitoring of the project's environmental performance based on their mandate.

9.5.5 Role of Project Contractor

954. The project contractor will be responsible for following items:

- Implementation of, or adherence to, all provisions of the IEE and EMP.
- Preparation of site specific EMPs (SSEMPs) as required. SSEMPs will be prepared by Contractor’s Environment Specialist, site in charge, HSE staff and project technical team before their mobilization and it will be submitted to Engineer of construction supervision consultant/PMU for review and approval. Site specific EMP template for guidance of contractors is provided as **Appendix A.9**.
- Contractor’s environmental performance will rest with the person holding the highest management position within the contractor’s organization. Reporting to their management, the contractor’s site managers will be responsible for the effective implementation of the EMP.
- The Contractor will be required to have qualified Environmental Specialists in their team to ensure all mitigation measures are implemented during the different development phases of the project.
- Contractor will Allocate financial resources for successful implementation of EMP.
- Contractor will develop OHS policy and guidelines for the project and ensure its implementation.
- Contractor will prepare method statement for each work site.

9.5.6 Role of BWMC

955. The BWMC will be responsible for following items:

- Implementation of, or adherence to, all provisions of the IEE and EMP.
- Preparation of site specific EMPs for operations phase.
- BWMC would be responsible to ensure that contractors engaged during operation phase of landfill site are executing activities in compliance to IEE/EMP.
- BWMC will be required to have qualified Environmental Specialist designated for LFS to ensure all mitigation measures are implemented in true letter and spirit.

9.6 Monitoring Parameters

956. A monitoring plan for the construction phase of the project, indicating environmental parameters, frequency and applicable standards is provided below as **Table 10.3** below.

957. During the procurement/pre-construction period, the monitoring activities will focus on (i) checking the contractor's bidding documents, particularly to ensure that all necessary environmental requirements have been included; and (ii) checking that the contract documents' references to environmental mitigation measures requirements have been incorporated as part of contractor's assignment and making sure that any advance works are carried out in good time.

958. During the construction period, the monitoring activities will focus on ensuring that any required environmental mitigation measures are implemented to address possible impacts.

959. In general, the construction impacts will be manageable, and no insurmountable impacts are predicted, provided that the EMP is implemented to its full extent as required in the Contract documents. However, experience suggests that some Contractors may not be familiar with this approach or may be reluctant to carry out some measures. For the proposed project, in order that the Contractor is fully aware of the implications of the EMP and to ensure compliance, environmental measures must be costed separately in the tender documentation and listed as BoQ items, and that payment milestones must be linked to environmental performance, vis a vis the carrying out of the EMP.

960. The effective implementation of the EMP will be audited as part of the loan conditions by ADB, and as part of regulatory/NOC compliance by Punjab EPA. In this regard, the PMU will guide the design engineers and Contractors on the environmental aspects and necessary EMP documentation. Monitoring during operation phase will be carried out by BWMC with support from PMU.

9.7 Environmental Training

9.7.1 Capacity Building and Training

961. Capacity building and training programs are necessary for the project staff to control the negative impacts resulting from the project construction and during its operation phase. They will also require trainings on monitoring and inspecting of such a project for environmental impacts and for implementation of mitigation measures.

962. The details of this capacity building and training program are presented in the **Table 10.7** below.

9.8 Environmental Staffing and Reporting Requirements

963. EMP implementation would be responsibility of all project stakeholders including PMU, BWMC, Project Construction contractors, O&M contractor and other suppliers involved in the project. Requirement of environmental staffing will be part of bidding documents and necessary cost will be allocated as BOQ item by the bidder. PMU will maintain environmental safeguard staffing (Environmentalist/Environment Associate) for construction and operation phase of the project to monitor and supervise EMP implementation and performance. Environment expert will also be part of CSC technical time and will produce bi-weekly and monthly environmental compliance reports during construction phase. Environment expert of CSC will be

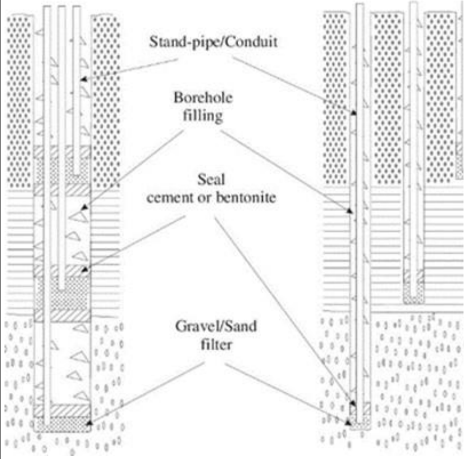
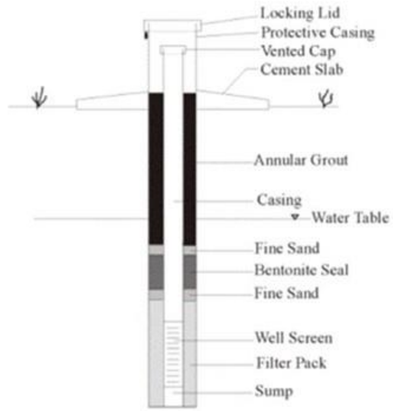
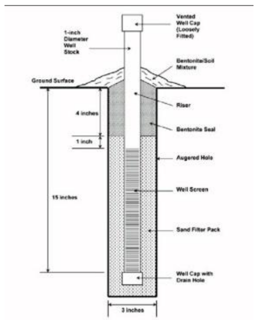
responsible to monitor the implementation of EMP during construction phase by project contractors.

964. Project contractors will also hire sufficient environmental officers to implement the EMP requirements and prepare necessary EMP documentation. Project contractor EMP staff will prepare daily environmental reports and submit to CSC for approval and record. BWMC will hire qualified environmental specialist during operation phase of the project who will be responsible for EMP implementation and reporting by BWMC and its O&M contractors during operation. Monthly environmental compliance report will be prepared by BWMC and circulated to concerned authorities. Further third-party environmental monitoring consultant will be hired on intermittent basis to monitor the EMP implementation and to report environmental non-compliances.

Table 9-1: Environmental Management and Mitigation Matrix

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
Design/Pre-Construction Phase	1 – SWM 2 – MRF (inc LL Restoration) 3 - IWMF	1.1	Site Selection	• Site selection for all sites must be conducted in accordance with international standards and guidelines for landfill development, including but not limited to the IFC Guidelines on Waste Management Facilities for Landfills. • Factors such as site capacity, accessibility, acceptability, stability, environmental sensitivity, land use, socio-economic receptors and climate hazards shall be assessed and evaluated at the time of site selection • Proposed selection of sites must consider impacts from leachate, litter, dust, vector and odors on surrounding environment.	EDCM	PMU	BC: during detailed designing of the sub-project
	1 – SWM 2 – MRF (Inc. LL Restoration) 3 - IWMF	1.2	Integration of IEE/EMP requirements into bidding documents	• The proposed 'Safeguards unit' that will be developed at the PMU will be assigned the task to check that design and bid documents are responsive to key environmental, social and safety considerations, and that the proposed method of work reflects the boundaries defined in the EMP. The bid documents must include the EMP, and its implementation cost must be reflected in the BOQ. • IEE/EMP implementation and monitoring requirements must be part of bidding documents and necessary contractual binding must be agreed by project contractors before award of contract. • Project contractors shall have qualified and experienced environmental staff to plan, arrange, implement, monitor, and report IEE/EMP requirements.	PMU	-	BC: during detailed designing of the sub-project
	1 – SWM 2 – MRF (inc.LL Restoration) 3 - IWMF	1.3	EMP Implementatio n	• PMU Punjab LG &CDD shall review the contractor capacity with respect to safeguard management and contracts shall be awarded accordingly. • The Contractor will be required to define an Occupational and Environmental Health and Safety procedure for all work, including work camp operation, management of cement dust, and use of Personal Safety Equipment. These procedures should be developed and approved by the PMU in collaboration with the focal agencies before the Contractor commences any physical works on ground. • PMU Punjab LG&CDD shall ensure the project contractors are selected on merit and necessary funds has been allocated in the contract documents for EMP implementation and monitoring.	PMU	PMU	BC: during detailed designing of the sub-project
	1 – Landfill 2 – Legacy Landfill (LL)	1.4	Land Acquisition and Resettlement Impacts	• Pending payment to all landowners must be paid before mobilization of construction contractors. • Social safeguard unit shall ensure that project affected people has been paid following appropriate procedures and there are no grievances about land acquisition process of the site.	EDCM	PMU	BC: during detailed designing of the sub-project

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
	1 – Landfill 2 – MRF (inc.LL Restoration)	1.5	Impacts due to Natural Hazards	• Bahawalpur Landfill and the MRF infrastructure shall be designed keeping in view the seismic zone 2 A building considerations. • Surface water diversion shall be included in the design to protect sites from urban/flash flooding. • Extreme precipitation events analysis shall be performed for landfill life i.e. 25 years, to predict and manage impacts of flash flooding. This shall also be applied to MRF site and Legacy Landfill. • On site waste storage at loading bay shall be kept to minimum during high precipitation events. • Emergency response plan shall be prepared by construction and operation phase contractors and will be submitted to PMU for approval to manage impacts of natural hazards such as earthquakes and floods.	PMU	-	BC: during detailed designing of the sub-project
	2 – Legacy Landfill	1.6	Impacts due to lack of site characterisation and baseline monitoring	• A full site characterization of the geology, hydrogeology and hydrology in the surrounding area will be undertaken. This will include as a minimum: ○ Installation of c. 8 No. permanent perimeter boundary monitoring wells around the boundary of the landfill. These wells should be drilled to c.15m depth or 2m below resting groundwater whichever is deepest. The wells should be drilled using a rotary drilling rig capable of allowing logging of strata to BS5930 or similar. If perched water bodies are encountered these should be sealed with bentonite prior to extending drilling to prevent creation of a preferential pathway. Nested wells should be installed if necessary to allow monitoring of different water bodies (perched and groundwater). The image below indicates a suggested borehole construction. The contractor will agree the well design with the PMU before drilling commences. All wells should be completed with a metal, lockable covers and constructed and protected to minimise risk of damage and designed to enable monitoring during the lifetime of the landfill (c.25 years). If necessary, the contractor should budget to replace wells should they become damaged or inoperable. Care should be taken to construct wells so that they do not silt up.	EDCM	PMU	2024-2025

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				  Typical monitoring-well design. (*Not to scale*) ○ Installation of 16No. permanent gas monitoring wells (c.4 per boundary). These should be shallow wells installed to the depth of the landfill. They should include a 1m below ground bentonite seal and at least 2m of perforated well screen and fitted with gas monitoring taps. The contractor should agree the design specification of the wells with the PMU before construction. ○ The well should be a permanent monitoring feature protected with metal lockable covers and should be designed to last the lifetime of the landfill (c.25years). The contractor should allow budget for replacement of the wells as necessary. A typical well design is shown below. 			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				○ The contractor should undertake monitoring of the above wells to ascertain the baseline conditions prior to restoration and to inform the site closure plan. ○ Groundwater monitoring should be undertaken quarterly for two years, and gas monitoring should be undertaken weekly for a six-week period capturing periods of high and low atmospheric pressure and then be reduced to monthly thereafter. Consideration could be given to installation of permanent remote gas monitoring equipment with telemetry such as GasClam ®. ○ Once the site characterisation has been completed, the contractor will prepare a detailed conceptual site model detailing risks from leachate migration to hydrogeology, hydrology, ecology and human health and risks of landfill gas migration to residents, business and the proposed adjacent MRF facility operations. ○ Once baseline conditions have been established the contractor will agree with the PMU the laboratory schedule and frequency of required further testing. This should be no less than monthly for groundwater and monthly for landfill gas unless four quarters of non-detectable concentrations are detected in which case a reduction in frequency can be agreed with PMU. At a minimum sampling and analysis will be conducted on a quarterly basis. ○ All monitoring data should be collated into an annual monitoring plan shared with the PMU. Any proposed adjustments to frequency or schedule of testing should be supported by monitoring evidence presented in the annual report. ○ Following completion of the site characterisation, the site closure plan should be developed detailing how landfill gas and leachate will be collected and treated, if necessary, details of final capping construction and restoration plans for the landfill longer term (e.g. used for ground mounted solar or grazing land), and details of how surface water will be controlled. Any proposed end-use should preclude anything that will break ground beyond the capping layer. ○ The baseline monitoring will also enable a cost benefit analysis to be undertaken regarding the feasibility of landfill gas to energy as a potential source of renewable energy for the site.			
	1 – SWM		Air Strike Risks	• Bird species, their abundance, timing and movements to and from the existing Legacy Landfill site are to be recorded for a period prior to the construction of the new Landfill.	EDCM	PMU	2024-2025

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• The project Proponent and the Project team will liaise with the Air Traffic Control Team at the Airport to ensure that reports of near misses and bird strikes are recorded and shared with them. • Assess risk implications relating to the identified birds and their behavior for the new landfill • Develop and implement additional monitoring, mitigation or design changes as needed to reduce the risks.			
	1 - SWM 2 – Legacy Landfill Restoration	1.7	Lack of Site Closure Plan	• A site closure plan will be developed for both the legacy landfill and the new landfill that details. This will be published prior to operation of the new landfill and closure of the legacy landfill. It will include details of: o How the site will be closed and restored and what its future land use will be. o Known details of the landfill, including the conceptual site model, construction details, likely types of waste and any known historical data. o Details of any local permit requirements. o Details of intermediate cover, final cover and post closure care. Timelines will be included. o The intermediate cover should control erosion, minimise water infiltration, reduce odours. The site closure plan will specify the materials, thickness and installation procedures to be used. o The final cover design will seal the landfill to prevent water infiltration and gas emissions. It should include specifications of the materials, slope and cap drainage system. o Details of how leachate will be managed, controlled and if necessary treated. o Details of how landfill gas will be collected and managed. o Details of the post closure monitoring plan including groundwater, surface water, and gas. It should outline the frequency and duration of the monitoring. o Details of the financial mechanisms in place to cover the closure and post closure costs ensuring funds are available to implement and maintain the closure plan.	EDCM	PMU	2024-2025

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				○ Details of who will manage the landfill, and how they will liaise with local stakeholders to address any concerns. ○ Outline procedures for addressing emergencies, unforeseen or unexpected events during the closure process and landfill lifetime such as gas and leachate leaks and fires, regulation changes or land use changes (e.g. encroachment of significant residential development nearby). ○ Details of record keeping and who should be kept informed via annual reporting, and what information will be publicly shared.			
Construction Phase	1 – Landfill 2 – MRF & Legacy Landfill 3 - WMF	2.1	Project Design	• Method statements must be prepared by the Contractor and approved by the Construction Supervision Consultant (CSC) prior to commencement of construction works for any of the components. • The contractor will prepare a Construction Environmental Management Plan detailing how the requirements of this EMP will be incorporated into their standard operating procedures and how the requirements will be managed and governed. • The CSC must closely monitor the construction works being conducted by the Contractor to ensure the finalized design is implemented in full and the design is developed completely in compliance of the approved finalized designs. • Any deviation by the Contractor from following the finalized design must be immediately highlighted and corrective measures must be implemented to ensure full compliance with the finalized design. • PMU PUNJAB LG&CDD shall ensure that construction activities are being carried out in compliance to project design following best international practices. It will closely review and monitor the activities of CSC and contractors involved in construction activities.	Contractors	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill	2.2	Air Quality Degradation	**Stockpiles** • At the site and the immediately adjoining areas, during earth-moving activities water will be sprinkled every three hours and at a higher frequency if felt necessary, at all construction sites to suppress dust emissions. • For both components, site levelling and grading will be carried out, wherever possible to maintain the natural elevations. • Stockpiled soil and sand shall be slightly wetted before loading, particularly in windy conditions and vehicles transporting soil, sand and other construction materials shall be covered with tarpaulin. • The need for large stockpiles shall be minimized by careful planning of the supply of materials from controlled sources. Stockpiles should not be located within 50 m of	Contractors	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				schools, hospitals or other public amenities and shall be covered with tarpaulin when not in use and at the end of the working day to enclose dust. If large stockpiles (>25m^3) of crushed materials are necessary, they should be enclosed with side barriers and covered when not in use. **Transport** • All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations. • Fuel-efficient and well-maintained haulage trucks shall be employed to minimize exhaust emissions. Vehicles should not be allowed to "idle" with engine running. • Limitations to speeds of such vehicles to between 5-15km/h within site boundaries. Lower speeds are important for dust control, safety, soil erosion and noise reduction. Offsite, speeds should comply with area limits and transport routes should be agreed in advance avoiding densely populated area. • Dust emissions due to road travel shall be minimized through good construction practices (such as keeping stockpiles down wind and away from communities) and sprinkling water over the access road. • It shall be ensured that the following measures are taken to control emissions from vehicles being used in the construction activity: ○ Periodically check and conduct maintenance of the construction machinery and haul vehicles. Generators, compressors and vehicles used during construction works will be maintained in a good condition to ensure that emissions are kept to a minimum level. ○ Regularly change the engine oil and use new engines/machinery/equipment having good efficiency and fuel burning characteristics. • Training of the technicians and operators of the construction machinery and drivers of the vehicles. • All type of machinery and generator must comply with the PEQS. Vehicles, which are not in compliance with PEQS are not allowed to use. • Periodic emission monitoring of vehicles, generator and batching plants is proposed. **Concrete Batch Plants & Generators** • Concrete plants to be controlled in line with statutory requirements and shall not be close to sensitive receptors. • The contractor should prepare a site-specific risk assessment prior to siting any batching plants. This will assess risks to the environment and local community from			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				air quality, dust, noise, and water pollution. A distance of 0.5km will be ensured between batching plant(s) and the nearest community, however this could be reduced if best available technology is deployed to limit risks. • Stack height of generators will be at least 3 metres above the ground. • Controlled technology generator and batching plants will be used to avoid excessive emissions. **Occupational health** • Maintaining levels of contaminant dusts, vapors, and gases in the work environment at concentrations below those recommended as TWA-TLV's (threshold limit value)—concentrations to which most workers can be exposed repeatedly (8 hours/day, 40 hrs/week, week-after week), without sustaining adverse health effects. · • Developing and implementing work practices to minimize release of contaminants into the work environment including: a. Direct piping of liquid and gaseous materials b. Minimized handling of dry powdered materials, Enclosed operations c. Local exhaust ventilation at emission/release points d. Vacuum transfer of dry material rather than mechanical or pneumatic conveyance e. Indoor secure storage, and sealed containers rather than loose storage • Where ambient air contains several materials that have similar effects on the same body organs (additive effects) **Dust Control** • For any earth moving that is to take place in the immediate vicinity from the site boundary, watering must be conducted as required to prevent visible dust emissions • Apply dust suppression measures (clear vegetation only from areas where work is to commence, plant or mulch areas that will not receive traffic, construct artificial wind breaks, or wind screens) frequently to maintain a stabilized surface. • Areas that cannot be stabilized, such as wind driven dust, must have an application of water at least twice a day • Apply dust suppressants (clear vegetation only from areas where work is to commence, plant or mulch areas that will not receive traffic, construct artificial wind breaks, or wind screens) in sufficient quantity and frequency to maintain a stabilized surface			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Apply water to at least 80 percent of the surface areas of all open storage piles daily when there is evidence of wind driven fugitive dust or install an enclosure all along the storage piles • Tarpaulin sheet should be provided on the storage piles to avoid dust emissions. • Periodic sprinkling on all roads used for any vehicular traffic at least twice per day during active operations and restrict vehicle speed to 20 kmph. • Wash down of construction vehicles (particularly tyres) prior to departure from site. • Burning of wastes at any site will not be allowed.			
	1 – Landfill 2 – MRF & Legacy Landfill	2.3	Health and Safety Hazard	• Work areas outside the project site, especially where machinery is involved, will be barricaded and will be constantly monitored to ensure that local residents, particularly children stay away while excavated areas being prepared for landfill related infrastructure will also be cordoned off. Also, no machinery will be left unattended, particularly in running condition. • Local communities in the project area will be briefed on traffic safety, especially women who are the main care providers to children. • Speed limit of 20 km/hr will be maintained by all project related vehicles and nighttime driving of project vehicles will be limited where possible. • Educate drivers on safe driving practices to minimize accidents and to prevent spill of hazardous substances and other construction materials during transport. • Contractor must take proper safety measures (placing warning tapes around excavations) to avoid people, especially children, accidentally falling into excavations. • All the working platforms must be cordon off with special care by well-trained skilled workers. • Contractor will prepare construction management plan which will include the hazard prevention and safety plan, which will address health and safety of the people in the project area. • PMU PUNJAB LG&CDD should ensure the contractor staff working in the the project are well trained and educated in the Health, Safety and Environment (HSE) hazards associated with their duties, and that of the public, in the project area.	Contractors	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill	2.4		• **General** • The Contractor will be required to prepare and implement an effective OHS Plan that is supported by trained first aid personnel and emergency response facilities. Construction contracts will include standard OHS measures and contractors will be	Contractors	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				bound to implement these fully. • Monitoring will be required to ensure that the OHS plan based on contract specifications is followed. • Cement feed hopper areas will be inspected daily to ensure compliance with the requirement of dust masks. • Surfaces (including flooring and work surfaces) in camps, kitchens, dining areas and workshops should be solid and easy to clean. Flooring for work camps must be float finished concrete or better. • All drivers engaged by Contractors must hold a valid license for the vehicle they are operating. • Work in confined space shall be executed with available safety standards. Adequate monitoring and equipment shall be available to detect deficient oxygen levels. • The Contractor shall submit to the Engineer of CSC for approval an emergency evacuation plan and practice the procedure annually. • The Contractor shall submit to the Engineer of CSC for approval a site layout plan, identifying work areas, accommodation, kitchen, dining area, sanitary facilities, location of generators, plant and vehicle parking, transport routes through the camp, pedestrian routes through the camp, evacuation routes, emergency exits, batching plants, storage areas, waste facilities etc. • Fire extinguishers should be provided throughout camps and work sites. Fire extinguishers should be inspected monthly and maintained as necessary. • An adequate and reliable supply of safe drinking water shall be made available at readily accessible and suitable places including at all camps. • The Contractor shall take samples from each supply of drinking water and arrange for analysis of these samples at EPA certified laboratory prior to its use by the Contractor's staff. The results of these tests for each supply must be submitted to the Engineer of CSC and must demonstrate that each water supply meets national and World Health Organization standards for drinking water. • The Contractor shall provide and maintain adequate hygienic kitchens which are sheltered and separated from the living quarters. Kitchens shall include raised and washable surfaces suitable for food preparation. • The Contractor shall provide and maintain adequate hygienic dining areas for staff. Workplaces and camps should be provided with both natural& artificial light. Artificial lighting should be powered by generator in the event of power cuts. • Public sensitization training should be provided to workers to avoid social conflicts between residents and the construction contractor, Occurrence of any such impacts			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				can be avoided by community sensitive project planning and implementation and through effective involvement of local administration. • All HSE protocols should be implemented in true letter and spirit. • Contractor must appoint an HSE resource to implement, monitor and report the HSE management plan to concerned authorities. • Contractor must ensure the provision of first aid facility at construction site and camps through hiring medics and establishing a dispensary at the campsite. • Reasonable number of first aid kits should be available on construction sites and within contractor camps. • Based on the type of hazard applicable during the proposed works at site, the following mitigation measures as per IFC guidelines for Occupational Health and Safety (OH&S) must be implemented:[30] **Mitigation Measures for Physical Hazards** ***Rotating and Moving Equipment*** • Designing machines to eliminate trap hazards and ensuring that extremities are kept out of harm's way under normal operating conditions. • Where a machine or equipment has an exposed moving part or exposed pinch point that may endanger the safety of any worker, the machine or equipment should be equipped with, and protected by, a guard or other device that prevents access to the moving part or pinch point. Guards should be designed and installed in conformance with appropriate machine safety standards. • Turning off, disconnecting, isolating, and de-energizing (Locked Out and Tagged Out) machinery with exposed or guarded moving parts, or in which energy can be stored (e.g. compressed air, electrical components) during servicing or maintenance. • Designing and installing equipment, where feasible, to enable routine service, such as lubrication, without removal of the guarding devices or mechanisms. • ***Vibration*** • Exposure to hand-arm vibration from equipment such as hand and power tools, or whole-body vibrations from surfaces on which the worker stands or sits, should be controlled through choice of equipment, installation of vibration dampening pads or			

[30] https://www.ifc.org/wps/wcm/connect/1d19c1ab-3ef8-42d4-bd6b-cb79648af3fe/2%2BOccupational%2BHealth%2Band%2BSafety.pdf?MOD=AJPERES&CVID=ls62x8l

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				devices, and limiting the duration of exposure. Limits for vibration and action values. Exposure levels should be checked based on daily exposure time and data provided by equipment manufacturers. ***Electrical*** • Marking all energized electrical devices and lines with warning signs; • Locking out (de-charging and leaving open with a controlled locking device) and tagging out (warning sign placed on the lock) devices during service or maintenance; • Checking all electrical cords, cables, and hand power tools for frayed or exposed cords and following manufacturer recommendations for maximum permitted operating voltage of the portable hand tools; · • Double insulating / grounding all electrical equipment used in environments that are, or may become, wet; using equipment with ground fault interrupter (GFI) protected circuits; · • Protecting power cords and extension cords against damage from traffic by shielding or suspending above traffic areas; · • Conducting detailed examination and marking of all buried electrical wiring prior to any excavation work. • Appropriate labeling of service rooms housing high voltage equipment (‘electrical hazard’) and where entry is controlled or prohibited; · ***Eye Hazards*** • Use of machine guards or splash shields and/or face and eye protection devices, such as safety glasses with side shields, goggles, and/or a full-face shield. Specific Safe Operating Procedures (SOPs) may be required for use of sanding and grinding tools and/or when working around liquid chemicals. Frequent checks of these types of equipment prior to use to ensure mechanical integrity is also good practice. Machine and equipment guarding should conform to standards published by organizations such as CSA, ANSI and ISO. ***Welding/Hot Work*** • Provision of proper eye protection such as welder goggles and/or a full-face eye shield for all personnel involved in, or assisting, welding operations. Additional methods may include the use of welding barrier screens around the specific workstation (a solid piece of light metal, canvas, or plywood designed to block welding light from others). Devices to extract and remove noxious fumes at the source may also be required. ·			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Special hot work and fire prevention precautions and Standard Operating Procedures (SOPs) should be implemented if welding or hot cutting is undertaken outside established welding workstations, including 'Hot Work Permits, stand-by fire extinguishers, stand-by fire watch, and maintaining the fire watch for up to one hour after welding or hot cutting has terminated. Special procedures are required for hot work on tanks or vessels that have contained flammable materials. ***Industrial Vehicle Driving and Site Traffic*** • Training and licensing industrial vehicle operators in the safe operation of specialized vehicles such as forklifts, including safe loading/unloading, load limits. · • Ensuring drivers undergo medical surveillance. · • Ensuring moving equipment with restricted rear visibility is outfitted with audible back-up alarms. · • Establishing rights-of-way, site speed limits, vehicle inspection requirements, operating rules and procedures (e.g. prohibiting operation of forklifts with forks in down position), and control of traffic patterns or direction. · • Restricting the circulation of delivery and private vehicles to defined routes and areas, giving preference to 'one-way' circulation, where appropriate. ***Ergonomics, Repetitive Motion, Manual Handling*** • Facility and workstation design with 5th to 95th percentile operational and maintenance workers in mind. • Use of mechanical assists to eliminate or reduce exertions required to lift materials, hold tools, and work objects, and requiring multi-person lifts if weights exceed thresholds. • Selecting and designing tools that reduce force requirements and holding times and improve postures. • Providing user adjustable workstations. • Incorporating rest and stretch breaks into work processes and conducting job rotation. • Implementing quality control and maintenance programs that reduce unnecessary forces and exertions. • Taking into consideration additional special conditions such as left-handed persons. ***Working at Heights*** • Installation of guardrails with mid-rails and toe boards at the edge of any fall hazard			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				area. • Proper use of ladders and scaffolds by trained employees. • Use of fall prevention devices, including safety belt and lanyard travel limiting devices to prevent access to fall hazard area, or fall protection devices such as full body harnesses used in conjunction with shock absorbing lanyards or self-retracting inertial fall arrest devices attached to fixed anchor point or horizontal lifelines. • Appropriate training in use, serviceability, and integrity of the necessary PPE. • Inclusion of rescue and/or recovery plans, and equipment to respond to workers after an arrested fall. • ***Fire and Explosions*** • Storing flammables away from ignition sources and oxidizing materials. Further, flammables storage area should be: • Remote from entry and exit points into camps • Away from facility ventilation intakes or vents • Have natural or passive floor and ceiling level ventilation and explosion venting • Use spark-proof fixtures • Be equipped with fire extinguishing devices and self-closing doors and constructed of materials made to withstand flame impingement for a moderate period of time. • Defining and labeling fire hazards areas to warn of special rules (e.g. prohibition in use of smoking materials, cellular phones, or other potential spark generating equipment). · • Providing specific worker training in handling of flammable materials, and in fire prevention or suppression. • ***Corrosive, oxidizing, and reactive chemicals*** • Corrosive, oxidizing and reactive chemicals should be segregated from flammable materials and from other chemicals of incompatible class (acids vs. bases, oxidizers vs. reducers, water sensitive vs. water based, etc.), stored in ventilated areas and in containers with appropriate secondary containment to minimize intermixing during spills. · • Workers who are required to handle corrosive, oxidizing, or reactive chemicals should be provided with specialized training and provided with, and wear, appropriate PPE (gloves, apron, splash suits, face shield or goggles, etc). · • Where corrosive, oxidizing, or reactive chemicals are used, handled, or stored,			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				qualified first-aid should be always ensured. Appropriately equipped first-aid stations should be easily accessible throughout the place of work, and eye-wash stations and/or emergency showers should be provided close to all workstations where the recommended first-aid response is immediate flushing with water. **Mitigations for Biological Hazards** • The Contractor should review and assess known and suspected presence of biological agents at the place of work and implement appropriate safety measures, monitoring, training, and training verification programs. • Project contractor must provide good working and sanitation conditions at camp and wok sites. Disease surveillance should be carried out to identify any exposure to parasites, such as hookworm, ascaris, and various mites, chiggers, ticks, and dengue. • Measures to eliminate and control hazards from known and suspected biological agents at the place of work should be designed, implemented, and maintained in close co-operation with the local health authorities and according to recognized international standards.			
	1 – Landfill 2 – MRF & Legacy Landfill	2.5	Noise and Vibration	• Equipment noise will be reduced at source by proper design, maintenance and repair of construction machinery and equipment. Noise from vehicles and power generators will be minimized by use of proper silencers and mufflers. • Excessive noise emitting equipment will not be allowed to operate and will be replaced. • Blowing of horns will be prohibited on access roads to work sites. • As a rule, the operation of heavy equipment shall be conducted in daylight hours. • Construction equipment, which generates excessive noise, shall be enclosed, or fitted with effective silencing apparatus to minimize noise. • Well-maintained haulage trucks will be used with speed controls. • Use of ear plugs and earmuffs must be ensured during construction. No employee should be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C). • Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible. • Periodic medical hearing checks should be performed on workers exposed to high noise levels.	Contractors	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• All the equipment and machinery used during construction phase should be well maintained and in compliance with PEQS. • Grievance redress mechanism to deal any public complaints related to noise is established.			
	1 – Landfill 2 – MRF & Legacy Landfill	2.6	Hazardous and non-hazardous waste disposal	• A waste management plan will be developed prior to the start of construction. This plan will cater to sorting of hazardous and non-hazardous materials prior to disposal, placing of waste bins at the project sites for waste disposal and an onsite hazardous waste storage facility i.e. designated area with secondary containment. • Licensed waste contractors will be engaged to dispose of all non-hazardous waste material that cannot be recycled or reused. • Excavated material from landfill cells will be stored at site and it will be used as daily cover within landfill cells. • All types of combustible and non-combustible waste including plastic or glass bottles and cans will be temporarily stored on site and later sold/handed over to a waste/recycling contractor who will utilize these wastes for recycling purposes. • Waste management training for all site staff to be included in Contractor's training plan. • Fuel storage areas and generators will have secondary containment in the form of concrete or brick masonry bunds. The volume of the containment area should be equal to 120% of the total volume of fuel stored. • Fuel and hazardous material storage points must be included in camp layout plan to be submitted for approval. Hazardous material storage areas shall include a concrete floor to prevent soil contamination in case of leaks or spills. Fuel tanks will be checked daily for leaks and all such leaks will be plugged immediately. • Designated vehicles/plant wash down and refueling points must be included in camp layout plan to be submitted for approval. • Hazardous waste will be initially stored on site at designated area and then handed over to EPA certified contractor to final disposal. • Record of waste generation and transfer shall be maintained by project contractors. • Spill kits, including sand buckets (or other absorbent material) and shovels must be provided at each designated location. • At the time of restoration, septic tanks will be dismantled and backfilled with at least 1m of soil cover keeping in view landscape of surrounding natural surface. • It will be ensured that after restoration activities, the campsite is clean and that no	Contractors	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				refuse has been left behind. • Clinical wastes will be temporarily stored onsite separately and will be handed over to approve waste contractor for final disposal. • Training will be provided to personnel for identification, segregation, and management of waste.			
	1 – Landfill 2 – MRF & Legacy Landfill	2.7	Waste Effluent Disposal	• It will be ensured that no untreated effluent is released to the environment. • A closed sewage treatment system including soak pits and septic tank will be constructed to treat the effluent from the construction/labor camps. • Sewage treatment system will be installed at each respective labor camp based on the number of laborers residing at the respective camp. • Wastewater from laundry, kitchen washings and showers will be disposed-off into soak pits or septic tank (where soak pit cannot be constructed) and after treatment it will disposed of in TMA provided drains in the project area. • Soak pits will be built in absorbent soil and shall be located 300 m away from a water well, hand pump or surface water body. Soak pits in non-absorbent soil will not be constructed. • Ensure that the soak pits remain covered all the time and measures are taken to prevent entry of rainwater into them. • Sprinkling of grey water or sewage will not be allowed; in case the septic tank gets filled with sludge, septic tank shall be emptied through vacuum truck and material shall be transferred to treatment facility or approved municipal drain. • Water being released from any batching plant(s) must be treated as per requirements of PEQS prior to release to sewerage system/any other water body. • Sewage at the end of construction period to be disposed of in nearest municipal drains after getting approval from concerned municipal authorities.	Contractors	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill	2.8	Soil Erosion and Sedimentation	• Any drainage structures, culverts or pipes crossing the project site may need to be modified or protected and the detailed designs must make provisions to protect or re-provision all infrastructure that may be affected by the construction works.	Contractors	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill	2.9	Soil Contamination	• It will be ensured that spill prevention trays are provided and used during refueling. Also, on-site maintenance of construction vehicles and equipment will be avoided as far as possible. In case on-site maintenance is unavoidable, tarpaulin or other impermeable material will be spread on the ground to prevent contamination of soil. • Regular inspections will be carried out to detect leakages in construction vehicles and	Contractors	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				equipment and all vehicles will be washed in external commercial facilities. • Fuels, lubricants, and chemicals will be stored in covered bounded areas, underlain with impervious lining. Appropriate arrangements, including shovels, plastic bags and absorbent materials will be available near fuel and oil storage areas.			
	1 – Landfill 2 – MRF & Legacy Landfill	2.10	Water Quality (Surface Water and Groundwater)	• During site development of component 1 and Component 2 sites necessary precautions will need to be taken to ensure runoff water from the site gets collected to a surface water drainage collection. The surface water collection should be designed with appropriate volume for the estimated surface water drainage. • During construction activity all the equipment's washed water will be diverted to oil water interceptor pits to collect the suspended solids and enable oils to be collected. The settled water will be reused for construction purposes, and for sprinkling on roads to control the dust emission, etc. The oil water interceptor pits should be designed to cope with a sufficient volume of wash water and if construction lasts longer than 1 year should be cleaned annually with sludge and oils being disposed of to licensed facilities. • Sewage will be discharged into receiving water bodies only after treatment. The design of the treatment plant will be agreed with the PMU before installation. • Within Component 1 there are no nearby existing irrigation channels near the project site which will be affected during project establishment. As such there is a low possibility that groundwater and surface water will be affected during the construction phase of the project. • Within Component 2 there is an irrigation channel located adjacent to the east of the site. Care should be taken to ensure no untreated discharge or uncontrolled surface water run-off impacts the channel. • Within Component 1 consideration shall be given to the stability of the sub-grade, the base liner system, the waste mass and the capping system. The sub-grade and the base liner will be sufficiently thick as per international standards and stable to prevent excessive settlement or slippage. • Within Component 1 the bottom and cap lining system for each landfill cell must be designed for the protection of soil, groundwater, and surface runoff. • An efficient leachate collection system must be provided for both the new landfill and legacy landfill to ensure leachate accumulation at the base of the landfill and keep it to a minimum. The leachate collection system for the legacy landfill will have to be designed retrospectively and should not create any preferential pathways to the underlying aquifer. This should be addressed during the design phase conceptual site model investigations.	Contractors	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill	2.10	Employment Conflicts	• The Construction Contractor will adopt a transparent hiring policy. Prior to the commencement of the construction activity, the local communities in the project area will be informed of the employment policy in place and number of people that can be employed for this project. • It will be ensured that maximum number of unskilled and semi-skilled jobs will be	Contractors	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				provided to the residents of the project area. • The PMU will ensure a balanced process of employment of the communities in the project area with preference given to those most directly affected by the project.			
	1 – Landfill 2 – MRF & Legacy Landfill	2.11	Communicable diseases	• A communicable diseases prevention program will be prepared for construction workers or residents near the construction sites.	Contractors	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill	2.12	Vegetation and Wildlife Loss	• Endeavors will be made to enhance the environment through a plantation of trees around the perimeter of both sites. • All preventive measures will be adopted to control the spill-over of chemicals and other effluents on the ground to protect the soil. • Ornamental trees and bushes will be planted in the project area, which will improve the scenic and aesthetic value of the area. • A buffer zone of indigenous plantation will be maintained along the perimeter of the landfill, MRF and legacy landfill. • *Acacia modesta, Dalbergia sissoo, Albizia lebbek, Phoenix dactylifera, Prosopis juliflora and Tamarix aphylla* are indigenous species of the area • Ornamental trees will also be planted to improve the aesthetics of the sites. • The plantation will start as one of the earliest activities of site development. Once the design of landfill is approved and necessary funds mobilized, plantation activity can be started in collaboration with Bahawalpur Development Authority (BDA) or BWMC can outsource the activity separately. • Special measures will be adopted to minimize impacts on birds, such as avoiding noise-generating activities. • Camp/s will be in existing clearings; as much as possible. • Off-road travel will be strictly prohibited and observance of this will be monitored during execution of the project • Vehicles speed will be regulated and monitored to avoid excessive dust emissions. • No hunting or killing of animals will be permitted. • No cutting down of vegetation or using vegetation or trees as firewood will be permitted. • Appropriate diffusers will be used to restrict the illumination within the project site. • Nighttime construction works will not be undertaken. • No off tracking will be practiced. Work area will be minimized, and movement will be restricted to designated routes.	Contractors	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
	1 – Landfill 2 – MRF & Legacy Landfill	2.13	Impacts on Historical/Archaeological Sites	• If evidence of any archaeological remains is found during the construction activities, the excavation work will be stopped immediately, and necessary next steps taken to identify the archaeological discovery based on the 'Chance Find' procedures.	Contractor	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill 1 – Landfill 2 – MRF & Legacy Landfill	2.14	Impacts associated with Construction of office and Administration Building and Other Infrastructure	• Water will be sprinkled regularly to suppress dust emissions. Off road travelling of vehicles will be prohibited. • Stockpiles will be appropriately located and out of wind to avoid dust emissions. Dry dusty materials should be sprinkled with water and properly covered to avoid dust emissions. • No cement and concrete waste will be left unattended. Construction debris will not be thrown from height to avoid dust emissions. Return unpaved areas to original or improved contours following construction. • Solid waste generated during construction of BWMC office and admin buildings will be managed through SSEMMP. • Set protocols for proper and regular maintenance of construction machinery, vehicles, and generators at building sites. Generators that will be used will be placed at suitable locations. • Contractor will not be allowed to store bulk quantities of fuel or hazardous material at building sites • Any fuel or chemicals stored at building sites (in small quantities) will be stored at designated site and containers/storage vessels be properly marked for their contents. Storage area will be provided with hard impervious surface and secondary containment. • Equipment and machinery with loose vibratory parts will not be allowed to use. Used equipment and machinery will be in compliance to PEQS. • Waste bins will be provided at appropriate places to manage waste. Daily housekeeping of the construction area will be carried out.	Contractor	CSC, PMU	DC
	1 – Landfill 2 – MRF & Legacy Landfill	2.15	Impacts associated with Construction of Access Roads	• The road widening will be to a standard that is suitable for movement of high-capacity waste carrying vehicles. • BWMC/PMU will maintain close coordination with the residents falling close to road widening works, project information leaflet will be distributed to them and awareness with respect to impacts (noise, dust and vibrations) associated with construction will be provided. If people are notified, their acceptance of the disturbance is usually	Contractor	CSC, PMU	DC

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				higher. • BWMC/PMU will arrange community consultation session before commencement of construction works to make public sensitization which will facilitate smooth execution of project activities. • Compaction with heavy vibration rollers should be avoided or minimized in built-up areas. • Work areas outside the project site, especially where machinery is involved, will be barricaded and will be constantly monitored to ensure that local residents, particularly children stay away. • Local communities in the project area will be briefed on traffic safety, especially women who are the main care providers to children. • Traffic diversions will be planned in such way that it does not create traffic congestion during road widening works. Road closure for the works will be avoided. • A proper drainage system will be provided to prevent excessive surface water run-off and impacts to local surface water bodies (e.g. irrigation channels).Off-road travel will be strictly prohibited and observance of this will be monitored during execution of the project. • Vehicle speed will be regulated and monitored to avoid excessive dust emissions. • Blowing of horns will be prohibited on access roads to work sites. • Periodic sprinkling on access road at least twice per day during construction phase and restrict vehicle speed to 20 kmph. • Project traffic will maintain maximum speed limit of 20 km/hr on all unsealed parts within project area. • Traffic is not disrupted by labour camps being set up roadside next to the construction sites. • Contractor will prepare construction management plan which will include the hazard prevention and safety plan, which will address health and safety of the people in the project area. • PMU Punjab LG&CDD should ensure the contractor staff working in the project are well trained and educated in the Health, Safety and Environment (HSE) hazards associated with their duties, and that of the public, in the project area. • Record of waste generation and transfer shall be maintained by project contractor. • Periodic water sprinkling will be carried out during widening works to suppress dust. • Fuel-efficient and well-maintained equipment and machinery shall be employed to			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				minimize exhaust emissions. • The need for large stockpiles shall be minimized by careful planning of the supply of materials from controlled sources. Stockpiles should not be located within 50 m of schools, hospitals or other public amenities and shall be covered with tarpaulin when not in use and at the end of the working day to enclose dust. If large stockpiles (>25m3) of crushed materials are necessary, they should be enclosed with side barriers and covered when not in use. • The contractor should prepare a materials re-use plan to promote efficient resource use within the scheme. • Prior to starting of work, the contractor should prepare a method statement for water supply pipeline works. This should be simple and explain the contractor's work process that is conducted on site, with safety and safeguard concerns. • Method Statement is very important, particularly for the road widening works. • Method Statement can be prepared for each stretch (say 1 km) /specific site based on the project area. • Method Statement should be in a Table format with appended site layout map and cover the following: • Work description 1. No. of workers (skilled & unskilled) 2. Details of Plant, equipment & machinery, vehicles 3. Work duration (total, and activity-wise, for example for preparation of sub grade, sub-base, base and wearing coarse 4. PPE (helmet, gloves, boots, etc.) details for each type of work 5. Details of materials at each site (type & quantity) 6. Risks/hazards associated with the work 7. Construction waste/debris generated (details & quantity) 8. 8.Detail the sequence of work process (step-by-step) including specific details of each work 9. Contractor's supervision & management arrangements for the work			

<table>
<tr><th rowspan="2">Project Activities</th><th rowspan="2">Component</th><th rowspan="2">Section</th><th rowspan="2">Impact</th><th rowspan="2">Mitigation Measures Recommended</th><th colspan="2">Responsibility</th><th rowspan="2">Timing</th></tr>
<tr><th>Execution</th><th>Monitoring</th></tr>
<tr><td></td><td></td><td></td><td></td><td>10. 10.Emergency: Designate (i) responsible person on site, and (ii) first aider
11. Typical site layout plan including placement of material, excavated earth, barricading etc.
12. The following should be included in the site layout plan:
i. Provide barricading/security personnel at the site to prevent entry/trespassing of pedestrian/vehicles into the work zone.
ii. Location of temporary stockpiles and provision of bunds
iii. Separation of stockpiles areas with workers/vehicle movement paths to avoid disturbing the stockpiled soil
iv. Wetting of soil to arrest dust generation by sprinkling water
v. Waste/surplus soil utilization and disposal plan – indicate expected duration of temporary stockpiling along the road and identify final surplus soil utilization/disposal site in consultation with PMU.
vi. PMU Punjab will ensure the identification of disposal sites for unsuitable excavated material in consultation with BWMC.
vii. PMU will inspect and monitor the borrow material areas prior to procurement to ensure that it is being used in sustainable way and no significant disfiguration of landscape is going on at quarry site.
viii. Stock piling of excavated material at places that are congested will be avoided as these piles can create traffic issues and public nuisance.
ix. Already available quarry sites for additional backfill material will be utilized. Development of new quarry site will be discouraged.
• Record of borrow materials will be maintained including details of quarry site, agreement and necessary approvals from concerned government authorities.</td><td></td><td></td><td></td></tr>
<tr><td>Operation Phase</td><td>1 – SWM
2 – Legacy Landfill</td><td>3.1</td><td>Leachate Generation</td><td>Component 1 – New SWM Landfill:
• Operate the landfill in accordance with applicable internationally recognized standards to minimize leachate generation, including the use of low-permeability landfill liners to prevent migration of leachate as well as landfill gas, a leachate drainage and collection system, and landfill cover (daily, intermediate, and final) to minimize infiltration.
• Leachate generated during active phase of LFS will be treated through Three stage open leachate treatment system and potable Anaerobic digestion treatment system for leachate. Anaerobic Digestion treatment system is potable arrangement for</td><td>O&M Contractor/ BWMC</td><td>BWMC, PMU</td><td>DO</td></tr>
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Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				treatment of leachate and can be operationalized during monsoon for 24/7 basis. During monsoon season, recirculation of leachate will be increased to avoid operational constraints of leachate collection, storage and treatment system at landfill site. • During monsoon, recirculation of leachate will be increased to avoid operational constraints of leachate collection, storage, and treatment system at landfill site. • Minimize the daily exposed working face and use perimeter drains and landfill cell compaction, slopes and daily cover materials to reduce infiltration of rainfall into the deposited waste. • Leachate collection will be augmented by a leachate recirculation system in the landfill design. • The operators of the landfill must ensure that an effective and efficient leachate control and monitoring system is maintained. This may be complimented by the establishment of groundwater monitoring wells and regularly collecting samples for laboratory analysis. Results of the analysis could aid the operators to determine the final fate of the collected leachate and/detect any potential leakages. Final decision rests with the landfill operator on the final number of wells as well as the frequency of sampling for groundwater quality. • The final vegetative cover plays an integral part in leachate production control. Its basic functions are to limit infiltration by intercepting precipitation directly, thereby improving evaporation from the surface, and to reduce percolation through the cover material by taking up soil moisture and transpiring it back to the atmosphere. Preferred plant species should be of those that do not have deep roots in order to protect the surface sealing. Further, these species should require minimal maintenance and human intervention. • Landfill operators must be properly and adequately trained to operate and maintain the installed control system. • A procedure for the rapid repair of leaks in the pipes, pumps and other equipment must be part of landfill operations. • An inventory of spare parts and repair equipment must be continuously in place to ensure immediate remedial action against breakdowns. • Strict quality assurance and construction guidelines during the installation of the HDPE liner should be strictly implemented. • In worst case, if leachate contamination is detected during ground water monitoring after few years of landfill operation, ground water modelling to determine possible contamination of leachate will be carried out and necessary design changes will be done.			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Detailed ground water quality baseline will be developed during operation phase of the project to trace any ground water contamination from landfill operations. **Component 2 – Legacy Landfill:** • A conceptual site investigation and site closure plan will be prepared prior to closure of the landfill. This risk assessment will model transport times from landfill to local receptors and model direction of flow (likely anticipated to be west towards the Sutlej River). Once this information is known, appropriate decisions can be made on future leachate collection. • The site closure plan will assess the risks of leachate generation to the environmental and human receptors and will assess whether installation of retrospective collection systems will significantly reduce environmental risks. It is possible that installation of retrospective measures could pose a greater environmental risk. • The closure, capping and restoration of the landfill will reduce surface water ingress through the landfill and will reduce leachate generation and overall improve the environmental risks posed by the sites current condition.			
	1 – Landfill		Air Strike Risk	**Develop and implement a mitigation plan to address potential for increased bird air strike risks. These may include items such as:** • Modified methods of waste handling or segregation • Provision and use of netting • Active dispersal and control of potentially hazardous birds	O&M Contractor/ BWMC	BWMC, PMU	DO
	1 - Landfill	3.2	Contamination of Soil and Groundwater	**Component 1 Mitigation:** **Cell Construction and Leachate Management:** • Appropriate liner and collection systems in compliance with international guidelines/criteria will have been installed as part of the design. • The leachate system will consist of a leachate collection layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) with pipe network to convey the leachate to treatment facility. • Bottom lining will be comprised of compacted sub-grade base, geo-synthetic clay liner (GCL) topped by 2 mm HDPE layer. • Silty sand or geotextile (500 GSM) will be covered for the protection of the HDPE on the side slopes. • Above geotextile gravel layer (30 cm thick) will be placed which will be topped up with sand layer (50 cm thick). • An efficient leachate collection and treatment system will be provided to ensure leachate accumulation at the base of the landfill and keep it to a minimum. • Thick topsoil layer (6 inches) capable of supporting vegetation in order to protect the landfill surface from wind and water erosion.	O&M Contractor/ BWMC	BWMC, PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Drain Layer (18 inches) of at bottom to maximize runoff of precipitation while minimizing infiltration and preventing ponding of water on the landfill. • Compacted soil layer or barrier of low permeability (1x10^{-5} cm/sec) to limit and control the amount of precipitation that enters the waste. • Vent layer of reasonable thickness comprised of sand and gravel. • The leachate system will consist of a leachate collection layer of either natural granular (sand, gravel) or synthetic drainage material (e.g. geonet or geo-composite) with pipe network to convey the leachate to treatment facility. • Leachate collection pond shall be in opposite direction from nearest surface water body. • Three Stage Open Pond Leachate Treatment System and Anaerobic digestion will be used for leachate treatment. Anaerobic digestion is fully enclosed and environmental much better options which is incorporated in the FS. • Slope of the landfill site shall be away from nearest surface water body. • Cut-off drains around active landfill site and peripheral drains around landfill site should be provided • Detailed analysis of leachate leakage detection on ground water quality will be carried out and necessary design changes/improvements will be done. **Transportation** • Waste hauling vehicles shall be covered during transport of waste to landfill site • Hauling vehicles shall not wash at the surface water bodies along the route as the wash water shall drain into the canal and will pollute the surface water source which is used by the animals of the nearby communities and for agriculture purpose. • To augment this system, regular quality control checks on the equipment /accessories will be implemented and incorporated during construction and operations. • Waste hauling vehicles shall be covered during transport of waste to landfill site • Any vehicle maintenance undertaken onsite shall be undertaken in dedicated areas on hard surfacing and in an area provided with surface water drainage and oil water interceptor. Spill kits will be provided to address any localized spills. • Any vehicular wheel washes will be provided with dedicated storage of water preventing any discharge to ground and will be desilted on a weekly basis or more frequently if necessary. • Site speed limits will be kept between 5-15km.hr to prevent dust generation potentially impacting surrounding land quality. • Hauling vehicles shall not wash at the surface water bodies along the route as the wash water shall drain into the canal and will pollute the surface water source which is used by the animals of the nearby communities and for agriculture purpose. • Any vehicle maintenance should be undertaken on hard surface areas with appropriate surface water drainage collection systems. • Any storage of bulk fuel / chemicals will be stored in appropriately in accordance with the type of chemical. No below ground storage will be undertaken. COSHH sheets should be kept for all chemicals onsite.			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• No refueling of vehicles will be undertaken onsite. **Wastewater Management** • Domestic sewerage of Bahawalpur facility shall not be discharged untreated in open area and drains. • Wastewater generated from vehicle wash area shall be contained and treated before final discharge **Monitoring** • Groundwater monitoring will be undertaken in accordance with the Groundwater Monitoring Plan in A-22. • Permanent ground water monitoring wells should be installed surrounding the boundary of the site keeping in view of the flow of ground water on both upstream and downstream of the disposal site and monitor the ground water quality of the upper strata for any contamination for disposal site every month. Annual monitoring reports should be provided to the PMU. • In the worst-case scenario, if leachate contamination is detected during ground water monitoring after few years of landfill operation, detailed ground water modelling to determine possible contamination of leachate will be carried out and necessary design changes will be implemented. • A detailed ground water quality baseline will be developed during the construction and early operational phase of the project to trace any ground water contamination from landfill operations. A full suite of laboratory testing should be undertaken, and laboratory detection limits should be less than the screening guidelines being used. • Dust monitoring should be undertaken daily, in line with the prevailing wind direction and action taken should excessive dust be recorded. **Component 2 Impacts** Component 2 includes the MRF and the Legacy Landfill operations. • Once operational, the MRF site will be operated on hard standing (concrete, tarmacadam or similar) along with appropriately designed surface water collection systems. This is significantly reducing the risk of soil and groundwater contamination impacts from site operations. • The MRF will be designed to avoid leachate generation. All surfacing where wastes are handled / stockpiled will be covered to prevent rainwater ingress/dust generation and located on hard standing with appropriate surface water drainage installed. • Any vehicular wash bays or maintenance areas will be provided with dedicated surface water drainage that will be treated prior to discharge offsite. • All wastes that are baled and stored onsite will be located on hard standing and will be covered prior to dispatch.			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	

				• The contractor operating the plant will prepare detailed standard operating procedures that will detail the control of leachate and other contaminants that may impact soil and groundwater. This will include details of how risks from any unforeseen events e.g. spills, extreme weather) will be managed. Spill kits and containment systems should be in place to prevent leaks and spills impacting soil and groundwater.
				• The closure of the legacy landfill will be undertaken in accordance with the site closure plan and a program of monitoring groundwater will be undertaken to monitor trends.
				• The site closure plan will include procedures for further remedial works if conditions are declining or posing a risk to surrounding receptors.
				• Future residential development should be prevented within 0.5km of the site boundary.
				• Permanent groundwater monitoring wells should be installed and monitored in accordance with the groundwater monitoring program in A-22.
				• Where possible, the project should influence the operation of the uncontrolled landfill site to implement measures to reduce soil and groundwater impacts during its remaining operational phase until 2027. These measures could include:
				  o Ensuring daily cover is placed over the waste
				  o Ceasing dumping in any area outside the legacy landfill the MRF.
				  o Installation of perimeter fencing and plantation.
				  o Establishment of landfill buffer
				  o Implementation of monitoring regime for gas, groundwater, dust and surface water.			

	1 – SWM 2 – Legacy Landfill	3.3	Landfill Gas generation	**Component 1 Mitigation:** • The DBO will prepare a detailed risk assessment following final design but prior to groundworks commencing. The detailed risk assessment should be in line with local and international guidelines, such as Landfill operators: environmental permits - Design and build your landfill site - Guidance - GOV.UK (www.gov.uk). This document will detail how landfill gas will be controlled and monitored throughout the lifetime of the landfill and how risks to onsite and offsite receptors will be minimised. • The landfill location is located c.250m away from the residential developments of Basti Yar Muhammad. The DBO should ensure that a minimum 250m buffer can be maintained between the face of landfill cells and residential development areas. This buffer will allow for off-site monitoring and allow for natural venting and or machinery access in the event of remedial measures being required. • The DBO will install a gas collection and control system (GCCS). The GCCS and 1000m3 flaring systems will be in place as part of the landfill design and thus no significant impacts on occupational or community health and safety are envisaged from landfill gas exposure. • Landfill gas capture and 1000m3 flaring systems will be in place as part of the landfill design and thus no significant impacts on occupational or community health and	O&M Contractor/ BWMC	BWMC, PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				safety are envisaged from landfill gas exposure. • Landfill gas will be collected through installation of perforated pipes within the cells. This gas will initially flare through 1000 m3 flaring system at start of landfill operations. Keeping in view the volume of gas generated after few years of operations feasibility for gas reuse including conversion into CNG will be carried out and accordingly design changes will be executed. • Both Horizontal and Vertical gas collection systems will be implemented in the landfill. The gabion of the gas collection wells will be filled with gravel, and these will be constructed with iron mesh. There will be a perforated HDPE pipe with pressure class in the center of the gas collection wells. The gap between the iron mesh and the perforated pipe will be filled with pebble stone. • The organic waste will be beneficially utilized when it is deposited in the bio reactor landfill where it will generate regular and increased quantity of landfill gas which will contain 55-60 percent of Methane. The methane can be converted into electricity or CNG. The CNG option is a much better option as the electricity tariff for green energy is very low in Pakistan and the CNG rates are quite high. • The landfill gas recovery must be designed from bottom up to avoid emission during landfill operation and drilling through the garbage when the cell is filled with waste. When two meters of waste layer will deposit in the first cell, a 30m x 30m or 50m x 50m grid of perforated gas recovery pipes will be installed over a 15cm layer of gravel under the pipe and another layer of 15cm gravel will be placed on top of the gas grid. The 30m length of the pipe will be joined with the second pipe with a ''T'' joint and vertical gas well is installed. When desired height 20-30m of the fill achieved the ring main will be installed and connected to final LFG to power generation. • A series of gas monitoring wells will be installed both on and off site and the risk assessment prepared by the DBO should propose the frequency of GHG monitoring that will be carried out during construction and operational phase of the project and accordingly, necessary design changes will be incorporated, if required. The frequency of monitoring should be more frequent until gas emission trends are established and if emissions are stable and well controlled less frequent monitoring may be proposed. Monitoring should also consider any seasonal variations such as temperature and atmospheric pressure. • PMU PUNJAB LG&CDD shall ensure that during operation phase of the project, if there are changes in the baseline ambient air quality, then a quantitative assessment will be carried out for flaring and necessary design changes will be incorporated to avoid air quality impacts from flaring. • As part of closure plan of existing dumping site, GHG monitoring will be carried out and necessary gas flaring system will be done. • Periodic GHG monitoring will be carried out during operation phase of the project.			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Landfill gas/fire emergency response plan (attached as **Appendix A-21**) shall be implemented. • Landfill operator will train its staff on landfill gas/fire emergency plan. • Landfill operator will allocate budget and necessary resources to manage landfill fire emergencies. • A site closure plan will be prepared, and the operator will ensure necessary funds are available to deliver the site closure plan and manage the landfill post closure during its active life (c.25-50years). **Component 2 Mitigation** • Given the wastes temporary storage at the MRF, significant landfill gas is not anticipated that will require mitigation. • With regards to Component 2, the legacy landfill will already be producing landfill gas. It is likely that this is currently venting naturally to the atmosphere. • The project designer is yet to undertake a detailed conceptual site model and risk assessment to determine the most appropriate restoration and site closure plan. However, it is likely that this will require covering and capping to prevent surface water ingress. A landfill gas capture and collection system should be installed beneath the cap of the landfill to ensure landfill gas can vent or be flared. The operator should establish whether it is financially feasible to capture landfill gas for energy generation. • As with Component 1, a buffer should be established and protected around the perimeter of the landfill site. The distance of the buffer (typically 250m or more) should be established by the risk assessment and will depend on the volume and pressure of landfill gas generated. If necessary, retrospective gas venting should be installed around sensitive receptors already within the buffer zone. • Permanent monitoring wells should be established around the perimeter of the landfill and monitored on a frequency to be determined by the site closure plan and risk assessment. The frequency of monitoring will depend on receptor location, landfill gas flow and pressure and concentration mix of the gas. If landfill gas is detected migrating off-site within the buffer, consideration should be given to the installation of passive or active gas venting measure within the land buffer. Measures may include: o Passive Gas Venting – Vertical Gas Venting Wells. Horizontal gas collection system, Leachate control, landfill gas permitter trenches. o Active Gas Venting – Gas blowers or compressors, gas extraction wells, flaring, installation of gas to energy system. • Consideration may need to be given to odour control. Landfill gas is the primary cause of odours therefore if odours are objectionable, mitigation may need to include			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				chemical scrubbers, biofilters or activated carbon to mitigate foul odours.			
	1 – SWM landfill 2 – Legacy Landfill	3.4	Air quality deterioration and Noise Generation	• Best management practices and good housekeeping measures will be implemented to minimize the release of objectionable odors across all components. **Landfill Cover:** • Potential odors impact from the landfills can be minimized or eliminated by adopting the following measures: ○ Daily cover will be placed on working surfaces of waste in the landfills (both new and remaining operational phase of the legacy landfill) to reduce the risk of fire, wind littering, odor, vector breeding and dust hazards in the landfill. ○ Suitable amount of daily cover will be stocked at the landfill site. ○ Final capping of landfill cells will be carried out to limit and control the amount of precipitation that enter the waste and to limit wind and water erosion and burrowing animal activity. This will not only prevent the odor of decaying waste from escaping from the landfill but also protect the site against intrusion of vermin and pests. The top cover system within Component 1 consists of following arrangements. ○ Thick topsoil layer (6 inches) capable of supporting vegetation to protect the landfill surface from wind and water erosion. ○ Drain Layer (18 inches) of at bottom to maximize runoff of precipitation while minimizing infiltration and preventing ponding of water on the landfill. ○ Compacted soil layer or barrier of low permeability ($1x10^{-5}$ cm/sec) to limit and control the amount of precipitation that enters the waste. ○ Vent layer of reasonable thickness comprised of sand and gravel. **General Housekeeping & Staff Welfare** • Appropriate and regular housekeeping (i.e. cleaning) will be done in all areas where solid waste will be processed (e.g. MRF). This will prevent the reproduction of flies, generation of obnoxious odors, scattering of plastic and papers, etc. • Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh Bridge, MRFs, material handler and waste compactor operators) must be ensured. • Mandatory health and medical check-ups for all employees especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m3 as an 8-hr TWA).	O&M Contractor/ BWMC	BWMC/PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				This should ideally be complimented by obtaining an Insurance Policy for Workmen especially engaged in the daily activities of the landfill. • Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE). **Composting Facility** • All the incoming ingredients that are anaerobic will be converted to aerobic state through combining them with a coarse, dry bulking amendment to increase the porosity and allow oxygen penetration. • Air should be thoroughly dispersed throughout the organic waste. This is done by frequently turning and mixing the wastes. • Oxidizing chemicals like hydrogen peroxide, potassium permanganate, and chlorine will be used by the wastewater treatment industry for odor control. • Organic waste lot which is creating objectionable odor will be attended immediately introduced in the composing system on priority basis. • Controlled compositing conditions will be maintained throughout the operation. • The mitigation measures for Component 2 Legacy Landfill will be determined by the site closure plan which is yet to be developed.			
	Component 1 – SWM Component 2 – Legacy Landfill	3.5	Disease vector generation and vermin attraction	• The most important control measure used to minimize vector problems at landfills is the application of daily cover. Cover should be present on all solid waste at all times, except the tipping face while it is being worked. Daily cover of at least 150mm of compacted soil or similar material or an effective layer of alternate daily cover (ADC) should be applied on finished portions of the daily cell during operation and at the conclusion of daily operations, and not less frequently than once per day. Alternative daily cover materials such as tarpaulins, foams, granular waste, etc, can be effective as vector control after careful site-specific evaluation. • Intermediate cover of 300mm (minimum) compacted soil should be used on all areas not at finished levels, but not to be further landfilled for a period of 30 days or more. • Final cover is typically applied as each area is brought to finished level through the operational life of the landfill. • There should be no uncontrolled or uncovered waste, including litter, tyres, brush, appliances, construction/demolition waste or even inert industrial waste on the landfill property. The only exception is compactable soil-like inert wastes, such as ash, but even this waste must be graded and compacted to avoid ponding water. • There should be no ponding water on the landfill property except as designed for	O&M Contractor/ BWMC	BWMC, PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				runoff storage or leachate treatment ponds. Such storage ponds can, however, aid vector reproduction if not designed and controlled properly to minimise stagnant water, nutrient build-up and plant growth. • Finally, the waste must be compacted and graded at reasonable maximum slopes (see the Working Face Guideline) to minimize voids within the waste that can harbor rodents. Rodents and foxes can readily dig into cover soil but have much more difficulty digging into compacted solid waste. • On-site landfill site personnel must be trained and must monitor the levels of key vectors daily as part of daily management. A simple monthly site walk-over can provide a baseline of vector activity so changes can be noted and translated into action. Observations of various droppings, sightings, tracks, insect counts, etc are useful indicators of activity. • Reports from regular walk-over assessments should be kept on file so changes that occur over time and in response to control measures can be assessed.			
	All Components	3.6	Occupational Health and Safety	• OHS management system will be prepared and implemented. • Designation of an Environment, Health and Safety (EHS) officer dedicated to the site. • All employees must be able to reach their workstations safely. All path, walkways, staircases, ladders and platforms must be stable and suitable for the tasks to be undertaken. • Strict use of Personal Protective Equipment (PPE) by all personnel (e.g. inspectors at the Weigh Bridge, material handler and waste compactor operators) must be ensured. Mandatory health and medical check-ups for all employees especially workers working at MRF as they may be exposed to general airborne dust above the level where it is considered a substance hazardous to health (10 mg/m3 as an 8-hr TWA). This should ideally be complimented by obtaining an Insurance Policy for Workmen especially engaged in the daily activities of the landfill. • Develop a written program (i.e. health information, instruction and training) which sets forth procedures, equipment, personal protective equipment, and work practices that are capable of protecting employees from the health hazards of working in a landfill and its auxiliary facilities. • Mandatory monitoring of air quality and noise levels in the working stations to maintain the same within local standards and whenever possible near ambient levels; Control of inhalation exposure to hazardous substances by the effective use of general ventilation within MRF and Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE). • Accidental fires must be addressed immediately. Appropriate operational procedures	O&M Contractor/ BWMC	BWMC, PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				involving the spreading and smothering of burning waste, rather than the use of water, must be implemented. • Emergency plan (including fire management) must be developed and implemented. Availability of first-aid kits and vehicles that can be used to bring any injured employee to the nearest doctor in cases of accidents. • Mandatory reporting of all accidents or incident of near misses of accidents and immediate adoption of corrective measures. • Management must provide all the necessary financial and manpower resources for the implementation and enforcement of all health and safety programs and activities of the project. • Regular training and orientation on safety practices will be implemented to impart knowledge of safe and efficient working environment. Furthermore, regular health checkups of all employees including contract workers will be conducted. Effective and proper housekeeping is recommended to reduce dust exposures to its direct vicinity. Heat levels must be monitored as well. Spot checks should be done to ensure that workers' welfare is addressed especially during summer months.			
	Component 3	3.7	Waste Collection and Hauling Impacts	• Capacity of BWMC will be increased though increase in its collection fleet. It will be done through procurement of both solid waste and non-solid waste carrying machinery under this project. • Door to Door collection of waste will be enhanced through media campaigns. Communication programs would be developed to encourage better management of waste. Proper PPEs will be provided to waste handlers. Key performance indicators will be developed to monitor improvements in the system. • All type of waste hauling will be carried out in purpose-built vehicles to avoid scattering of waste at hauling routes. Drivers of waste carrying vehicles will be trained with respect to environmental sensitization. Drivers are allowed to commute only on designated routes through purpose-built vehicles for waste hauling. • Multiple transactions of waste will be avoided through use of main and mobile TSs. Improved segregation practices will be introducing once door to door collection desired efficiency achieved. Necessary legal bindings with respect to waste storage by Public will be introduced. • A comprehensive traffic management plan (TMP) must be developed and implemented. • As part of the TMP, it will be ensured that the movement of heavy vehicles related to landfill operations is minimized during the peak traffic hours of the day in order to prevent congestion and accidents as far as possible. • Furthermore, the movement of heavy vehicles within Bahawalpur city related to	O&M Contractor/ BWMC	BWMC, PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				landfill operations must be restricted to specific routes containing least number of sensitive receptors and low traffic volumes. • Waste hauling through dirt tracks will be strictly prohibited. Waste hauling through mechanically unfit vehicles or noisy vehicles will not be allowed. • Waste transporters will be directed to use designated routes and follow recommended speed limit for waste hauling and such routes will be metaled roads instead of dirt tracks.			
	All Components	3.8	Wind Blown Litter	The facility operator, as necessary, will implement the following procedures and techniques to control litter: • All trucks must be tarped upon entering and exiting the facility. They should only untarp and tarp at the active area. This policy will be strictly enforced. Daily waste entering the landfill site will be subject to immediate compaction to minimize the area and debris subject to the impacts of wind. • If possible, on windy days, the daily fill face tipper locations shall be selected for its protection to minimize effects of wind. • Waste that is more susceptible to windblown distribution may, on windy days, be worked immediately into the fill face and covered with a layer of daily cover, as needed, or the waste may be excluded from the site. • Portable skid-mounted litter fences may be provided for deployment downwind as close as practical to the working area, as needed. • Semi-permanent fencing may be provided around the fill area as an additional barrier to the migration of litter off-site when litter has not been contained by the portable litter fences. (Examples of additional barriers include but not limited to, a four-foot minimum temporary construction fence and/or a ten-foot or higher semi-permanent fence.) The utilization will be continually evaluated, and the fence will be relocated or added as needed. • Permanent fencing (ten-foot high with an additional three-foot kicker) may be constructed with possibility of placement on an eight-foot-high berm. • On very windy days, when all other procedures are not successful in controlling blowing litter, the operator may apply cover material more frequently or immediately to the incoming waste load. • Buffer zones resulting from required facility setbacks along the site’s perimeter should provide some protection of adjacent properties. • As a final control measure, personnel will be dispatched, as needed or daily if conditions require, to collect any litter that has escaped the above control measures • Portable litter vacuums may be used to collect litter that has accumulated on litter	O&M Contractor/ BWMC	BWMC, PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				fences. If fences are positioned properly, this can be a very efficient method of collecting litter. • The main highway leading to the site will be routinely inspected for litter. If the highway has litter associated with the trucks entering the facility, then the litter will be picked up on a routine basis. All necessary safety precautions must be followed. • Before and after photos of any litter removal effort may be taken in the event anyone questions the level of effort spent on litter collection. • Site management's cell phone numbers may be provided to community/neighbors. • The management of litter at the landfill is a daily activity. In most instances the above procedures and techniques should properly manage litter effectively. However, there will be occasions and situations when litter will be distributed by the wind in such a manner that the above procedures will not totally manage the litter and contain the litter on-site. In these situations, the facility operator may not be able to collect all litter within the day the litter problem occurred. However, the facility operator should proceed with collecting the litter off site and complete the retrieval of wind-blown litter at the earliest practicable time. • Waste carrying vehicle shall be maintained with respect to vibratory parts, oil change and emissions. • Vehicles which are not in compliance to PEQS shall not be allowed to transport waste to MRF and LFS. • Vehicle drivers will be trained on safe driving practices, • Use of horns and waste scattering during waste transport to MRF and LFS shall be not allowed. • Consultation with communities falling along the route of waste transport will be conducted on periodic basis and their response/concerns shall be promptly addressed by landfill/MRF operator.			
	Component 1 and 2	3.9	Aesthetic Aspects	• Boundary walls shall be constructed alongside the facility. • The indigenous plants shall be planted alongside the access road and around the landfill sites which will act as buffer zone. • The waste transfer vehicles shall be covered. • A reasonable area will be allocated for plantation within and at boundary of facility to improve aesthetic appeal of the area. • Plantation will start as one of the earliest activities of site development. Once the	O&M Contractor/ BWMC	BWMC/PMU	DO

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				design of landfill is approved and necessary funds mobilized, plantation activity can be started in collaboration with Bahawalpur Development Authority or BWMC can outsource the activity separately.			
	Component 1	3.10	Management of Construction and Demolition Waste	• All components of construction & Demolition Waste shall be processed, recycled and reused. • All Concrete, PCC and RCC will be processed to Produce Class II and Class III recycled Sub-Base and Base materials. • Recovered Asphalt Concrete will be mixed in Recycled concrete or reused by mixing with fresh Asphalt concrete. • All metal will be recovered and recycled. • Wood component will be Processed and used as Mulch or raw materials for compost. • Processed waste will be used as Cover material for landfills.	O&M Contractor/ BWMC	BWMC/PM U	DO
	Component 2 - MRF	3.11	Impacts associated with operations of MRF	• Conduct risk assessment for MRF operations and prepare method statement in line. with risks and suggested mitigation measures. • Procure MRF machinery or plant with designed noise data from the supplier. • Move noisy machinery/plant into areas where there are no workers, or few i.e. dedicated area. • Provided enclosure if machinery/plant has to remain in the working area, enclose it within a sound-insulating enclosure if possible. • Where enclosure is not possible, reduce noise by other engineering means such as: ○ lining guards/panels with noise dampening material. ○ providing acoustic screens. ○ lining the inside of hoppers with impact-deadening material. ○ fitting anti-vibration mountings. ○ fitting silencers to exhaust systems. ○ ensuring good maintenance to stop rattles and prevent noise from wear. • Provide job rotation to reduce exposure of noise. • Provide hearing protection to workers. • Where noise levels still exceed 85dB(A) ensure workers wear hearing protection (earplugs or earmuffs) within the designated and clearly marked zones.			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Conveyor belts shall not be too high or low (making the person stoop and/or stretch) • Conveyor belts shall not be too wide (making the person reach too far). • Provide adequate foot clearance under conveyor. • Provide proper access to belt surface. • Provided adequate illumination at work area for clear visibility. • Speed of belt shall be controlled. • Emergency arrangements shall be in place to stop to the belt in case of break or fatigue. • Provide adequate working space of workers engaged at conveyor belts • Provide sufficient job rotation. • Provision of adequate welfare and hygiene facilities. • Provision of a risk-based health surveillance programme. • Control of inhalation exposure to hazardous substances by the effective use of general ventilation, Local Exhaust Ventilation (LEV) the appropriate use of respiratory protective equipment (RPE). • Provision of training and supervision. • Periodic inspection of MRF machinery to ensure its integrity and cleanliness. • Haphazard material stocking shall be avoided to reduce slip and trips hazards. • Work at height will be supervised and work platform shall be inspected prior to start of work. • Necessary PPEs shall be provided to workers for noise, airborne dust and work at height.			
	Component 1 and 2	3.12	Impacts associated with operations of composting plant and AD plant	• Inventory and quality of organic waste reaching the composting facility shall be maintained. • No mixed waste shall be introduced in the compositing facility. • pH, C/N and C/P ratio shall be maintained as per design recommendations. • Air should be thoroughly dispersed throughout the organic waste. This is done by frequently turning and mixing the wastes.			

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Temperature should be maintained between 50 to 60oC for active composting period. • Incoming organic waste shall not be stored for longer time without processing at the facility as it will create odor. • Leachate drains shall be provided at compositing pads. Collected leachate shall be sprayed to the landfill site. • Adequate stock of bulking agents shall be available at the facility. • Facility shall be secured and fenced to avoid rodents such as snakes and rats. • Fumigation shall be carried out on periodic basis to kill pathogens. • Housekeeping of the facility shall be ensured through dedicated staff to remove chances of vectors breeding. • Proper PPEs shall be provided to workers involved in compositing operation. • Local exhaust ventilation system shall be operational all the time to limit impacts of objectionable odor.			
Closure & Post Closure Phase	1	4.1	Closure and Post Closure Impacts	• Appropriate selection of soil type for final cover will be ensured to prevent water infiltration and minimize infiltration of precipitation into the waste and the subsequent generation of leachate; control landfill gas migration; and minimize long term maintenance needs. • Appropriate selection of soil type for final cover will be ensured to prevent direct or indirect contact of living organisms with the waste materials and their constituents. • Application of final cover components that are consistent with post closure use and local climatic conditions. • Necessary environmental objectives and controls (including technical specifications) will be defined and implemented. • Necessary surveillance protocols for final capping, leachate and gas monitoring will be established and implemented. • Future Land use of the site will be defined in consultation with local communities and government agencies. • It will be ensured that financial resources, and monitoring arrangements are in place for closure and post closure activities. • PMU PUNJAB LG&CDD will ensure that financial instruments are in place to cover the costs of closure and post-closure care and monitoring.	BWMC	BWMC	During Closure & Post Closure

Project Activities	Component	Section	Impact	Mitigation Measures Recommended	Responsibility		Timing
					Execution	Monitoring	
				• Long term integrity and security of the site will be maintained. ● Continuous monitoring of gas and groundwater quality will be undertaken. The frequency of which will be determined by the regular monitoring during operation. If conditions are stable, the monitoring frequency can be reduced.			

CSC: Construction Supervision Consultant

BC: Before Construction

DC: During Construction

PMU: Project Management Unit

DO: During Operation

BWMC: Bahawalpur Waste Management Company

Table 9-2: Component 1 and 2 ‘Pre-Construction’ Environmental Monitoring Plan for Baseline Development.

965. The results of all monitoring will be collated into monthly and annual reports and shared with the PMU. Action should be agreed if results exceed the appropriate screening criteria. Monitoring parameters and frequency should be reviewed depending on conditions encountered and adjusted accordingly in agreement with the PMU. Groundwater monitoring should be undertaken in accordance with the Groundwater Monitoring Programme in A23.

Parameter to be measured	Component	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility	
							Implementor	Monitor
Ambient Air Quality	Component 1 & 2	To establish baseline air quality levels	CO, NO_2, SO_2, O_3 & PM_{10} (particulate matter smaller than 10 microns) concentration at receptor level, PM2.5	1-hr and 24-hr concentration levels	At three random receptor locations in the project area, both upwind and downwind	Once	Contractor	CSC
Ambient Noise	Component 1 & 2	To establish baseline noise levels	Ambient noise level near receptors in project area	A-weighted noise levels – 24 hours, readings taken at 15 s intervals over 15 min. every hour, and then averaged	At three random receptor locations in the project area	Once	Contractor	CSC

Groundwater Quality in vicinity of landfill site	Component 1 & 2	To establish groundwater quality in project area	Groundwater quality in project area	Water samples should be obtained and analysed either using onsite measuring equipment or via analytical laboratory in accordance with Groundwater Monitoring Programme in A23.	A minimum of 8-12 permanent boreholes (up and down gradient) should be installed around the perimeter of the landfill. The contractor should determine the required amount based on final design and after undertaking appropriate risk assessment. Boreholes should be replaced immediately if damaged.	In accordance with groundwater monitoring program in A23.	Contractor	CSC

Table 9-3: Construction Phase Monitoring Requirements

This section applies to both the Construction of Component 1 but also the construction of the MRF and implementation of site closure measures for the Component 2 Legacy Landfill.

Project Activity and Potential Impact	Component	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility
Noise Disturbance due to noise from construction activity	Component 1 and 2	To determine the effectiveness of noise abatement measures on sound pressure levels	Ambient noise level at different locations in project area	A-weighted noise levels – 24 hours, readings taken at 15 s intervals over 15 min. every hour at 15 m from receptors, and then averaged	At three random receptor locations in project area	Quarterly basis on a typical working day	Contractor’s Environmental officer, CSC
Air Quality Dust emissions from construction vehicles and equipment	Component 1 and 2	To determine the effectiveness of dust control program on dust at receptor level	CO, NO_2, SO_2, O_3 & PM_{10} (particulate matter smaller than 10 microns) concentration at receptor level.PM 2.5	1-hr, 8 hr and 24-hr concentration levels	At three random receptor locations in project area	Quarterly basis on a typical working day	Contractor’s Environmental officer, CSC
			Visible dust Dust Monitoring	Visual observation of size of dust clouds, their dispersion and the direction of dispersion Particulate matter – PM2.5 and PM10. Weather Data Prevailing Wind Direction	Construction site	Visual once daily during peak construction period. Analytical Monitoring once monthly or if significant dust generation is experienced or complaints received.	Contractor’s Environmental officer, CSC

Project Activity and Potential Impact	Component	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility
Safety precautions by Safety workers	All	To prevent accidents for workers and general public	Number of near miss events and accidents taking place	Visual inspections	Construction site	Once Daily	Contractor's Environmental officer, CSC
Soil Contamination	All	To prevent contamination of soil from oil and toxic chemical spills and leakages	Incidents of oil and toxic chemical spills	Visual inspections	At construction site and at vehicle and machinery refuelling & maintenance areas	Weekly	Contractor's Environmental officer, CSC
Solid Waste & Effluent disposal Insufficient procedures for waste collection, storage, transportation and disposal	Component 1 and 2	To check the availability of waste management system and implementation	Inspection of solid and liquid effluent generation, collection, segregation, storage, recycling and disposal will be undertaken at all work sites in project area	Visual inspections	At work sites in project area	Once daily.	Contractor's Environmental officer, CSC
Groundwater Monitoring	Component 1 and 2	To check impact on groundwater quality during construction	In accordance with Groundwater Monitoring Programme outlined in **Appendix A-23**.	Onsite and Laboratory Analysis	Minimum 12 wells – quarterly – assumed 2 years construction	In accordance with groundwater monitoring programme in A23.	Contractors Environmental Officer CSC

Table 9-4: 'Operation Phase' Environmental Monitoring Plan

This table relates to the operation of the landfill in Component 1 but also to the operation of the MRF and ongoing monitoring of the legacy landfill once it has been restored. The operator should ensure that they budget to undertake monitoring for the lifetime of the landfill which can be for 25-50years post closure depending on the landfill composition. During bidding the contractor shall demonstrate to the PMU how they have budgeted for this. Any changes to the monitoring regime should be agreed in writing with the PMU in advance of actioning any changes.

Parameter to be measured	Component	Objective of Monitoring	Parameters to be Monitored	Measurements	Location	Frequency	Responsibility
Groundwater Quality in vicinity of landfill site	Component 1 and 2	To assess whether landfill operation is causing any seepage into the groundwater aquifers in project area and contaminating it.	Groundwater quality in project area.	In accordance with groundwater monitoring programme in A23.	Minimum of 12 Locations around Landfill Site Perimeter. Final number will be determined by operator following a risk assessment.	Monthly	BWMC
Surface Water Quality	Component 1 and 2	To assess whether landfill is impacting local irrigation channels.	Surface-water	Water samples for comparison against PEQS parameters	8 Locations – random to be determined based on site specific risk assessment.	Quarterly	BWMC
Drinking Water Wells	Component 1 and 2	To assess whether landfill is impacting local drinking water wells.	Private drinking wells.	Water samples for comparison against PEQS parameters	Random to be determined based on site specific risk assessment.	Quarterly	BWMC
Landfill gas	Component 1 and 2	To assess whether landfill operations are causing landfill gas that is migrating offsite.	Landfill gas from perimeter wells installed around landfill and onsite surface emissions.	CH4, CO2, O2, H2S, VOCs, Gas Flow Rate, Barometric Pressure, Borehole Pressure Temperature, Weather Observation, Perched Water Level.	A minimum of 16 Locations to be installed as permanent installations round the perimeter of both the new and legacy landfill.	Weekly for 6 weeks and then Monthly	BWMC

Ambient Air Quality in vicinity of Landfill site	Component 1 and 2	To assess whether landfill operation is causing deterioration of ambient air due to flaring	Ambient air quality in project area	Ambient air quality monitoring against PEQS/WHO parameters	At three locations around the landfill site in the project area	Quarterly	BWMC
Solid Waste Management Plan	Component 1 and 2	To assess that solid waste generated from Landfill operation is managed as per IEE/EMP requirements	Solid waste inventory is being maintained Only MSW is reaching the Landfill	Solid waste inventory audit	Each component of Landfill	Monthly Closure and Post Closure EMP	BWMC
Vector Management	Component 1 and 2	To assess that operations are not causing offensive vector levels.	Site Walk Through	Visual	Each component of landfill	Monthly	BWMC
Dust Management	Component 1 and 2	To assess that operations are not causing unacceptable dust levels	Portable dust monitoring in areas of active working	Particulate matter –PM1, PM2.5 and PM10. Total Suspended Particles Weather Data Prevailing Wind Direction & Speed	Working face of landfill and transport routes	Daily to Weekly depending on weather conditions.	BWMC

Table 9-5: Capacity Development and Training Programme

Provided by	Organized by	Contents	No. of training events	Duration	Cost (PKR)
Pre-construction Phase Monitoring Consultants/Organizations offering specialized services in environmental management and monitoring	CSC & PMU	Short seminars and courses on: Environmental Management Plan and Environmental Monitoring Plan	Two seminars for Contractor management staff and project staff	1 day	300,000/Training
Construction Phase Monitoring Consultants/Organizations offering specialized services in environmental management and monitoring	CSC & PMU	Short seminars on Environmental risks associated with construction phase. Development of Environmental Performance Indicators Occupational Health and Safety (OHS) issues	Two seminars for Contractor management staff and project staff dealing in environment and social issues	1 day	300,000/Training
Operation Phase **Landfill Facility Operator authorized representative or**	Landfill Facility Operator	Short seminars on Environmental risks	Bi-annual seminars	1-2 Day	800,000/Year

Provided by	Organized by	Contents	No. of training events	Duration	Cost (PKR)
3rd party trainer for Closure/Post Closure training		associated with operation phase. Development of Environmental Performance Indicators/ Occupational Health and Safety (OHS) issues			
Total			**14,00,000** **(PKR 1.4 million)**		

9.9 Component 1&2 Environmental Management Costs

966. The **Table 9-6** below provides cost estimates for 'Pre-Construction phase' monitoring while **Table 9-7** and **Table 9-8** provides cost estimates for 'Construction phase' and 'Operation phase' monitoring of key environmental parameters.

967. The costs associated with implementation of the EMP and the necessary mitigation measures are provided as **Table 9-9** below. The **Table 9-10** below provides the 'Capacity development and training programme' for project contractors for the proposed landfill development.

968. It is assumed that the time taken to undertake monitoring will be part of the full-time environmental site engineers role for each component site, and thus costs for monitoring time have not been included.

969. Costs include purchase of monitoring equipment for each component site. These are assumed to be one-off costs, but the contractor may wish to factor in replacements and upgrades given the project will run for c.25 years. It is recommended that environmental monitoring equipment should be renewed approximately every 5 years, have maintenance annually and be calibrated each time it is used.

970. An annual report of monitoring results should be prepared for each component and issued to the PMU and ADB. A review meeting should be held annually to discuss and agree any changes to monitoring regime. Any agreement on changes should be documented in the annual report. Annual reporting costs are not included.

971. Costs provided below are estimates for **each** component and the contractor should present final costing for PMU approval.

Table 9-6: Annual Cost Estimates for 'Pre-Construction Phase' Environmental Monitoring – COSTS PER COMPONENT

Monitoring Component	Parameters	Quantity	Amount PKR	Details
Air Quality	CO, NO_2, SO_2, O_3 PM_{10},$PM_{2.5}$	3 (Once only at 3 locations)	150,000	3 readings @ PKR 50,000 per sample
Noise Levels	dB(A)	3 (Once only at 3 locations)	90,000	3 readings @ PKR 30,000 per reading
Ground Water Quality	In accordance with environmental monitoring plan	8 perimeter wells plus 4 off-site private/surface water wells monitored in accordance with Groundwater Monitoring Programme	4,000,000	144 samples annually @ PKR 30,000 per sample.
Groundwater Monitoring	Onsite	Initial one-off purchase	500,000	One off cost to purchase groundwater sampling equipment: 50m groundwater depth/temperature

				monitoring tape (Solinst 201 or similar); EC meter; pH meter; Purging pump; Sampling bailers; Decontamination equipment.
Contingencies			237,000	5% of monitoring cost
Total (PKR):			**4,977,000 per component** **4,477,000 subsequent years*** **(*purchase of monitoring equipment will not be required every year)**	
Total All Components			**9,954,000**	

Table 9-7: Annual Cost Estimates for 'Construction Phase' Environmental Monitoring – Component 1 and Component 2 (Inc. Regeneration activities of Legacy Landfill).

Monitoring Component	Parameters	Quantity	Amount PKR	Details
Air Quality	CO, NO_2, SO_2, O_3 ,PM_{10}.$PM_{2.5}$	12 (Quarterly basis at 3 locations)	600,000	12 readings @ PKR 50,000 per sample
Noise Levels	dB(A)	12 (Quarterly basis at 3 locations)	360,000	12 readings @ PKR 30,000 per reading
Groundwater Quality	In accordance with groundwater monitoring programme.	8 perimeter wells plus 4 off-site private/surface water wells monitored in accordance with Groundwater Monitoring Programme	4,000,000	144 samples annually @ PKR 30,000 per sample.
Dust & Vector Monitoring	Particulate matter –PM1, PM2.5 and PM10. Total Suspended Particles Weather Data Prevailing Wind Direction & Speed	Daily +5	2,000,000	Cost of monitoring equipment – **One off Cost** such as aeroqual dust sentry – www.aeroqual.com Vector Monitoring – Visual – No cost.

Gas Monitoring	CH4, CO2, O2, H2S, VOCs, Gas Flow Rate, Barometric Pressure, Borehole Pressure Temperature, Weather Observation, Perched Water Level.	16 perimeter wells. monthly during construction.	2,000,000	One off cost of portable monitoring equipment –GasData GFM435 Landfill Gas Analyser or Similar - such as: GasData GFM435 Landfill gas analyser MCERTS | Ribble Enviro Ltd. (ribble-enviro.co.uk)
Contingencies			448,000	5% of monitoring cost
Total (PKR)			**8,960,000 – First Year** **4,960,000 subsequent year/s**	
Total All Components:			**17,920,000 – First year** **9,920,000 subsequent years**	

Table 9-8: Annual Cost Estimates for 'Operation Phase' Environmental Monitoring – Component 1 and Component 2.

(Note: Component 2 should be considered as already operational and therefore these costs should be accounted for from "Current" through to Post Regeneration. These costs should be confirmed by the contractor responsible for undertaking the regeneration and ongoing management of Component 2)

Monitoring Component	Parameters	Quantity	Amount PKR	Details
Surface Water Quality or Local Shallow Drinking Wells	As per groundwater monitoring plan in A23	8 (Quarterly basis)	960,000	32 readings @ PKR 30,000 per sample
Groundwater Quality Perimeter Wells	As per groundwater monitoring plan in A23	Monthly – Quarterly as per groundwater monitoring plan	4,000,000	144 samples annually @ PKR 30,000 per sample.
Ambient Air Quality Monitoring	CO, NO_2, SO_2, O_3 ,PM_{10}.$PM_{2.5}$	3 (Quarterly basis @ 3 locations)	600,000	12 readings @ PKR 50,000 per reading
Gas Monitoring	CH4, CO2, O2, H2S, VOCs, Gas Flow Rate, Barometric Pressure, Borehole Pressure Temperature, Weather Observation, Perched Water Level.	16 perimeter wells. - Monthly	2,000,000	One off cost of portable monitoring equipment –GasData GFM435 Landfill Gas Analyser or Similar - such as: GasData GFM435 Landfill gas analyser MCERTS | Ribble Enviro Ltd. (ribble-enviro.co.uk) .
Dust & Vector Monitoring **(For Component 2, this would not be necessary once fully restored)**	Particulate matter –PM1, PM2.5 and PM10. Total Suspended Particles Weather Data Prevailing Wind Direction & Speed	Daily	2,000,000	Cost of monitoring equipment – **One off Cost** such as aeroqual dust sentry – www.aeroqual.com Vector Monitoring – Visual – No cost.
HSE monitoring	HSE officer		600,000	50,000 per month
Contingencies			508,000	5% of monitoring cost
Total (PKR)			**10,668,000**	

Table 9-9: Total Estimated Costs for EMP Implementation (All Components)

Component	Item	Description	Estimated Total Cost (PKR)
1 & 2	**Installation of permanent perimeter monitoring wells – Gas and Groundwater for both sites**	Estimate – 16No. Groundwater wells to 25m per component and 32 gas monitoring wells to c. 5m per component	**20,000,000**
1 & 2	**Consultancy fees for Component 2 – Legacy Landfill - Site Closure Planning**	To undertake further site investigation, risk assessment, modelling and prepare site closure planning documents.	**10,000,000**
1 & 2	**Staff, audit and monitoring cost**[31]	1 Environmental Engineer – 1-year full time (@ 100,000 PKR per month)	**1,200,000**
1 & 2	**Monitoring Activities – Equipment & Laboratory Costs**	Provided separately in **Table 9-6, Table 9-7 and Table 9-8.**	-
All	**Mitigation Measures**		
1 & 2	**(i) Water sprinkling**	To suppress dust emissions	800,000
1	**(ii) Solid waste collection & disposal**	From construction sites (based on initial estimates)	700,000
1 & 2	**(iii) Plantation around project boundary to control odour levels**	To plant vegetation all along the landfill boundary to limit odour emissions	15,000,000
1	**(iv) Chemicals/pesticides to prevent/minimize disease vector generation, first aid, dispensary**	Chemicals to be injected into the influent streams in order to minimize/prevent disease vector generation	10,000,000
	Contingencies	5% of EMP implementation cost	2,885,000
	Total Estimated Cost (PKR)		**60,585,000**

[31]To cover staff cost and expenses of Environmental Specialist for Contractor

Table 9-10: Capacity Development and Training Programme for Project Contractor(s)

Provided by	Organized by	Contents	Target Audience	Venue	Duration
Pre-construction Phase PMC offering specialized services in environmental management and monitoring	CSC & PMU	Short seminars and courses on: Environmental Management Plan and Environmental Monitoring Plan	Contractor staff	PMU Office, Bahawalpur	One day long training seminar
Construction Phase PMC offering specialized services in social management and monitoring	CSC & PMU	Short seminar on Environmental risks associated with construction phase. Development of Environmental Performance Indicators Occupational Health and Safety (OHS) issues	Contractor staff	PMU Office, Bahawalpur	One day long training seminar

10 Public Consultation and Information Disclosure

972. This section describes the process and outcomes of the consultations carried out with various groups of stakeholders as part of the environmental and social assessment. It includes a brief discussion on the concerns expressed by the stakeholders during the consultation meetings and responses provided in order to address the concerns through necessary mitigation measures.

973. The specific objectives of the consultation were: (i) obtaining local and indigenous knowledge about the environment and people living in the project area; (ii) interaction with the project affected population and other stakeholders for the collection of primary and secondary data on environment and people; and (iii) engaging stakeholders for maximization of the project benefits.

974. Two rounds of comprehensive stakeholders' consultations were organized with a total of over 104 different stakeholders consulted. The first round of public consultations was conducted in the month of first week of November 2022, while the second round of public consultation was completed in the month of December, 2022. Information on positive and negative impacts associated with constructional and operational stage and proper mitigation of adverse impacts were shared at these consultations.

975. Based on the past EIA/IEE studies, the sample size used in this study is determined based on the cost, time, or convenience of collecting the data, and the need for it to offer sufficient statistical power. Larger sample sizes generally lead to increased precision.

976. Details on the public consultations conducted are provided below with the pictorial evidence and list of persons consulted provided as **Appendix A.3**.

10.1 Identification of Stakeholders

977. There are three types of stakeholders for the proposed landfill site development as described below.

10.1.1 Primary Stakeholders

978. The primary stakeholders are primarily the Project Affected Persons (PAPs) and public including women residing in the project area - for example, people living in the project area particularly those affected by the footprint of the Mari Sheikh Shijra mouza Nouabad Landfill site, Bahawalpur. These are the people who are directly exposed to the project's impacts, though in most cases they may not be receiving any direct benefit from the project. The local community and women of the area were also consulted.

10.1.2 Secondary Stakeholders

979. The secondary stakeholders are typically institutional stakeholders – for instance, related government department/agencies, local government, and organizations that may not be directly affected by the project; however, they may influence the project and its design. In the case of the proposed landfill site development, the secondary stakeholders are as follows:

- Bahawalpur Waste Management Company (BWMC)
- Environment Protection Agency (EPA), Government of Punjab, Divisional Office Bahawalpur and Head Office in Lahore.

- Wildlife Departments, Government of Punjab
- The ADB (The Financing Agency)
- Tehsil Municipal Authority (TMA), Bahawalpur
- Agricultural Department, Bahawalpur.
- Representatives of local communities
- Irrigation Department, Government of Punjab, Bahawalpur.
- Revenue Department, Government of Punjab, Bahawalpur
- Social Welfare and Baitul-Mall, Bahawalpur.
- Al-Fatah Development (Non-government organization)
- Public at large

10.1.3 Key stakeholders

980. The stakeholders considered to possess the ability to significantly influence a project, or who are critical to the success of a project are considered key stakeholders. Key stakeholders may be from the primary and/or secondary stakeholder groups. In this context of the proposed landfill site development, these are considered to be local leaders, influential community members and other local representatives including Imams of mosques and teachers of local schools.

10.2 Information Disclosure and Consultation

10.2.1 Scope of Consultations

981. The consultations were conducted and recorded by Mr. Saeed (Sr. Sociologist), Mr. Adnan Shareef (Sociologist), Mr. Ali Hassan (Sociologist) and Mr. Sher Zaman (Environmentalist). The stakeholders were also briefed by PMU Project Infrastructure Engineer Mr. Rizwan Jabbar and Ms. Zunaira. During these consultations, the primary and secondary stakeholders were briefed on the project components in detail and all their concerns and feedback was recorded.

982. All consultations were carried out in accordance with the ‘meaningful consultation’ guidelines of ADB’s SPS 2009 and their outcome is discussed in the proceeding sections. Consultations were also held with the PMU, Local Government Board and the design consultants.

983. As part of the present environmental and social assessment, detailed consultations with over 160 different stakeholders were conducted through village meetings and focus group discussions (FGDs) with the communities, including women in the project area. Separate meetings were held with the institutional stakeholders in the form of one-to one meetings i.e. with EPA, BWMC, etc. Specially, prepared consultation performa was used during the data collection. Details of this consultation process are described in the **Table 8.1** below and the locations of the public consultations are provided in **Figure 8.1** below. Photographs of institutional stakeholders are provided in **Figure 8.2.** Photographs of FGDs are provided in **Figure 8.3.**

Figure 10-1: Map of Public Consultation Locations

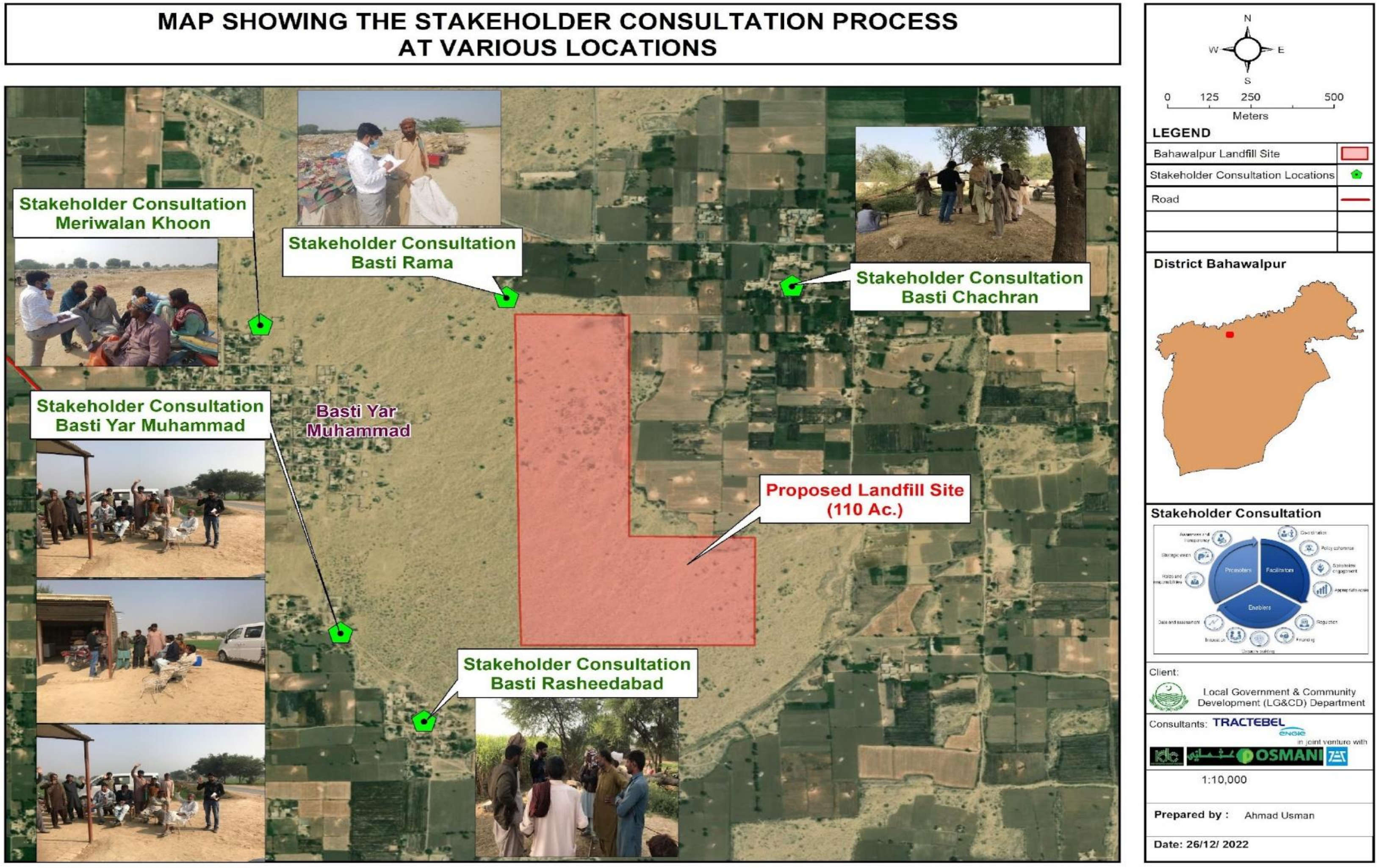


Table 10-1: List of Stakeholder Consultation and Concerns

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns	Consultant Response
1	07/11/22	Basti Yar Muhamamd	14	● Jobs should be provided to the locals ● Odour issue during landfill operation will cause the inconvenience to locals especially in summer season ● Skin diseases, and dengue can be boosted in the area.	● People were briefed regarding Waste Management current and proposed practices and anticipated issues ● Provided briefings on the landfill technology which will eliminate disease and odour related issues ● Implementation of EMP i.e. spraying of fleas and mosquito killer reagents at site. ● Locals will be preferred for Jobs
2	08/11/22	Basti Chachran	22	● Transportation of Waste may cause the smell issues ● Odour and smell issues in the waste storage area (cell area) ● Diseases, such as skin allergies, dengue, typhoid	● People were briefed regarding Waste Management current and proposed practices and anticipated issues ● Educating about the landfill technology to be implemented, which will eliminate disease and odour related issues ● Implementation of EMP i.e. spraying of fleas and use of mosquito killer reagents at site ● Preparation of buffer zone along the boundary limits of the landfill site
2	08/11/22	Meriwalan Khoon	10	● People were in favour of the project ● Some persons also demanded the jobs.	● Waste Management and transportation plan will be properly implemented. ● Educating about the landfill technology to be implemented, ● The concept of no waste touches the ground will be implemented

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns	Consultant Response
3	08/11/22	Basti Rama	14	● People were not well aware about the land fill sites and its process, details were provided during the one-to-one meetings ● People were in favour of the project ● Some persons also demanded the jobs and infrastructure development.	● A media news will be advertising once the project is approved. ● Educating about the landfill technology to be implemented, ● The concept of no waste touches the ground will be implemented ● Locals should be preferred for jobs
4	09/11/22	Basti Marian wala Khoon	10	● People were not well aware about the land fill sites and its process, details were provided during the one-to-one meetings ● People were in favour of the project ● Some persons also demanded the jobs and infrastructure development.	● A media news will be advertising once the project is approved. ● Educating about the landfill technology to be implemented, ● The concept of no waste touches the ground will be implemented ● Locals should be preferred for jobs
5	06/12/22	Basti Dera Mastee	6	● People were not aware about the land fill sites and its process, details were provided during the one-to-one meetings ● People were in favour of the project ● Some persons also demanded the jobs and infrastructure development.	● A media news will be advertising once the project is approved. ● Educating about the landfill technology to be implemented, ● The concept of no waste touches the ground will be implemented ● Locals should be preferred for jobs
6	06/12/22	Basti Rasheedabad	13	● Jobs should be provided to the locals ● Odour issue during will cause the inconvenience to locals especially	● People were briefed regarding Waste Management current and proposed practices and anticipated issues

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns	Consultant Response
				in summer season and during the transportation ● Skin diseases, and dengue can be boosted in the area.	● Provided briefings on the landfill technology which will eliminate disease and odour related issues ● Implementation of EMP i.e. spraying of fleas and mosquito killer reagents at site. ● Locals will be preferred for Jobs
7	07/12/22	Basti Kumharan wali	15	● Jobs should be provided to the locals ● People were not interested to leave the government land; however, they were also briefed that no dislocation is required for the proposed project.	● People were briefed regarding Waste Management current and proposed practices and anticipated issues. ● Provided briefings on the landfill technology which will eliminate disease and odour related issues ● Implementation of EMP i.e. spraying of fleas and mosquito killer reagents at site. ● Locals will be preferred for Jobs ● No land acquisition is involved

Table 10-2: Consultations with Government Stakeholders

Sr. No.	Date	Department of Consultation	Name/Designation of Person	Comments/Concerns	Consultant Response
1	11-11-22	Bahawalpur Waste Management Company (BWMC)	Irfa Mehmood (Head-BWMC)	He expressed an interest in facilitating the necessary fulfilment of the environmental and social safeguard criteria. Along with need assessment of the Regional Waste Management Practices.	After the detail design and all mandatory financial arrangement related with project, proponent will make also consider the regional landfill option in liaison with PMU.

Sr. No.	Date	Department of Consultation	Name/Designation of Person	Comments/Concerns	Consultant Response
				He emphasized on early execution of the project d obtain the approval before to start any activity at site.	
2	11-11-22	City Implementation Unit (CIU)- Bahawalpur	Rizwan Jabbar (Infrastructure Engineer)	He expressed about the project as the most demanding activity in Bahawalpur.	The design will be finalized and all Codal formalities will be completed in due timelines.
3	11-11-22	Agricultural Department	Sohail Shanee (Agricultural Officer)	He desired that during the production of compost (if any) the agricultural department may be taken on board for its utilization.	During the implementation of project Agricultural Department of Bahawalpur should be taken on board for regular consultation and compost utilization.
4	11-11-22	Environment Protection Department - Bahawalpur	Ansar Abbas (Assistant Director) - Bahawalpur	He suggested that for disposal of hazardous waste a separate cell may be designated, he further emphasized that regular monitoring may be conducted to ascertain the GHG emissions.	Regular monitoring as per environment monitoring plan will be conducted to ascertain the GHG emissions.
5	11-11-22	Social Welfare Department	Rizwan Ullah (Social Welfare officer)- Bahawalpur	He appreciated the project and added that this will uplift the environmental sustainability in the project area in general and district Bahawalpur as whole.	Project implementation should be following ADB SPS 2009.
6	11-11-22	Irrigation Department	Junaid Iqbal (SDO-Irrigation)	He appreciated the project and asked about the leaching disposal measurements in the project design.	The design must cater the leaching treatment facility at the landfill site.

Sr. No.	Date	Department of Consultation	Name/Designation of Person	Comments/Concerns	Consultant Response
7	11-11-22	Environment Protection Agency- Punjab	Nasim ur Rehman (Director-EPA-Punjab)	He appreciated the project and added that environmental should obtained before the commencement of the project.	Project implementation should be compliant with ADB SPS 2009.
8	11-11-22	Wildlife Department (WLD) -Bahawalpur	Mir Yaqoob (AD-WLD)	He appreciated the project and mentioned that in or around the proposed site no threatened species are there.	Project implementation should be compliant with ADB SPS 2009.
9	11-11-22	Civil Society Representative	Jamshaid Karim Khan	He appreciated the project and offered if the NGO can do something for the proposed project.	During the project implementation all the stakeholders must be taken on board.

Figure 10-2: Consultations with Institutional Stakeholders

	
Discussion with the institutional stakeholders	**Consultations with Director EPA-Punjab**
	
Discussion about project with CIU and BWMC	**Consultations with Wildlife Officer Punjab**
	
Consultation with the Agricultural and Social Welfare Officer	**Consultations with Social Welfare Person**

10.2.2 Social Safeguard Focused Group Discussions

984. After initial survey by Social Safeguard team, the overall number of directly affected people from the proposed landfill site was known. Every affected person was reached out and interviewed by social safeguard team as per ADB requirements. These people were interviewed about the land area they share in the project area and their entire social status including details of their income, food expenditure, basic life amenities, living background etc. Till date, 80% of those people including both men

and women have been interviewed and their observations have been noted down while the rest is in progress.

985. Consultation with the affected persons was conducted within their settlements to encourage and facilitate their participation. 66% men and 34% women were interviewed. Separate sessions were arranged for the women. During the consultation process, a verbal detailed description of the Project activities was provided to those interviewed.

Figure 10-3: Focus Group Discussions (FGDs) for Bahawalpur Landfill

	
Consultations with Local Community of Basti Yar Muhammad	**Consultations with Local Community of Mari Sheikh Shijra**
	
Consultation with affected persons in Basti Rama	**Consultation with affected persons in Basti Rasheedabad**

10.2.3 Findings of the Public Consultations/Focal Group Discussions

986. No major land acquisition and resettlement issues were expressed by the local as land is already under possession of BWMC.

987. All the Indirectly affected people included the population living in the vicinity of the project area. Those people complained about the smell issues and spreading of different diseases in the project area due to open dumping of untreated solid waste in the proposed landfill site. Due to variation in direction and flow of wind in summers, the odour problem was observed to be increased and hence causing the spread of fever and skin diseases.

988. Power load shedding is adversely affecting the daily lives of residents as the only source of power in the vicinity of the project area is through solar panels which the locals have installed on their own finances.

989. Health, education, and drinking water facilities should be provided, following the Project development.

990. There are no public tube wells and pipeline structure to facilitate water source for the people in the vicinity of the project area. The locals have installed private tube wells to keep up with the water resources.

10.2.4 Response from Social Safeguards Team

991. Our team made sure that the affected people were given full surety regarding their demands.

992. The people indirectly affected from the project were told about the new technological installation in the project area as installation of new engineered landfill would reduce the odour issue and hence reduction in spreading of different diseases.

993. There is a big opportunity for the installation of solar powered panels in the surroundings of the project area.

994. The people were made sure that their demands reach to the higher authorities and that the basic life amenities be provided to them once work on project gets initiated.

Figure 10-4: Women Consultation in the Project Area

10.2.5 Consultations with Scavengers and Scrap Dealers

995. During the scoping of environmental and socioeconomic studies of the project area, these groups were identified as important stakeholders which will be influenced in some form or another. To gather more information on the nature and extent of this influence, a data collection and analysis strategy was devised by the environmental experts, relevant literature consulted and compiled (included previously our project data), questionnaires drafted, and site visits conducted. All these activities are described below.

996. The process of consultation was planned to begin with contacting the workers collecting waste door-to-door every morning and progressing step by step through scrap collection and sorting facilities of various capacities, possibly including the transporters associated along the way, up till the larger scrap recycling or management facilities.

997. The initial few visits conducted by the environmental team, covering most of the groups, yielded some useful data which projects a picture of the current operations within the informal waste management system structure. Details of their operations, income levels and their opinions, particularly concerns, are given in at the end of this section. The summary of the consultation data is provided in the **Table 8.3** below. Photographs of scavenger's consultations are provided in **Figure 8.4.**

998. Based on these consultations, some general conclusions can be derived regarding the prevailing scavenging and informal waste recycling system in operation, as well as its scope of potential involvement in the proposed ISWMS, which are summarized below:

- Majority of stakeholders consulted expressed the need for some form of government formalization, management or oversight is needed in order to better manage the operation of the landfill site, once developed, regardless of their position or significance in the system's chain.

- Improvements in physical equipment and facilities made available to the operators will serve to improve their working conditions and income levels.
- The reason that most scavengers and waste-pickers adopt this line of work is due to necessity born out of a lack of employment opportunities of any other kind.
- Those stakeholders in the waste management business doing well financially appear to have been involved in this line of work for a longer period, pointing to the benefits of persistence and experience in this business. In their position, they are no longer limited by work options and do this type of business more by choice and in anticipation of significant profits.

Table 10-3: Consultations with Scavengers and Scrap Dealers

Sr. No.	Date	Location of Consultation	Total No. of Participants	Comments/Concerns
1	12/12/2022	Khan Gah Shreef (Scrap Dealer)	5	The scrap business generates a reasonable money depending on availability of the scrape. The rates remain variable in the market based on demand and supply working principle. Scrap business does generate a relatively stable income, although low, as the owner and employees have gotten accustomed to the market.
2	12/12/2022	Main Victoria Bazar-Bahawalpur	3	The scrap dealer informed that due of proper disposal system and non-availability of smelting furnaces in the area they sale metal scrap in multan and other large-scale dealers. they informed that substantial amount of income is involved once the sufficient scrape is available.
3	12/12/2022	Shahi Bazar Bahawalpur	6	Highly informal income source necessitated due to lack of education, employment options and government support or supervision of any kind. They feel that their young children who should be in schools also have no option but to assist in their work to generate enough income to survive.
4	12/12/2022	Fareed Bazar - Bahawalpur	3	(Small intermediate scrap dealer) For them, this is a steady source of income generation. Their waste sorting activity is not as labour intensive since the waste they receive has already undergone some preliminary sorting. The employee and owner consulted were generally satisfied with their working conditions.

Table 10-4: Responses from Scavengers based on Survey Questions

Name, Details	Responses
Shahi Bazar –Bahawalpur	**Amount of waste collected/day:** Waste quantity varies from 1.5tonne to 05 tonnes depending on availability of scrape **Usefulness of that waste:** The waste is sorted out on spot and the recyclable material is sold to further scrape dealer **Procedure for collection:** The waste is brought to the store by several small waste pickers and sold in this store. The waste is normally not sorted before. **Usual cost and time spent:** It takes the entire day in sorting out the waste. The usual cost depends on quantity of waste brought to the store. 60,000 rent monthly for the godown space. 5 employees, 2 for waste collection and 2 for handling facility operations and 1 for office. **Amount of income generated:** It varies from 300,000-500,000 rupees/day (depending on waste) **Source of income:** This is their only source of income **End use of waste:** The waste is further sold to bigger waste collecting dealers. **Motivation/reason for this job:** Lack of job opportunities. **Working relationship with any government authority:** Private business **Expected improvements in the system:** Mode of transportation for waste picking should be improved
Fareed Bazar - Bahawalpur	**Amount of waste collected/day:**

Name, Details	Responses
	Waste quantity varies from 1.5 tonne to 08 tonnes depending on availability of scrape **Usefulness of that waste:** The waste is sorted out on spot and the recyclable material is sold to further scrape dealer. **Procedure for collection:** The waste is brought to the store by several small waste pickers and sold in this store. The waste is normally not sorted before. **Usual cost and time spent:** It takes the entire day in sorting out the waste. The usual cost depends on quantity of waste brought to the store. 100,000 rent monthly for the godown space. 8 employees, 4 for waste collection and 3 for handling facility operations and 1 for office. **Amount of income generated:** It varies from 500,000-800,000 rupees/day (depending on waste) **Source of income:** This is their only source of income **End use of waste:** The waste is further sold to bigger waste collecting dealers. **Motivation/reason for this job:** Lack of job opportunities. **Working relationship with any government authority:** Private business **Expected improvements in the system:** Mode of transportation for waste picking should be improved

Name, Details	Responses
• Asim BWMC employee, Bahawalpur • Shahid BWMC employee, Bahawalpur • Zafar BWMC employee, Bahawalpur	These workers are hired by BWMC for dumping of solid waste across the city. They dump the waste in places designated by BWMC and put soil layers over the dumped waste. These workers demanded that more jobs should be generated in this sector and that the system should be regulated and made centralized and networks be developed among different waste picking private community, so that the waste picking process is made efficient, clean and productive.
• Sami 52, owner of scrap business, Ring Road Bahawalpur • Anwar 35, co-owner of scrap business, Bahawalpur	**Amount of waste collected:** Amount of waste generated varies widely every day. But according to a rough estimate, they collect approximately 70-100 kg waste every day **Usefulness of that waste:** The waste after its sorting is sent to different industries to make ready-to-use products from it. The waste is then melted/molded according to the desired end product. **Procedure for collection:** Usually, the waste is bought from small scale waste pickers and then sorted out in separate categories at store. **Usual cost and time spent:**

Name, Details	Responses
	The time spent on the process depends on the waste brought to the store. But normally it takes 5-6 hours every day to sort out the waste and set them. **Amount of income generated:** The income normally generated from selling the waste is Rs 10,000-15,000 per day **Source of income:** This is the only source of income of these people **End use of waste:** The waste is finally sent to different recycling plants in the outskirts of District Bahawalpur, to convert the scrap material into useful raw material or products **Motivation/reason for this job:** This business provides a greater profit margin as compared to most small-scale businesses. **Working relationship with any government authority:** This is a private run company **Expected improvements in the system:** The waste collection process should be made systematic and regulated by the government. Priority should be given to waste delivery system as most of the waste is left untouched on the dump sites because of lack of transportation to the targeted scrap stores.

Figure 10-5: Consultations with Scavengers/Scrap Dealers

10.2.6 Public Hearing in October 2023

999. A public hearing was undertaken in October 2023 at the Rasheedia Auditorium in Bahawalpur as part of the EIA review and approval process. A total of 83 members of the public and government officials attended the meeting.

1000. During the public hearing a summary of the project translated in Urdu was distributed among the participant, see **Appendix-16**.

1001. The meeting was opened by the Assistant Director (Environment) of the PICIIP who introduced the guest panel. A series of presentations were then given covering key issues including:

- The legal and regulatory basis of the proposed project.
- The importance of public participation in the review process.
- Current solid waste management practices and their deficiencies.
- The critical need for and significance of the proposed project for the city.
- The technical, financial, environmental, and social aspects of the proposed project.
- Further details were then provided with respect to the mitigation measures that would be applied to the environmental aspects of the project.
- The sources for funding the project and the economic opportunities which it would provide to local people.

1002. The meeting was then opened to contributions from the audience. Key issues raised included:

- Concerns about the leachate and toxins resulting from the waste.
    - A description of the leachate collection and treatment system was provided along with the engineering design that would be implemented.
- Questions about the revegetation and tree planting around the site.
    - Details of the proposed tree planting were provided.
- Exploration of the economic opportunities and jobs for the community.
    - The audience were told that 400-500 jobs would be created during construction with around 200 during operation.
- Questions about the impact on air quality and noise around the landfill.
    - The issues were addressed to the satisfaction of the audience.

1003. At the end of the meeting, there appeared to be no objection in principle to the project amongst the attendees.

1004. The Proceedings of the meeting providing further details on the event and the attendance list are provided in **Appendix A-17**.

10.3 Consultation Plan for Construction and Operation Phase

1005. Consultation plan for construction and operation phase of Bahawalpur Landfill site will be prepared in order to take response of project stakeholders and general public about the project during its implementation.

1006. Periodic meaningful consultations and community feedback surveys will be carried out following ADB SPS, 2009 consultation requirements to develop positive perception about the project. In this regards city implementation unit as well as project construction contractor and supervision consultant will play a key role to involve all the stakeholders for such consultations during the implementation.

1007. Record of such consultations will be maintained at PMU/BWMC/CIU offices and necessary changes in operational modalities will be introduced in the system in light of the response provided by the consultees.

1008. Consultation is an ongoing process and will be continued throughout the life cycle of the project to inform the local community about the project and to develop positive perception for the project.

10.4 Public Disclosure and Information

A ADB Disclosure Requirements

1009. The purpose of disclosure is to engage all stakeholder through disclosure process aims to: establish a systematic and inclusive approach to stakeholder engagement; build and maintain a constructive relationship with stakeholders; incorporate stakeholders' views and concerns into project design/implementation; mitigate negative social and environmental impacts of the project; and enhance project acceptance and socio-environmental sustainability.

1010. The Periodic consultations and community feedback surveys will also be carried out to develop positive perception about the project. In this regards city implementation unit as well as project construction contractor and supervision consultant will play a key role to involve all the stakeholders for such consultations during the implementation.

1011. Record of such consultations will be maintained at PMU/BWMC/CIU offices and necessary changes in operational modalities will be introduced in the system considering the response provided by the consultees.

1012. **B Provincial EPA Disclosure Requirements**

1013. Under Punjab EPA EIA/IEE Regulation 2021 during the EIA review and approval process disclosure will be carried out to all stakeholders and public. The following will be the procedure of EIA disclosure.

1014. Provincial Agency shall cause to be published in any English or Urdu national newspaper and in a local newspaper of general circulation in the area affected by the project, a public notice mentioning the type of project, its exact location, the name and address of the proponent and the places at which the EIA of the project can be accessed.

1015. The date fixed shall not be earlier than 07 days from the date of publication of the notice.

1016. The Provincial Agency shall also ensure the circulation of the EIA to the concerned Government Agencies and solicit their comments thereon.

1017. All comments received by the Provincial Agency from the public or any Government Agency shall be collated, tabulated and duly considered by it before decision on the EIA.

C IEE Report disclosure

1018. The IEE report will be disclosed on ADB project website

1019. To obtain the PEPA approval, the EIA report will be disclosed on i) PICIIP project website and ii) EPA website.

1020. As per ADB right to information, any person can request any type of project related information from the project web

1021. Report will be translated into Urdu / local language and made available at suitable locations for local community /AP.

11 Grievance Redressal Mechanism

11.1 General

1022. The ADB Policy (SPS 2009) requires establishment of a local grievance redress mechanism to receive and facilitate resolution of the Displaced/Affected Persons concerns and grievances regarding the project's social and environment performance. The measures have been identified to mitigate any potential environmental and social impacts to be caused due to implementation of the landfill works.

1023. However, despite best efforts, there is chance that the individuals / households affected by the project or other stakeholders are dissatisfied with measures adopted to address adverse environmental impacts of the project. To address such situations an effective Grievance Redress Mechanism (GRM) will be established to ensure timely and successful implementation of the project. It will also provide a public forum to the aggrieved to raise their objections and the GRM would address such issues adequately. It will receive, evaluate and facilitate the resolution of displaced persons' concerns, complaints and grievances about the social and environmental performance at the level of the project.

1024. The GRM will aim to investigate charges of irregularities and complaints receive from any displaced persons and provide a time-bound early, transparent and fair resolution to voice and resolve social and environmental concerns link to the project.

1025. The PMU LG&CDD shall make the public aware of the GRM through public awareness campaigns. The name of contact person(s) and his/her phone number, PMU contact numbers will serve as a hotline for complaints and shall be publicized through the media and placed on notice boards outside their offices, construction camps of contractors, and at accessible and visible locations in the project area. The project information brochure will include information on the GRM and shall be widely disseminated throughout the project area. Grievances can be filed in writing, via web-based provision or by phone with any member of the PMU.

1026. First tier of GRM. The PMU is the first tier of GRM which offers the fastest and most accessible mechanism for resolution of grievances. The PMU staff for environment and social safeguards will be designated as the key officers for grievance redressal. Resolution of complaints will be completed within seven (7) working days. Investigation of grievances will involve site visits and consultations with relevant parties (e.g., affected persons, contractors, traffic police, etc.). Grievances will be documented and personal details (name, address, date of complaint, etc.) will be included, unless anonymity is requested. A tracking number will be assigned for each grievance, including the following elements:

- Initial grievance sheet (including the description of the grievance), with an acknowledgement of receipt handed back to the complainant when the complaint is registered;
- Grievance monitoring sheet, mentioning actions taken (investigation, corrective measures);
- Closure sheet, one copy of which will be handed to the complainant after he/she has agreed to the resolution and signed-off;

- The updated register of grievances and complaints will be available to the public at the PMU office, construction sites and other key public offices in the project area. Should the grievance remain unresolved, it will be escalated to the second tier.

1027. Second Tier of GRM. The PMU will activate the second tier of GRM by referring the unresolved issue (with written documentation) to the Bahawalpur Waste Management Company (BWMC), who will pass unresolved complaints upward to the Grievance Redress Committee (GRC). The GRC will be established by BWMC before start of site works. The GRC will consist of the following persons: (i) Project Director; (ii) representative of District government; (iii) representative of the affected person(s); (iv)representative of the local Deputy Commissioners office (land); and (v) representative of the Punjab EPA (for environmental-related grievances). A hearing will be called with the GRC, if necessary, where the affected person can present his/her concerns/issues. The process will facilitate resolution through mediation. The local GRC will meet as necessary when there are grievances to be addressed. The local GRC will suggest corrective measures at the field level and assign clear responsibilities for implementing its decision within fifteen (15) working days. The contractor will have observer status on the committee. If unsatisfied with the decision, the existence of the GRC will not impede the complainant's access to the Government's judicial or administrative remedies.

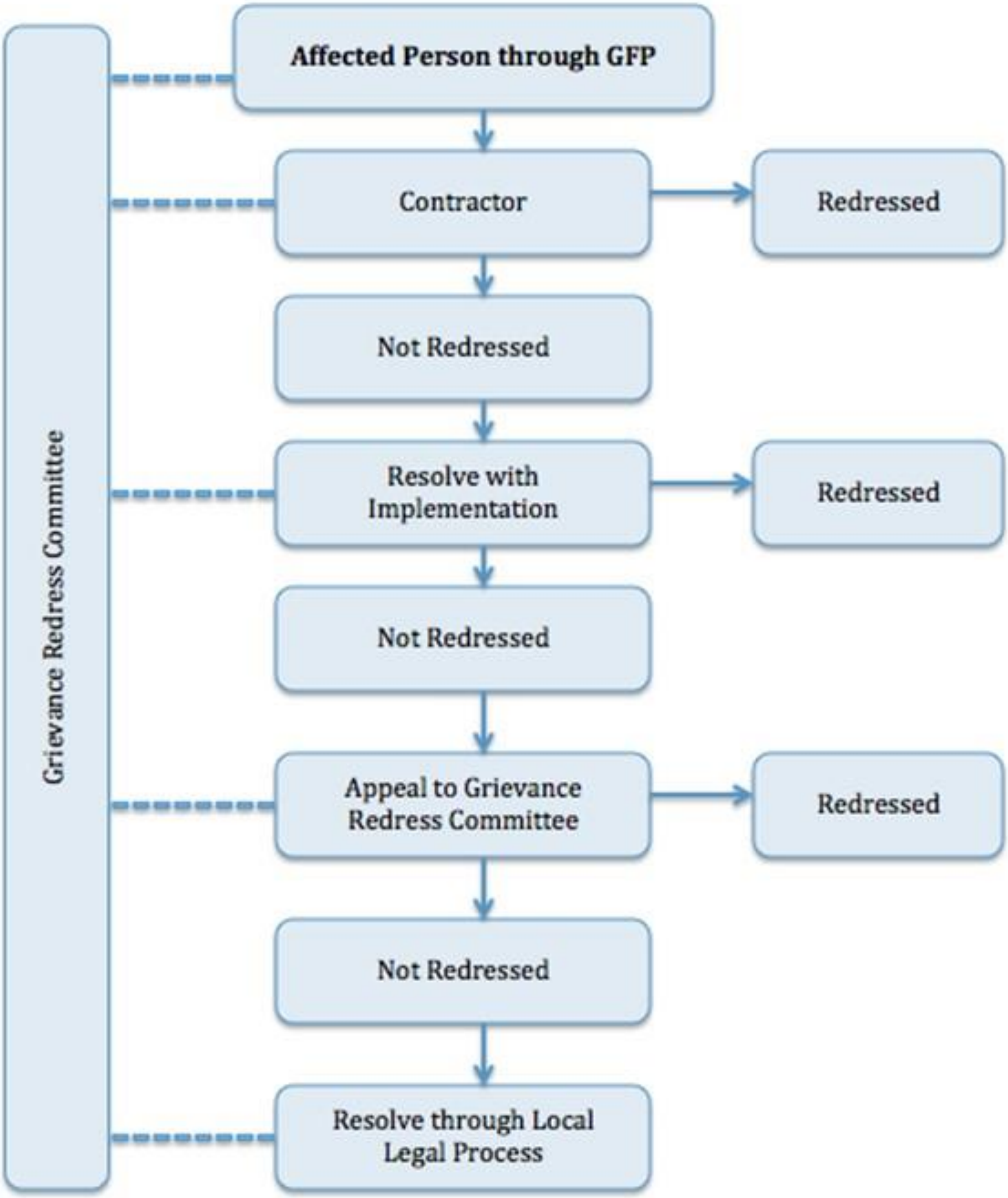
1028. The functions of the local GRC are as follows: (i) resolve problems and provide support to affected persons arising from various environmental issues and including dust, noise, utilities, power and water supply, waste disposal, traffic interference and public safety as well as social issues and land acquisition (temporary or permanent); asset acquisition; and eligibility for entitlements, compensation and assistance; (ii) reconfirm grievances of displaced persons, categorize and prioritize them and aim to provide solutions within a month; and (iii) report to the aggrieved parties about developments regarding their grievances and decisions of the GRC.

1029. The BWMC officers will be responsible for processing and placing all papers before the GRC, maintaining a database of complaints, recording decisions, issuing minutes of the meetings and monitoring to see that formal orders are issued, and the decisions carried out.

1030. Third tier of GRM. If a grievance cannot be resolved directly by the PMU (first tier) or GRC (second tier), the affected person can seek alternative redressal through the district or sub-district committees as appropriate. The PMU or GRC will be kept informed by the district, municipal or national authority. The grievance redress mechanism and procedure are depicted in the **Figure 11-1**below. The monitoring reports of the EMP implementation will include the following aspects pertaining to progress on grievances: (i) Number of cases registered with the GRC, level of jurisdiction (first, second and third tiers), number of hearings held, decisions made, and the status of pending cases; and (ii) lists of cases in process and already decided upon may be prepared with details such as Name, ID with unique serial number, date of notice, date of application, date of hearing, decisions, remarks, actions taken to resolve issues, and status of grievance (i.e., open, closed, pending).

1031. To provide greater clarity, the pictorial description of the GRM is provided in **Figure 11-1** below.

Figure 11-1: Grievance Redressed Mechanism



12 Conclusion and Recommendations

1032. The proposed Integrated Solid Waste Management System (ISWMS) project will be delivered via three components:

- **Component 1** - Construction of a new engineered landfill or solid waste management facility (SWMF) at Mari Sheikh Shijra, Mouza Nouabad. This is anticipated to be completed by Q4 – 2027. This component will also include the provision of a construction and demolition waste recycling and composting plant.
- **Component 2** – Closure of a legacy landfill and construction of a new material transfer station (MRF) on land to the north at Khanuwali. The MRF will be completed by Q4 2027, with the legacy landfill closed and rehabilitated between Q4 2028 and Q4 2030. The MRF will also include an anaerobic digestion plant, plastics recycling and new transfer station. The existing transfer station will be closed as part of this component.
- **Component 3** – Improvement of existing waste collection and transport system across Bahawalpur City to provide a fully functioning Integrated Solid Waste Management System (ISWMS). Improvement of the waste collection system will be delivered by Q4 2027.

1033. All the proposed ISWMS components within Bahawalpur city are crucial for the successful operation of the SWMF. Together they provide a strategic approach to sustainable waste management covering all sources and all aspects, including generation, segregation, transfer, sorting, treatment, recovery, and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency.

1034. The operational protocols and modalities of the ISWMS have been proposed to improve environmentally sound practices with respect to waste management and attempting to close existing bottlenecks in the system. They will enable the waste generated to be broadly categorized as industrial, agricultural, residential, and medical waste types.

1035. The development of a proposed new engineered landfill (or SWMF) is designed to support the BWMC and other involved agencies, to completely transform the solid waste management system in Bahawalpur city. Complete with institutional strengthening, recycling and other support initiatives, the project includes the installation of primary and secondary Municipal Solid Waste (MSW) collection systems and the development of an international standard MSW management facility that will accommodate Bahawalpur’s residual MSW for at least 25 years.

1036. **Component 1** of the project comprises the development of a new engineered landfill (SWMF) within Bahawalpur and will comprise the central most important aspect of the project as its development will ensure that solid waste generated from Bahawalpur city is managed in future in accordance with international best practice and will reduce the current risks posed to the environment and human health from uncontrolled tipping. Given the sensitive nature of this development and given it will be the first component of the project to be commenced in 2024, significant technical studies have already been undertaken to understand and mitigate the environmental risks posed. Further technical studies will be undertaken for the other components to gather data and better understand the risks posed by eventual closure of the legacy landfill and development of the MRF which both comprise **Component 2** of the project. It is not envisaged that the provision of improved waste collection infrastructure (Lorries, Bins etc) comprising **Component 3** of the project will pose significant environmental risks requiring mitigation.

1037. **All three components delivered will completely transform waste management in the Bahawalpur region, which combined will have significant positive social benefits.**

1038. Primary and secondary data has been collected and used to assess the environmental impacts of Component 1. Whilst the development of landfill sites come with significant environmental risks due to the by-products of landfill gas and leachate, with appropriate mitigation these risks can be managed and the legacy risk is considered **low**, however it will be imperative that these risks are monitored closely for the lifetime of the landfill and that appropriate site closure plans are established, and these are adequately funded. The Design Build Operate contractor should ensure appropriate funds are placed into escrow for the long-term management of the landfills' lifetime beyond its operational use. This applies to both the new landfill of Component 1 and closure of the legacy landfill of Component 2.

1039. The site at Mari Sheikh Shijra mouza Nouabad fulfilled most of the criteria required for landfill site selection comprising Component 1. It is far enough away from the city. The population is sparse and although there are a few sensitive receptors, proper environmental assessments are being carried and resettlement plans are being prepared to minimize both environmental and socioeconomic impacts. Most of the surrounding area is barren and agricultural. Given the locations of other alternative sites, all were either agricultural or semi-urban areas, which at least places this site as the most ideal as compared to the other sites.

1040. Component 2 of the project will ensure wastes are appropriately sorted and promotes recycling of waste within the region with the Material Recycling Facility and Plastic Recycling Facility. This will have a significant environmental benefit. The inclusion of an Anaerobic Digestion Plant and solar power will ensure that the facility mostly runs on renewable energy. Component 2 will also ensure that the legacy landfill site is appropriately managed and closed reducing the existing risks posed to environment from uncontrolled landfill gas and leachate generation. Whilst some technical data has been gathered for Component 2, a significant part of the project will be further site characterisation and site closure planning work to ensure regeneration controls the risk to the environment and is appropriate to control risks to receptors (human health and environmental).

1041. Component 3 of the project will completely transform how waste is collected from source. This element is not anticipated to have significant environmental and social risks and will mean waste is appropriately collected, can be recycled or deposited within an engineered landfill. This project will also involve re-education of residents around waste management to reduce waste being dumped on streets attracting disease spreading vectors. Overall, it is considered that this component will have a significant environmental and social net benefit.

1042. This IEE report highlights all potential environmental impacts associated with the project. The environmental impacts associated with the project will need to be properly mitigated, through the existing institutional arrangements described in this report, including insuring that the requirement of the EMP contained in this report are included in bidding and contract documentation. This is imperative as it will ensure that budgets are identified from the outset for the environmental monitoring requirements.

1043. Most of the environmental impacts are associated with the operational phase of the project since these will be long term, such as generation of objectionable odour, landfill gas, leachate, vermin and disease vector generation, contamination of Soil and Groundwater, etc. An efficient Leachate Collection and Removal System (LCRS) is included in the design to manage leachate impacts. Landfill gas recovery system and its reuse through conversion into CNG is part of project design in order to manage and maximize utilization of Landfill gas. A dedicated MRF, AD Plant and compost plant will be established to manage organic waste and recyclables. C&D waste will also be recycled to maximize beneficial use.

1044. Similar controls will need to be designed for the legacy landfill site. This report recommends that further site characterisation of the legacy landfill is undertaken and that a detailed site closure plan is prepared to ensure the risks posed by this site are controlled. This should be undertaken concurrently with the development of the new landfill to ensure that environmental risks posed by the legacy landfill site are reduced as much as possible. This includes detailed perimeter monitoring and the inclusion of a passive gas venting buffer zone between the landfill and any existing / future development near to the boundary.

1045. During the construction phase, the overall responsibility for the implementation and monitoring of the EMP rests with the Project Director (PD), Project Management Unit (PMU), PICIIP LG&CDD, Punjab. The PD at the PMU, using the Construction Supervision Consultant (CSC), will supervise the implementation of the proposed mitigation measures and monitor the implementation progress in the field. During the operation phase, the overall responsibility for the implementation and monitoring of the EMP rests with Managing Director, BWMC. The environmental mitigation measures will have to be clearly defined in the bidding and contract documents, and appropriately qualified environmental staff retained by the Consultant to supervise the implementation process. The EMP includes measures to minimize project impacts due to noise and air pollution, waste generation etc. The EMP contained within this IEE document is considered sufficient for issuance as part of the Contracts to the successful bidder(s) and for subsequent use during the project works. It should be mentioned that prior to the commencement of works, this EMP must be further updated by the Contractor into site specific EMPs (SSEMPs) for review and approval of ADB. In these SSEMPs, aspects such as a detailed traffic management plan, identification of locations for disposal of debris and spoil and any other details which shall become available later must be included for efficient implementation of all proposed mitigation measures and the subsequent monitoring of these measures.

1046. This project has been assigned environmental category ‘B in accordance with the ADB’s Safeguard Policy Statement (SPS) 2009 and in Schedule II, Category G-Waste Storage and Disposal (Rule 1) as per Punjab EPA Review of IEE and EIA Regulations, 2022. Thus, a comprehensive IEE report has been prepared for the proposed project.

1047. This IEE report will be reviewed and approved by ADB and after completion it will be disclosed on ADB and PMU PICIIP websites in compliance to ADB SPS, 2009.

1048. An action plan with clear roles and responsibilities of stakeholders has been provided in the report. The PMU, Contractors and the Construction Supervision Consultant are the major stakeholders responsible for the action plan. The action plan must be implemented prior to commencement of construction work.

1049. Mitigation measures must be assured by a program of environmental monitoring conducted during construction and operation to ensure that all measures in the EMP are implemented and to determine whether the environment is protected as intended. This will include observations on and off-site, document checks, and interviews with workers and beneficiaries, and any requirements for remedial action will be reported.

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Appendix A.1 Rapid Environmental Assessment (REA) Checklist

BAHAWALPUR: LANDFILL SITE

Country/Project Title:	PAKISTAN/ Punjab Urban Development Projects
Sector Division:	Urban Development - Waste Management

Screening Questions	Yes	No	Remarks
A. Project Siting Is the project area adjacent to or within the following environmentally sensitive areas?			
Cultural Heritage Site		No	• There are not any such sites within 500 m of the radius
Protected Area		No	• There are not any such sites within 500 m of the radius
Wetland		No	• There are not any such sites within 500 m of the radius.
Mangrove		No	• Not applicable
Estuarine		No	• There are not any such sites in 500 m of the radius.
A buffer zone of protected area		No	• There are not any such sites within 500 m of the radius
A particular area for protecting biodiversity		No	• There are not any such sites within 500 m of the radius
B Potential Environmental Impacts • Will the Project cause…			
Impacts associated with transport of wastes to the disposal site or treatment facility		Yes	• Although the specific route for transport of the wastes to the landfill site is yet to be finalized, however, considering the proximity of the site to the populated areas, it is expected that the vehicles will collect and transport the wastes by moving through highly populated areas, however waste will be transported in purpose built closed vehicles thus no significant risk are expected.
Encroachment on historical/cultural areas; disfiguration of the landscape by road embankments, cuts, fills, and quarries?		No	• No such acts are anticipated during construction or operations as site is located away from historical/cultural areas.
Encroachment on precious ecology (e.g. sensitive or protected areas)?		No	• No such acts are anticipated during construction or operations as site is located away from protected areas.
Alteration of surface water hydrology of waterways crossed by roads, resulting in increased sediment in streams affected by increased soil erosion at the construction site?		No	• No such acts are anticipated during construction or operations. However, the excavated soil from the landfill site constructions will be handled appropriately.
Deterioration of surface water quality due to silt runoff and sanitary wastes from worker-based camps and chemicals used in construction?	Yes		• Construction camps generate solid and liquid wastes therefore they should be built appropriately and away from settlements.

Screening Questions	Yes	No	Remarks
Degradation of aesthetic and property value loss?	Yes		• The development of the proposed landfill site is expected to significantly affect the aesthetics of the project area as well as significantly diminish the property value of the land in this area considering the nuisance effects such as odor as well as possible health impacts from disease vector generation, groundwater contamination etc. These impacts will be mitigated through development of buffer zone and leachate control technologies.
Nuisance to neighboring areas due to foul odor and influx of insects, rodents, etc.?		No	• Due to application of daily cover no foul odor and influx of insects, rodents etc. is expected.
Dislocation or involuntary resettlement of people?		No	• No dislocation or involuntary resettlement of people is expected as per now.
Disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		No	• No such impacts are expected on the poor while no indigenous peoples are in the project area that would be impacted.
Risks and vulnerabilities related to occupational health and safety due to physical, chemical, biological, and radiological hazards during project construction and operation during project construction and operation?		No	• No significant occupational health and safety hazards exist at the site considering that toxic gases will not be released from landfill due to presence of gas collection and treatment system.
Public health hazards from odor, smoke from fire, and diseases transmitted by flies, insects, birds and rats?		No	• Public health hazards from odor, smoke from fire, and diseases transmitted by flies, insects, birds and rats are not anticipated as project design will address all such issues.
Deterioration of water quality as a result of contamination of receiving waters by leacheate from land disposal system?		No	• No surface water bodies are in the project area and thus no contamination in this regard is possible.
Contamination of ground and/or surface water by leachate from land disposal system?		No	• Ground water contamination is not expected as leachate from landfill site will be collected and treated before final disposal, and it will not reach to ground water.
Land use conflicts?		No	• The selected land is already owned by BWMC therefore no land use conflicts are expected.
Pollution of surface and ground water from leachate coming form sanitary landfill sites or methane gas produced from decomposition of solid wastes in the absence of air, which could enter the aquifer or escape through soil fissures at places far from the landfill site?		No	• As project will have efficient leachate and gas management system therefore no surface and ground water pollution are expected.
Inadequate buffer zone around landfill site to alleviate nuisances?		No	• Based on the sensitive receptor mapping of the site there are no

Screening Questions	Yes	No	Remarks
			sensitive receptors within 250m radius.
Road blocking and/or increased traffic during construction of facilities?	Yes		• While no roadblocks are expected, however, a significant increase in heavy vehicles/trucks transporting the waste to the landfill site is expected.
Other social concerns relating to inconveniences in living conditions in the project areas may trigger upper respiratory problems and stress?	Yes		• The selected land is owned by BWMC therefore no or limited conflicts are expected.
Noise and dust from construction activities?	Yes		• During the development of the infrastructure at the site during the construction phase, significant noise and dust emissions are expected from the movement of construction vehicles and equipment.
Temporary silt runoff due to construction?		No	• No silt run-off is expected.
hazards to public health due to inadequate management of landfill site caused by inadequate institutional and financial capabilities for the management of the landfill operation?	Yes		• A high risk exists considering the limited institutional and financial capacities in the country along with limited experience and expertise with regards to the operation and management of landfill sites.
Emission of potentially toxic volatile organics from land disposal site?	Yes		• Toxic emissions such as landfill gas from the site are possible.
Surface and ground water pollution from leachate and methane gas migration?		No	• No surface and ground water pollution are expected as landfill will have leachate and gas management system.
Loss of deep-rooted vegetation (e.g. trees) from landfill gas?	Yes		• Landfill site is located in desert, therefore no loss of deep-rooted vegetation (e.g. trees) from landfill gas is expected.
Explosion of toxic response from accumulated landfill gas in buildings?		No	• Landfill gas collection and treatment system will be in place.
Contamination of air quality from incineration?		NO	• Incineration is planned at the site and emissions are well managed significant air pollution is expected due to the landfill site operation specifically in proximity. Uncontrolled venting and flaring will also result in air quality degradation.
Health and safety hazards to workers from toxic gases and hazardous materials in the site?		NO	• During construction phase no toxic gases will be released while during operation phase landfill gas collection and treatment system will be installed.
Social conflicts if workers from other regions or countries are hired?		No	• No such impacts are expected.
Does a large population influx cause an increased burden on social infrastructure and services (such as water supply and sanitation systems)?		No	• No such conflicts are expected since local labour will be utilized as far as possible.

Screening Questions	Yes	No	Remarks
Risks to community health and safety due to the transport, storage, use, and disposal of materials such as explosives, fuel, and other chemicals during construction and operation?	Yes		• The risks to community health and safety exist, particularly during the construction phase, considering the proximity of the project site to the residential settlements in the project area.
• Community safety risks due to both accidental and natural causes, especially where the structural elements or components of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation, and decommissioning.		NO	• Landfill site will be fenced and community access to site is not allowed.
• Could the Project potentially increase the climate or disaster vulnerability of the surrounding area (e.g., by encouraging settlement in areas more affected by floods in the future or encouraging settlement in earthquake zones)?		No	

Recommendations

The proposed project is recommended to be categorized as Category ‘A’ based on the potential impacts related with lactates, transportation of waste and its nuisance and operations related potential impacts.

Thus, severity of expected impacts to be potential and irreversible especially land use of the landfill area.

Project Category Recommendation

It is recommended that based on the available project information and subsequent analysis, the project should be placed in:

Category‘A’ ☐ Category‘B’ Category‘C’ ☐

Please provide an explanation to justify the Categorization above:

Severity of expected impacts as evident from above table are adverse and irreversible and as per ADB Safeguard Policy, a project may be classified as Category A if it is likely to have adverse environmental impacts

Screening & Categorization Conducted by: Endorsed by:

____________________________ ______________________

Environment Officer, PIU Head of PIU

Approved by: Endorsed by:

________________________________ ______________________

ADB Environment Safeguards Focal Point Project Officer, ADB

Appendix A.2 Questionnaires for Conducting FGDs & Surveys

Focal Group Discussion (FGDs)

Project Name:

Venue:

Sr no ____

Date:

Sr no	Name	Profession	CNIC	Moza/Village UC, Tehsil & District	Signature/Thumb
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

SOCIO ECONOMIC AND RESETTLEMENT SURVEY FOR KPCIP SUB PROJECTS

Date: ____________ Sr No. ____________

1. Identification

1.1 Name of Respondent ____________ 1.2 Father's Name ____________

1.3 Respondent CNIC No: ____________ 1.4 Tribe ____________

1.5 Address: Village: ____________ Town: ____________

Tehsil: ____________ District: ____________ Province: ____________

1.6 Demographic Profile of Respondent (Children up to 10 yrs (#): M ,FM =T .)

Sr. No.	Relationship with Respondent (See codes)	Sex Male=1 Female= 2	Age (Yrs.)	Education (See Codes)	Name of Business/ Occupation (See Codes)		Income From Business/ Occupation (Rs./ Annum)		Diseases During Last Year (See codes)
					Main	Secondary	Main	Secondary	
1	SELF								
2									
3									
4									
5									
6									
7									
8									
9									
10									

*Other: Rent from property, remittances, net sale of items during a year, net income from agriculture etc.

Demographic Codes:

Relationship: 1=Self, 2=Wife, 3=Son, 4=Daughter, 5=Father, 6=Mother, 7=Brother, 8=Sister, 9=Grand Father, 10=Grand Mother, 11=Bhabhi, 12=Nephew, 13=Father-in-Law, 14=Mother- in-Law, 15=Others

Sex: 1=Male, 2=Female

Education: 1= Primary 2= Middle 3= Matric, 4= Intermediate, 5= BA/BSc, 6= MA/MSc, 7=LLB, 8=Engineer, 9=MBBS, 10=Technical Diploma, 11=Dars-e-Nizami, 12=CanRead Quran, 13= Can Insert Signatures, 14= Illiterate,

Occupations: 1=Agriculturist, 2=Shopkeeper, 3= Trader, 4= Govt. Servant, 5=Private Servant, 6=Timber Labour, 7=General Labour, 8=Livestock, 9=Fishing, 10= 8=Driver, 11=Health Related, 12=Educator/Teacher, 13=House-Maid, 14= House Wife, 15=Gone Abroad, 16=Gone out City within Pakistan

Diseases: 1=Diarrhea, 2=Measles, 3=Hepatitis, 4=Typhoid, 5=HIV/AIDS, 6=Polio, 7=Cholera, 8=Tuberculosis, 9=Heart Disease, 10=No Disease,

1.7 Are you member of any village Community organization ____ 1. Yes ☐ 2. No ☐

1.8 If yes, which of the following organizations?

i. Religious ii. Political iii. Law & Order
iv. Educational (formal/informal)
v. Community Organization vi. Local Jirga
vii. Youth Organization viii. Any other

2. Land Utilization

Land	Acre	Kanal	Marla
Total Area owned			
Total Cultivated Area			
Area Under Rabi(winter) Crops			
Area Under Kharif (summer) Crops			
Uncultivated Area			
Waste land			
Area Under Farm Houses			
Barren Land			

2.1 Cropping Pattern, Yield and Cost

Sr. No.	Major Crops	Area Sown		Average. Production (Kgs)	Price/40 kgs (Rs.)	Total Cost Incurred (Rs.)
		Acre	Kanal			
1	Wheat					
2	Maize					
3	Cotton					
4	Rice					
5	Sugarcane					
6	Orchards					
7	Other (__________)					
8	Grand Total:					

2.2 Land Tenure Status: ☐ Owner ☐ Tenant ☐ Share Cropper ☐ Leaser

2.3 Land Rent (Rs. / acre) ____________

3. **Possession of Household Goods**

Item	No.	Value (Rs.)	Item	No.	Value (Rs.)
Television			Car		
Washing machine			Van/Pickup		
Geyser			Gas Cylinder		
Electric fan			VCR/DVD Player		
Electric iron			Dish Antenna/Cable Connection		

Item	No.	Value (Rs.)	Item	No.	Value (Rs.)
Sewing machine			Telephone/Mobile		
Radio/tape recorder			Electric Water Pump		
Motor cycle/ scooter			Computer		
Other ________			Other ________		
Total:			Total:		

4. Average Monthly Expenditure on Food and Non-Food Items

4.1 Monthly Expenditure on Food & Non-Food Items (Rs.)

a) Expenditures on Food Items

Sr. No.	Item	Qty. / Month	Expenditure (Rs.)
1.	Wheat / Atta (Flour)		
2.	Maize Flour		
3.	Ghee		
4.	Sugar		
5.	Legumes		
6.	Vegetables		
7.	Tea Leaves		
8.	Milk		
9.	Other Specify		
10.	Total:		

b) Exp. On Non-Food Items:

1.	Fire wood		
2.	Gas Cylinder		
3.	Kerosene Oil		
4.	Washing Material		
5.	Other Specify		
6.	Total:		

4.2	Expenditure on clothes and shoes during last year:	Rs.
4.3	Occasional expenses during last year (such as meeting social obligation expenditure)	Rs.
4.4	Av. Monthly utility bills for:	Electricity (Rs.)
	Communication (Rs.)	Water (Rs.)
4.5	Annual Expenditure on Health Care (Rs.):	

5. **Social Organizations**

5.1 Specify the existing village/social organizations in your area and state their functional status?

Sr. No.	Name of Organization	Category	Registered/ Unregistered	Functions
1		Religious		
2		Educational		
3		Skill Development		
4		Social Welfare		
5		Women Organization		
6		Other		

6. Leadership Pattern

6.1 Which type of people is influential in village matters and how they decide these matters?

Sr.#	Person / Status	Decision Pattern
1	MPA / MNAs	
2	Head of Tribe	
3	Spiritual / Religious Leader	
4	Land Lord / Lumber Dar	
5	School Teacher	
6	Community Leader	
7	Government Official	
8	Retd. Government Official	
9	Any other (specify)	

6.2 Were their decisions considered final and implemented successfully? ☐ 1. Yes ☐ 2. No

i) Level of acceptability (%) _______ ii) Successful implementation (%) __________

6.3 Are the general relationship among people in the locality essentially based upon?

1. Competition ______________ 2. Conflict ______________
3. Co-operation ______________ 4. Don't Know ___________

6.4 Were you involved in any dispute in the past 5 years? ☐1. Yes ☐2. No

6.5 If yes, what was the nature of dispute and how was it resolved

Nature of Dispute	Method of Resolution
1. ______________	______________
2. ______________	______________
3. ______________	______________

7. **Credit**

7.1 Have you obtained credit during last year? Yes [ ], No. [ ], if yes, source of credit:

Formal [ ], Informal [ ]

7.2 Please write the name of relevant source

Formal source (s) ____________________

Informal source (s) ____________________

Percentage of interest ____________________

7.3 Purpose of Loan (Tick)

Purchase House	[ ]	Rs. ________
Business	[ ]	Rs. ________
Repair of House	[ ]	Rs. ________
Medicare of Family Member	[ ]	Rs. ________
Family/ Social matters	[ ]	Rs. ________
Farm inputs	[ ]	Rs. ________
Livestock	[ ]	Rs. ________
Other (specify)	[ ]	Rs. ________

7.4 Mode of repayment (Tick the relevant)

1) One time [ ] 2) Through installments [ ],

i) Quarterly installments [ ] ii) Six-monthly [ ],
iii) Annual [ ] iv) Other (specify) ________

7.5 How much repayment has been made so far? a) 100%[ ], b)75% [ ], c) 50% [ ], d) 25% [ ], Less than 25 % [ ]

8. **Housing Conditions**

8.1 Do you have your own house?

1) Yes ____ 2) No. ____

If yes then

8.2 Total Area of the house: square ft. Present Value (Rs)________.

Type of Room	No. of Room	Katcha (tick)	Pacca (tick)	Semi Pacca (tick)
Living rooms				
Animal shed				
Other shed				
Bathroom				
Latrine				
- Open				
- Flush				

- Other					

8.3 Other Assets Area (Ft.)

Shop(Sq. ft): L ___ W ___
Khokha: ___
Electric Pump / Hand Pump (No.): ___
Hydropower Generator: ___
Other (______) (No.): ___

8.4 Trees

- Mature Fruit Trees (No.): ___ ___
- Mature Shade Trees (No.) ___ ___

9. Access to Social Amenities (Tick)

Social Amenities	Available	Satisfactory	Non-Satisfactory	No Access
Electricity				
Sui Gas				
Water Supply				
Telephone				
Sewerage/Drainage				
BHU				
School				
Others				

10. Livestock Inventory

Livestock	No.	Present Value (Rs.)
Buffaloes		
Cows		
Horse		
Donkey		
Mule		
Sheep		
Goat		
Poultry		
Other		

11. Women's Participation and Decision Making in Different Activities

11.1 Women participation in different household activities:

Activities	Participation (%)	Decision Making (%)
Household activities		

Child caring	[ ]	[ ]
Farm/Crop activities	[ ]	[ ]
Livestock rearing	[ ]	[ ]
Sale & Purchase of properties	[ ]	[ ]
Social obligations (marriage, birthday & other functions)	[ ]	[ ]
Local representation (councilor/ political gathering)	[ ]	[ ]
Others	[ ]	[ ]

11.2 Women issues in the project area

____

____

11.3 Women views about the project

____

____

12. Perceptions of Respondents for Action Associated with the Project

	Increase	Decrease
Employment opportunities	[ ]	[ ]
Marketing facilities opportunities	[ ]	[ ]
Living standard	[ ]	[ ]
Unemployment	[ ]	[ ]
Income generating activities	[ ]	[ ]
Mobility (Access to Resources)	[ ]	[ ]
Quality of drinking water	[ ]	[ ]
Agriculture water	[ ]	[ ]
Trend of fish farm	[ ]	[ ]

Other specify_______________________________

13. General Remarks of the Respondents

14. Resettlement Part

14.1 Do you feel any resettlement impact? Yes ______ No

If yes then

Category	Area Acre	Kanal	Value of Land (Rs.)	Remarks
Cultivated				
Uncultivated				
Grazing				
Barren Land				
Waste Land				
Other				
Total				

14.2 Affected Cropping Area

Yes ______ No ______

If yes then

Name of Crop	Acre	Kanal	Value (Rs.)
Rabi			
Kharif			
Total:			

14.3 Affected residential structures

Name of Structure	Types of Structures			Area		Value of Structure
	Kacha	Pacca	Semi Pacca	Sq. ft.	Rft.	
Houses						
Boundary Wall						
Other						

14.4 Impact on Farm House

Yes ______ No ______

If yes then

Name	Type of Farm House			Area		Value (Rs.)
	Kacha	Pacca	Semi Pacca	Sq.ft	Rft.	
Rooms						
Cattle Shed						
Boundary Wall						
Other						

14.5 Impact of Tube wells

Yes ______ No ______

If yes then

Types of Tube wells	No.	Value (Rs.)
Electric		
Diesel		
Turbine		
Other		
Total:		

14.6 Impact on Utility

Yes ______ No ______

If yes then

Types	Nos. / Area
Electric poles	
Transformer	
Transmission line	
Telephone	
Other	
Total:	

14.7 Impact on Community Structure

Name	Yes	No	Value (Rs.)
Schools			
Mosque			
Graveyard			
Health Centre			
Shrine			
Others			
Total:			

14.8 How to shift shrines / graveyards?

____

____

14.9 Miscellaneous Impacts of the Project

____

____

14.10 Do you have any alternate residence place?

Yes [ ] No [ ]

If yes then (tick relevant)

Own Land / House	Yes/No	Location	Distance from current residence (km)
Tenancy			
Relative			
Other			

14.11 Mode of Payment

Land for land ______
Cash compensation ______
Kind ______
Other ______

15. Project

______

______

16. Views / Comments of Interviewers

______

______

Name & Signature of Interviewer: ______ Date: ______

Scavenging Activity Questionnaire

1) Name:

2) Occupation:

3) Age:

4) Residence City:

    - --

5) How much waste do you normally collect in a day?

6) Is all of the waste you collect useful, or do you have to sort it after collection as well?

7) What is the procedure you normally follow in your waste collection activity?

8) What is the usual cost (money) and time (man-hours) you put in the waste collection activity every day or every month?

9) What is the amount of (daily or monthly) income you generate from your activity?

10) Is this your only income source?

11) If no to Q10, what is your other occupation?

12) If no to Q10, what is your total income, and what percentage income is from waste collection?

13) Where does the waste go after you have processed it?

14) What is your motivation (reason) to do this activity?

15) Do you feel a sense of satisfaction that your work makes a positive difference to the cleanliness of the area?

16) What is your working relationship, if any, with any government department or authority (BWMC etc.) of your city?

17) What kind of improvements would you like to see in your work? Any kind of assistance from government?

Appendix A.3 Details of public consultations

Sr. No.	Name	Address	Contact Number.	Signature
32.	Ali Raza	Dese Masti	[redacted]	
33.	Asbab Ali	Dese Masti	[redacted]	
34.	YousAf Ali	"	[redacted]	
35.	Zohaib Hassan	"	[redacted]	
36.	Shazaib Khan	"	[redacted]	
37.	M.Waqas	"	[redacted]	
38.	Usama Arshad	"	[redacted]	
39.	Muhammad Fawad Arif	Rasheedabad	[redacted]	
40.	Ali Raza	Rasheedabad	[redacted]	
41.	M. Shakeel	"	[redacted]	
42.	Muzlim Hussain	"	[redacted]	
43.	Waqas Ali	"	[redacted]	
44.	Suban Ali	"	[redacted]	
45.	Asif Ali	"	[redacted]	
46.	Amir Ali	"	[redacted]	
47.	Haider	"	[redacted]	
48.	Rizwan	"	[redacted]	
49.	[illegible]	"	[redacted]	

Sr. No.	Name	Address	Contact Number.	Signature
32.	Ali Raza	Dera Hasti	[redacted]	aliraza
33.	Asbab Ali	Dera Hasti	[redacted]	
34.	Yousaf Ali	〃	[redacted]	
35.	Zohaib Hassan	〃	[redacted]	
36.	Shazaib Khan	〃	[redacted]	
37.	M. Waqas	〃	[redacted]	
38.	Usama Arshad	〃	[redacted]	
39.	Muhammad Fawad Arif	Rasheedabad	[redacted]	
40.	Ali Raza	Rasheedabad	[redacted]	
41.	M. Shakeel	〃	[redacted]	
42.	Muzlim Hussain	〃	[redacted]	
43.	Waqas Ali	〃	[redacted]	
44.	Suban Ali	〃	[redacted]	
45.	Asif Ali	〃	[redacted]	
46.	Amir Ali	〃	[redacted]	
47.	Haider	〃	[redacted]	
48.	Rizwan	〃	[redacted]	
49.	Umer	〃	[redacted]	

Annex-A-3-2

Sr. No.	Name	Address	Contact Number.	Signature
50.	M. Junaid	″	[redacted]	M. Junaid
51.	M. Awais	″	[redacted]	M. Awais
52.	Zeeshan	″	[redacted]	[illegible]
53.	Aamir Shehzad	Village Khumbhan	[redacted]	Aamir
54.	Yasir Sindhu	Village Khumbhan	[redacted]	[illegible]
55.	FAHAD Mahmood	″	[redacted]	Fahad
56.	Naveed Akram	″	[redacted]	[illegible]
57.	Nauman Afzal	″	[redacted]	[illegible]
58.	Afzal	″	[redacted]	[illegible]
59.	Usman Siddique	–	[redacted]	[illegible]
60.	Taimoor	–	[redacted]	[illegible]
61.	Fahad Saleem		[redacted]	[illegible]
62.	Asif Ali	–	[redacted]	[illegible]
63.	Abrar Ahmad		[redacted]	[illegible]
64.	ALi Husnain	–	[redacted]	Ali
65.	Usman Ali Butt	–	[redacted]	[illegible]
66.	M. Shahzaib	–	[redacted]	M. Sub
67.	Ali Raza		[redacted]	[illegible]

Annex-A-3-3

Sr. No.	Name	Address	Contact Number.	Signature
68.	M. Qaiser	"	[redacted]	M. Qais
69.	Rzaq	"	[redacted]	Rzaq
70.	فاروق احمد	میراں والا گھوں	[redacted]	فاروق احمد
71.	محمد صابر	"	[redacted]	صابر
72.	ریاست	"	[redacted]	ریاست
73.	M. Ikram-ul-Haq	"	[redacted]	[illegible]
74.	Malik Akhtar Abbas	"	[redacted]	[illegible]
75.	Akbar Ali	"	[redacted]	اکبر
76.	Azam	"	[redacted]	[illegible]
77.	[illegible]	"	[redacted]	[illegible]
78.	Waqas	"	[redacted]	[illegible]
79.	Faisal	"	[redacted]	FAISAL
80.	Hassan Haroon	"	[redacted]	Hassan
81.	Akbar	"	[redacted]	Akbar
82.	IRfan	-	[redacted]	[illegible]
83.	TANVEER ASHRAF	-	[redacted]	[illegible]
84.	Khalid Hussain	-	[redacted]	[illegible]
85.	Ali Rasheed	-	[redacted]	[illegible]

Annex-A-3-4

Sr. No.	Name	Address	Contact Number.	Signature
	فرقان حسین			فرقان
86.	Saifullah	Yar Muhammad		
87.	Ustad Parviz	〃		
88.	Adeel manzoor	〃		
89.	Raza Jutt	〃		
90.	Zohaib	〃		
91.	ADIL	〃		
92.	Awais	〃		Awais
93.	Hussnain	〃		
94.	Sulman	〃		
95.	Shafiq	〃		

Appendix A.4 Environmental Baseline Monitoring

Air Quality Analysis at Proposed Landfill Site

Integrated Environment Laboratory

AMBIENT PARTICULATE MATTER MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	30-11-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air	**Monitoring Instrument:**	AQMS 65
Location	Basti Rama		

Sr. No	Time	Parameters		Results (Average 24 Hrs)	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
		Units			
	Hours	(µg/m³)	(µg/m³)		
1.	09:00 A.M	21.2	71.97	14.93 (µg/m³)	64.03 (µg/m³)
2.	10:00 A.M	18.93	72.84		
3.	11:00 A.M	17.01	71.29		
4.	12:00 P.M	16.26	74.58		
5.	01:00 P.M	16.29	73.03		
6.	02:00 P.M	16.65	72.32		
7.	03:00 P.M	16.59	69.79		
8.	04:00 P.M	16.19	68.57		
9.	05:00 P.M	15.09	65.35		
10.	06:00 P.M	13.86	63.83		
11.	07:00 P.M	13.09	62.1		
12.	08:00 P.M	13.49	63.58		
13.	09:00 P M	13.99	60.85		
14.	10:00 P M	14.36	60.13		
15.	11:00 P M	12.1	59.61		
16.	12:00 A M	13.98	56.88		
17.	01:00 A M	13.12	56.35		
18.	02:00 A M	14.69	57.64		
19.	03:00 A M	13.99	58.07		
20.	04:00 A M	13.57	56.38		
21.	05:00 A M	13.16	57.23		
22.	06:00 A M	12.29	59.51		
23.	07:00 A M	13.97	60.42		
24.	08:00 A M	14.49	64.41		
PEQSAA				35 (µg/m³)	150 (µg/m³)
WHO				15 (µg/m³)	45 (µg/m³)

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization µg/m³= Micrograms per Cubic Meter

Note:

- Selected measurement units were µg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring:

HEAD OFFICE: 2nd Floor, Suite # 11, Anwar Tower, 99-Shadman, Lahore, Pakistan
PESHAWAR OFFICE: Suite # 302, Level-III, Afzal Appartement, Near Phase-III Chowk, Peshawar

Integrated Environment Laboratory

AMBIENT PARTICULATE MATTER MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	01-12-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air	**Monitoring Instrument:**	AQMS 65
Location	Basti Yar Muhammad		

Sr. No	Time	Parameters		Results (Average 24 Hrs)	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
		Units			
	Hours	(µg/m³)	(µg/m³)		
1.	09:00 A.M	18.61	67.31	12.34 (µg/m³)	59.37 (µg/m³)
2.	10:00 A.M	16.34	68.18		
3.	11:00 A.M	14.42	66.53		
4.	12:00 P.M	13.67	69.92		
5.	01:00 P.M	13.7	68.37		
6.	02:00 P.M	14.06	67.56		
7.	03:00 P.M	14	65.13		
8.	04:00 P.M	13.6	63.91		
9.	05:00 P.M	12.5	60.59		
10.	06:00 P.M	11.27	59.17		
11.	07:00 P.M	10.5	57.44		
12.	08:00 P.M	10.9	58.92		
13.	09:00 P M	11.4	56.2		
14.	10:00 P M	11.77	55.47		
15.	11:00 P M	9.51	54.95		
16.	12:00 A M	11.39	52.22		
17.	01:00 A M	10.53	51.69		
18.	02:00 A M	12.1	52.98		
19.	03:00 A M	11.4	53.41		
20.	04:00 A M	10.98	51.72		
21.	05:00 A M	10.57	52.57		
22.	06:00 A M	9.7	54.85		
23.	07:00 A M	11.38	55.76		
24.	08:00 A M	11.9	59.75		
PEQSAA				35 (µg/m³)	150 (µg/m³)
WHO				15 (µg/m³)	45 (µg/m³)

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization µg/m³= Micrograms per Cubic Meter

Note:

- Selected measurement units were µg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Integrated Environment Laboratory

AMBIENT PARTICULATE MATTER MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	Project Name:	Bahawalpur Landfill Site
Monitoring Date:	02-12-2022	Reporting Date:	13-12-2022
Source	Ambient Air	Monitoring Instrument:	AQMS 65
Location	Basti Karim Bukhsh		

Sr. No	Time	Parameters		Results (Average 24 Hrs)	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
		Units			
	Hours	(µg/m³)	(µg/m³)		
1.	09:00 A.M	22.12	76.3	15.85 (µg/m³)	68.36 (µg/m³)
2.	10:00 A.M	19.86	77.17		
3.	11:00 A.M	17.93	75.62		
4.	12:00 P.M	17.18	78.91		
5.	01:00 P.M	17.21	77.36		
6.	02:00 P.M	17.57	76.65		
7.	03:00 P.M	17.51	74.12		
8.	04:00 P.M	17.11	72.9		
9.	05:00 P.M	16.01	69.69		
10.	06:00 P.M	14.78	68.16		
11.	07:00 P.M	14.01	66.43		
12.	08:00 P.M	14.41	67.91		
13.	09:00 P M	14.91	65.19		
14.	10:00 P M	15.28	64.45		
15.	11:00 P M	13.02	63.94		
16.	12:00 A M	14.9	61.21		
17.	01:00 A M	14.04	60.69		
18.	02:00 A M	15.61	61.97		
19.	03:00 A M	14.91	62.4		
20.	04:00 A M	14.49	60.71		
21.	05:00 A M	14.08	61.56		
22.	06:00 A M	13.21	63.84		
23.	07:00 A M	14.89	64.75		
24.	08:00 A M	15.41	68.74		
PEQSAA				35 (µg/m³)	150 (µg/m³)
WHO				15 (µg/m³)	45 (µg/m³)

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization µg/m³= Micrograms per Cubic Meter

Note:

- Selected measurement units were µg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Annex-A-4-3

Integrated Environment Laboratory

AMBIENT PARTICULATE MATTER MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	Project Name:	Bahawalpur Landfill Site
Monitoring Date:	03-12-2022	Reporting Date:	13-12-2022
Source	Ambient Air	Monitoring Instrument:	AQMS 65
Location	Basti Meriwala Khoon		

Sr. No	Time	Parameters		Results (Average 24 Hrs)	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
		Units			
	Hours	(µg/m³)	(µg/m³)		
1.	09:00 A.M	15.66	60.87	9.39 (µg/m³)	52.93 (µg/m³)
2.	10:00 A.M	13.39	61.74		
3.	11:00 A.M	11.47	60.19		
4.	12:00 P.M	10.72	63.48		
5.	01:00 P.M	10.75	61.93		
6.	02:00 P.M	11.11	61.22		
7.	03:00 P.M	11.05	58.59		
8.	04:00 P.M	10.65	57.47		
9.	05:00 P.M	9.55	54.25		
10.	06:00 P.M	8.32	52.73		
11.	07:00 P.M	7.55	51		
12.	08:00 P.M	7.96	52.48		
13.	09:00 P M	8.45	49.76		
14.	10:00 P M	8.82	49.03		
15.	11:00 P M	6.56	48.51		
16.	12:00 A M	8.44	45.79		
17.	01:00 A M	7.58	45.25		
18.	02:00 A M	9.15	46.54		
19.	03:00 A M	8.45	46.97		
20.	04:00 A M	8.03	45.29		
21.	05:00 A M	7.62	46.13		
22.	06:00 A M	6.75	48.41		
23.	07:00 A M	8.43	49.32		
24.	08:00 A M	8.96	53.31		
PEQSAA				35 (µg/m³)	150 (µg/m³)
WHO				15 (µg/m³)	45 (µg/m³)

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization µg/m³= Micrograms per Cubic Meter

Note:

- Selected measurement units were µg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Integrated Environment Laboratory

AMBIENT PARTICULATE MATTER MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	Project Name:	Bahawalpur Landfill Site
Monitoring Date:	04-12-2022	Reporting Date:	13-12-2022
Source	Ambient Air	Monitoring Instrument:	AQMS 65
Location	Basti Rasheedabad		

Sr. No	Time	Parameters		Results (Average 24 Hrs)	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
		Units			
	Hours	(µg/m³)	(µg/m³)		
1.	09:00 A.M	20.88	65.87	14.61 (µg/m³)	57.95 (µg/m³)
2.	10:00 A.M	18.61	66.74		
3.	11:00 A.M	16.69	65.19		
4.	12:00 P.M	15.94	68.48		
5.	01:00 P.M	15.97	66.93		
6.	02:00 P.M	16.33	66.22		
7.	03:00 P.M	16.27	63.69		
8.	04:00 P.M	15.87	62.47		
9.	05:00 P.M	14.77	59.25		
10.	06:00 P.M	13.54	57.73		
11.	07:00 P.M	12.77	56		
12.	08:00 P.M	13.17	57.48		
13.	09:00 P M	13.67	54.76		
14.	10:00 P M	14.04	54.03		
15.	11:00 P M	11.78	53.51		
16.	12:00 A M	13.66	50.78		
17.	01:00 A M	12.8	50.25		
18.	02:00 A M	14.37	51.54		
19.	03:00 A M	13.67	51.97		
20.	04:00 A M	13.25	50.29		
21.	05:00 A M	12.84	51.13		
22.	06:00 A M	11.97	53.41		
23.	07:00 A M	13.66	54.32		
24.	08:00 A M	14.17	58.31		
PEQSAA				35 (µg/m³)	150 (µg/m³)
WHO				15 (µg/m³)	45 (µg/m³)

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization µg/m³= Micrograms per Cubic Meter

Note:

- Selected measurement units were µg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Annex-A-4-5

Integrated Environment Laboratory

AMBIENT PARTICULATE MATTER MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	Project Name:	Bahawalpur Landfill Site
Monitoring Date:	05-12-2022	Reporting Date:	13-12-2022
Source	Ambient Air	Monitoring Instrument:	AQMS 65
Location	Basti Chachran		

Sr. No	Time	Parameters		Results (Average 24 Hrs)	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
		Units			
	Hours	(µg/m³)	(µg/m³)		
1.	09:00 A.M	17.24	62.39		
2.	10:00 A.M	14.97	63.25		
3.	11:00 A.M	13.06	61.71		
4.	12:00 P.M	12.3	65		
5.	01:00 P.M	12.33	63.45		
6.	02:00 P.M	12.69	62.74		
7.	03:00 P.M	12.63	60.21		
8.	04:00 P.M	12.23	58.99		
9.	05:00 P.M	11.13	55.77		
10.	06:00 P.M	9.9	54.25		
11.	07:00 P.M	9.13	52.52		
12.	08:00 P.M	9.53	54	10.97 (µg/m³)	54.49 (µg/m³)
13.	09:00 P M	10.03	51.28		
14.	10:00 P M	10.4	50.55		
15.	11:00 P M	8.14	50.03		
16.	12:00 A M	10.02	47.3		
17.	01:00 A M	9.16	46.77		
18.	02:00 A M	10.73	48.05		
19.	03:00 A M	10.03	48.49		
20.	04:00 A M	9.61	46.8		
21.	05:00 A M	9.2	47.65		
22.	06:00 A M	8.33	49.93		
23.	07:00 A M	10.01	50.84		
24.	08:00 A M	10.53	54.83		
PEQSAA				35 (µg/m³)	150 (µg/m³)
WHO				15 (µg/m³)	45 (µg/m³)

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization µg/m³= Micrograms per Cubic Meter

Note:

- Selected measurement units were µg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Integrated Environment Laboratory

AMBIENT AIR GASES MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	30-11-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air Gases	**Monitoring Instrument:**	AQMS 65
Location	Basti Rama		

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)
1.	09:00 A.M	0.34	5.46	8.06	7.28
2.	10:00 A.M	0.39	6.31	8.24	7.15
3.	11:00 A.M	0.31	6.38	8.51	6.42
4.	12:00 P.M	0.42	7.13	7.42	6.55
5.	01:00 P.M	0.45	6.53	7.29	6.7
6.	02:00 P.M	0.34	6.71	7.4	5.78
7.	03:00 P.M	0.32	7.25	7.75	6.4
8.	04:00 P.M	0.27	6.39	7.91	7.59
9.	05:00 P.M	0.23	5.55	7.43	5.42
10.	06:00 P.M	0.29	5.32	7.55	5.91
11.	07:00 P.M	0.15	6.1	8.13	7.34
12.	08:00 P.M	0.21	6.43	7.24	7.01
13.	09:00 P M	0.17	7.24	7.67	6.58
14.	10:00 P M	0.22	5.52	7.52	6.24
15.	11:00 P M	0.15	5.09	8.35	7.09
16.	12:00 A M	0.27	6.27	7.6	7.37
17.	01:00 A M	0.24	6.34	7.14	6.3
18.	02:00 A M	0.11	5.59	7.3	6.11
19.	03:00 A M	0.23	7.38	7.18	5.89
20.	04:00 A M	0.24	6.59	6.81	6.2
21.	05:00 A M	0.29	6.35	6.24	6.57
22.	06:00 A M	0.27	5.88	7.1	6.73
23.	07:00 A M	0.29	6.63	7.39	7.02
24.	08:00 A M	0.32	5.87	7.49	6.89
Average Concentration		0.27	6.28	7.63	6.60
PEQSAA		06	40	80	120
WHO		04	—	26	40

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization $\mu g/m^3$= Micrograms per Cubic Meter

Note:

- Selected measurement units were $\mu g/m^3$ & mg/m^3 otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Annex-A-4-7

Integrated Environment Laboratory

AMBIENT AIR GASES MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	01-12-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air Gases	**Monitoring Instrument:**	AQMS 65
Location	Basti Yar Muhammad		

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)
1.	09:00 A.M	0.56	9.47	12.93	12.76
2.	10:00 A.M	0.61	10.32	13.11	12.63
3.	11:00 A.M	0.53	10.39	13.38	11.9
4.	12:00 P.M	0.64	11.14	12.29	12.03
5.	01:00 P.M	0.67	10.54	12.15	12.18
6.	02:00 P.M	0.56	10.72	12.27	11.26
7.	03:00 P.M	0.54	11.26	12.63	11.88
8.	04:00 P.M	0.49	10.4	12.78	13.07
9.	05:00 P.M	0.45	9.56	12.3	10.9
10.	06:00 P.M	0.51	9.33	12.42	11.39
11.	07:00 P.M	0.37	10.11	13	12.82
12.	08:00 P.M	0.43	10.44	12.11	12.49
13.	09:00 P M	0.39	11.25	12.54	12.06
14.	10:00 P M	0.44	9.53	12.39	11.72
15.	11:00 P M	0.37	9.1	13.22	12.57
16.	12:00 A M	0.49	10.29	12.47	12.86
17.	01:00 A M	0.46	10.35	12.01	11.78
18.	02:00 A M	0.33	9.6	12.17	11.59
19.	03:00 A M	0.45	11.39	12.05	11.37
20.	04:00 A M	0.46	10.6	11.68	11.68
21.	05:00 A M	0.51	10.36	11.11	12.05
22.	06:00 A M	0.49	9.89	11.97	12.21
23.	07:00 A M	0.51	10.64	12.26	12.5
24.	08:00 A M	0.54	9.88	12.36	12.37
Average Concentration		**0.48**	**10.27**	**12.40**	**12.08**
PEQSAA		**06**	**40**	**80**	**120**
WHO		**04**	**—**	**26**	**40**

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization $\mu g/m^3$= Micrograms per Cubic Meter

Note:

- Selected measurement units were $\mu g/m^3$ & mg/m^3 otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Integrated Environment Laboratory

AMBIENT AIR GASES MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	02-12-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air Gases	**Monitoring Instrument:**	AQMS 65
Location	Basti Karim Bukhsh		

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)
1.	09:00 A.M	0.9	12.42	14.87	16.63
2.	10:00 A.M	0.85	13.27	15.05	16.5
3.	11:00 A.M	0.77	13.34	15.32	15.77
4.	12:00 P.M	0.88	14.09	14.23	15.9
5.	01:00 P.M	0.91	13.49	14.1	16.05
6.	02:00 P.M	0.9	13.67	14.21	15.13
7.	03:00 P.M	0.79	14.21	14.57	15.75
8.	04:00 P.M	0.73	13.35	14.72	16.94
9.	05:00 P.M	0.69	12.51	14.24	14.77
10.	06:00 P.M	0.75	12.29	14.36	15.26
11.	07:00 P.M	0.61	13.06	14.54	16.69
12.	08:00 P.M	0.67	13.39	14.05	16.36
13.	09:00 P M	0.63	14.2	14.48	15.93
14.	10:00 P M	0.68	12.48	14.33	15.59
15.	11:00 P M	0.61	12.05	15.15	16.44
16.	12:00 A M	0.73	13.23	14.41	16.72
17.	01:00 A M	0.7	13.3	13.95	15.66
18.	02:00 A M	0.57	12.55	14.11	15.46
19.	03:00 A M	0.69	14.34	13.99	15.24
20.	04:00 A M	0.7	13.55	13.62	15.55
21.	05:00 A M	0.75	13.31	13.05	15.92
22.	06:00 A M	0.73	12.84	13.91	16.08
23.	07:00 A M	0.75	13.59	14.2	16.37
24.	08:00 A M	0.79	12.83	14.3	16.24
Average Concentration		0.73	13.22	14.34	15.86
PEQSAA		06	40	80	120
WHO		04	—	25	40

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization $\mu g/m^3$= Micrograms per Cubic Meter

Note:

- Selected measurement units were $\mu g/m^3$ & mg/m^3 otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Annex-A-4-9

Integrated Environment Laboratory

AMBIENT AIR GASES MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	03-12-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air Gases	**Monitoring Instrument:**	AQMS 65
Location	Basti Merwala Khoon		

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)
1.	09:00 A.M	0.46	6.21	8.97	9.1
2.	10:00 A.M	0.51	7.06	9.15	8.97
3.	11:00 A.M	0.43	7.13	9.42	8.24
4.	12:00 P.M	0.54	7.88	8.33	8.37
5.	01:00 P.M	0.57	7.28	8.2	8.52
6.	02:00 P.M	0.46	7.46	8.31	7.6
7.	03:00 P.M	0.44	8	8.67	8.22
8.	04:00 P.M	0.39	7.14	8.82	9.41
9.	05:00 P.M	0.35	6.3	8.34	7.24
10.	06:00 P.M	0.41	6.07	8.46	7.73
11.	07:00 P.M	0.27	6.85	9.04	9.16
12.	08:00 P.M	0.33	7.18	8.15	8.83
13.	09:00 P M	0.29	7.99	8.58	8.4
14.	10:00 P M	0.34	6.27	8.43	8.06
15.	11:00 P M	0.27	5.84	9.26	8.91
16.	12:00 A M	0.39	7.02	8.51	9.19
17.	01:00 A M	0.36	7.09	8.05	8.12
18.	02:00 A M	0.23	6.34	8.21	7.93
19.	03:00 A M	0.35	8.13	8.09	7.71
20.	04:00 A M	0.36	7.34	7.72	8.02
21.	05:00 A M	0.41	7.1	7.15	8.39
22.	06:00 A M	0.39	6.63	8.01	8.55
23.	07:00 A M	0.41	7.38	8.3	8.84
24.	08:00 A M	0.44	6.62	8.4	8.71
Average Concentration		**0.38**	**7.01**	**8.44**	**8.42**
PEQSAA		**06**	**40**	**80**	**120**
WHO		**04**	**—**	**26**	**40**

PEQSAA: Punjab Environmental Quality Standards for Ambient Air

WHO: World Health Organization $\mu g/m^3$= Micrograms per Cubic Meter

Note:

- Selected measurement units were $\mu g/m^3$ & mg/m^3 otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Integrated Environment Laboratory

AMBIENT AIR GASES MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	04-12-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air Gases	**Monitoring Instrument:**	AQMS 65
Location	Basti Rasheedabad		

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m^3)	$(\mu g/m^3)$	$(\mu g/m^3)$	$(\mu g/m^3)$
1.	09:00 A.M	0.45	8.66	10.77	11.75
2.	10:00 A.M	0.5	9.51	10.95	11.62
3.	11:00 A.M	0.42	9.58	11.22	10.89
4.	12:00 P.M	0.53	10.33	10.13	11.02
5.	01:00 P.M	0.56	9.73	10	11.17
6.	02:00 P.M	0.45	9.91	10.11	10.25
7.	03:00 P.M	0.43	10.45	10.47	10.87
8.	04:00 P.M	0.38	9.59	10.62	12.06
9.	05:00 P.M	0.34	8.75	10.14	9.89
10.	06:00 P.M	0.4	8.52	10.25	10.38
11.	07:00 P.M	0.25	9.3	10.84	11.81
12.	08:00 P.M	0.32	9.63	9.95	11.48
13.	09:00 P M	0.29	10.44	10.38	11.06
14.	10:00 P M	0.33	8.72	10.23	10.71
15.	11:00 P M	0.25	8.29	11.06	11.56
16.	12:00 A M	0.38	9.47	10.31	11.84
17.	01:00 A M	0.35	9.54	9.85	10.77
18.	02:00 A M	0.22	8.79	10.01	10.58
19.	03:00 A M	0.34	10.58	9.89	10.36
20.	04:00 A M	0.35	9.79	9.52	10.67
21.	05:00 A M	0.4	9.55	8.95	11.04
22.	06:00 A M	0.38	9.08	9.81	11.2
23.	07:00 A M	0.4	9.83	10.1	11.49
24.	08:00 A M	0.43	9.07	10.2	11.36
Average Concentration		**0.38**	**9.46**	**10.24**	**11.07**
PEQSAA		**06**	**40**	**80**	**120**
WHO		**04**	**—**	**25**	**40**

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization $\mu g/m^3$= Micrograms per Cubic Meter

Note:

- Selected measurement units were $\mu g/m^3$ & mg/m^3 otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

HEAD OFFICE: 2nd Floor, Suite # 11, Anwar Tower, 93-Shadman, Lahore, Pakistan
PESHAWAR OFFICE: Suite # 302, Level-II, Afzal Appartement, Near Phase-II Chowk, Peshawar

Integrated Environment Laboratory

AMBIENT AIR GASES MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	05-12-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air Gases	**Monitoring Instrument:**	AQMS 65
Location	Basti Chachran		

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)
1.	09:00 A.M	0.37	8.13	10.95	10.77
2.	10:00 A.M	0.42	8.98	11.13	10.64
3.	11:00 A.M	0.34	9.05	11.4	9.91
4.	12:00 P.M	0.45	9.8	10.31	10.04
5.	01:00 P.M	0.48	9.2	10.18	10.19
6.	02:00 P.M	0.37	9.38	10.29	9.27
7.	03:00 P.M	0.35	9.92	10.65	9.89
8.	04:00 P.M	0.3	9.06	10.8	11.08
9.	05:00 P.M	0.26	8.22	10.32	8.91
10.	06:00 P.M	0.32	7.99	10.44	9.4
11.	07:00 P.M	0.18	8.77	11.02	10.83
12.	08:00 P.M	0.24	9.1	10.13	10.5
13.	09:00 P M	0.2	9.91	10.56	10.07
14.	10:00 P M	0.25	8.19	10.41	9.73
15.	11:00 P M	0.18	7.76	11.24	10.58
16.	12:00 A M	0.3	8.94	10.49	10.86
17.	01:00 A M	0.27	9.01	10.03	9.79
18.	02:00 A M	0.14	8.26	10.19	9.6
19.	03:00 A M	0.26	10.05	10.07	9.38
20.	04:00 A M	0.27	9.26	9.7	9.69
21.	05:00 A M	0.32	9.02	9.13	10.06
22.	06:00 A M	0.3	8.55	9.99	10.22
23.	07:00 A M	0.32	9.3	10.28	10.51
24.	08:00 A M	0.35	8.54	10.38	10.38
Average Concentration		**0.30**	**8.83**	**10.42**	**10.08**
PEQSAA		**06**	**40**	**80**	**120**
WHO		**04**	**—**	**26**	**40**

PEQSAA: Punjab Environmental Quality Standards for Ambient Air

WHO: World Health Organization $\mu g/m^3$= Micrograms per Cubic Meter

Note:

- Selected measurement units were $\mu g/m^3$ & mg/m^3 otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature

Incharge Environmental Monitoring

Air Quality Analysis of the legacy landfill

Integrated Environment Laboratory

AMBIENT PARTICULATE MATTERS MONITORING REPORT

Reference Number	PICIIP/ENV/051-2023		
Project Name:	Punjab Intermediate Cities Improvement Investment Project	**Monitoring Location:**	Existing Transfer Station Band Road, TMA Office Opposite Model Bazar, Bahawalpur
Monitoring Date:	16-05-2023	**Source:**	Ambient Air
GPS Coordinates:	29°23'58.0"N 71°41'06.4"E	**Monitoring Instrument:**	AQMS06, Serial # 1310

Sr. No	Time	Parameters		Results (Average 24 Hrs)	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
		Units			
	Hours	(μg/m³)	(μg/m³)		
1.	08:00 AM	38.62	129.06		
2.	09:00 AM	36.35	128.92		
3.	10:00 AM	34.43	128.37		
4.	11:00 AM	33.63	131.66		
5.	12:00 PM	33.71	130.11		
6.	01:00 PM	34.07	129.4		
7.	02:00 PM	34.01	125.67		
8.	03:00 PM	33.61	125.65		
9.	04:00 PM	32.51	122.43		
10.	05:00 PM	31.28	120.91		
11.	06:00 PM	30.51	119.15		
12.	07:00 PM	30.91	120.65		
13.	08:00 PM	31.41	117.94	32.35 (μg/m³)	121.11 (μg/m³)
14.	09:00 PM	31.78	117.21		
15.	10:00 PM	29.52	116.69		
16.	11:00 PM	31.4	113.95		
17.	12:00 AM	30.54	113.43		
18.	01:00 AM	32.11	114.72		
19.	02:00 AM	31.41	115.15		
20.	03:00 AM	30.99	113.46		
21.	04:00 AM	30.58	114.31		
22.	05:00 AM	29.71	116.59		
23.	06:00 AM	31.39	117.5		
24.	07:00 AM	31.91	121.49		
PEQSAA				35 (μg/m³)	150 (μg/m³)
WHO				15 (μg/m³)	45 (μg/m³)

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization
Note:

- Selected measurement units were μg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst — Signature of Chief Chemist

Integrated Environment Laboratory

FOR ENVIRONMENTAL MONITORING, ANALYSIS & SURVEYS

Integrated Environment Laboratory

AMBIENT GASES MONITORING REPORT

Reference Number	FICIIP/ENV/051-2023		
Project Name:	Punjab Intermediate Cities Improvement Investment Project	**Monitoring Location:**	Existing Transfer Station Band Road, TMA Office Opposite Model Bazar, Bahawalpur
Monitoring Date:	16-06-2023	**Source:**	Ambient Air
GPS Coordinates:	29°23'58.0"N 71°41'06.4"E	**Monitoring Instrument:**	AQMS65, Serial # 1310

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m³)	(µg/m³)	(µg/m³)	(µg/m³)
1.	08:00 AM	0.85	16.73	19.61	18.02
2.	09:00 AM	0.87	16.75	21.38	17.39
3.	10:00 AM	0.83	16.6	22.05	18.65
4.	11:00 AM	0.99	16.69	22.7	19.95
5.	12:00 PM	0.97	16.67	22.98	20.19
6.	01:00 PM	0.99	17.4	24.22	20.81
7.	02:00 PM	1.01	16.51	25.32	21.25
8.	03:00 PM	1.05	16.64	25.4	21.37
9.	04:00 PM	0.94	16.68	26.82	22.76
10.	05:00 PM	0.92	16.27	23.74	21.28
11.	06:00 PM	0.82	16.9	21.59	20.69
12.	07:00 PM	0.79	15.69	20.6	16.83
13.	08:00 PM	0.74	15.61	20.64	17.48
14.	09:00 PM	0.72	15.6	19.75	16.88
15.	10:00 PM	0.75	15.21	19.3	17.42
16.	11:00 PM	0.69	14.8	18.81	17.72
17.	12:00 AM	0.65	14.38	18.78	17.35
18.	01:00 AM	0.64	14.88	18.61	17.11
19.	02:00 AM	0.68	15.18	18.47	16.97
20.	03:00 AM	0.69	15.68	18.72	15.84
21.	04:00 AM	0.70	16.05	18.3	15.59
22.	05:00 AM	0.74	16	18.21	16.33
23.	06:00 AM	0.76	16.42	18.05	15.89
24.	07:00 AM	0.82	16.35	17.98	15.05
Average Concentration		0.82	16.02	20.91	18.27
PEQSAA		05	40	80	120
WHO		04	---	25	40

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization
Note:

- Selected measurement units were µg/m³ & mg/m³ otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature of Chief Chemist

Integrated Environment Laboratory

FOR ENVIRONMENTAL MONITORING, ANALYSIS & SURVEYS

Integrated Environment Laboratory

AMBIENT NOISE MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Project Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	30-11-2022	**Reporting Date:**	13-12-2022
Source:	Ambient Noise	**Monitoring Instrument:**	Noise Meter-IEC651-Type-2
Location	Basti Rama		

Sr. No.	Monitoring Time	Unit	Minimum	Maximum	Leq
Day Time			Day Time		
1.	09:00 A.M		46.2	48.5	47.3
2.	10:00 A.M		47.3	49.5	48.4
3.	11:00 A.M		45.3	46.1	45.7
4.	12:00 P.M		45.2	47.8	46.5
5.	01:00 P.M		48.7	51.6	50.1
6.	02:00 P.M		48.7	49.4	49
7.	03:00 P.M		45.1	46.3	45.7
8.	04:00 P.M		47.8	48.2	48
9.	05:00 P.M		50.1	52.3	51.2
10.	06:00 P.M		49.8	50.7	50.2
11.	07:00 P.M		52.3	54.7	53.5
12.	08:00 P.M		46.3	48.2	47.2
13.	09:00 P.M	dB(A)	44.3	45.8	45
14.	10:00 P.M		48.6	50.4	49.5
Night Time			Night Time		
15.	11:00 P.M		46.3	47.5	46.9
16.	12:00 A.M		48.6	49.1	48.8
17.	01:00 A.M		50.3	51.7	51
18.	02:00 A.M		45.8	47.2	46.5
19.	03:00 A.M		48.2	49.7	48.9
20.	04:00 A.M		46.5	48.9	47.7
21.	05:00 A.M		45.3	46.3	45.8
22.	06:00 A.M		44.8	45.7	45.2
Day Time			Day Time		
23.	07:00 A.M		48.6	49.7	49.1
24.	08:00 A.M		48.6	47.6	48.1

Day Time 06:00 AM – 10:00 PM
Night Time 10:00 PM – 06:00 AM
PEQS limit : 65 – 55 dB
WHO limit: 70 dB

PEQS: Punjab Environmental Quality Standards for Ambient Noise
WHO: World Health Organization Leq= Log Equivalent Continuous Sound Level

Note:

- Selected measurement units were dB(A) otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

HEAD OFFICE: 2nd Floor, Suite # 11, Anwar Tower, 99-Shadman, Lahore, Pakistan
PESHAWAR OFFICE: Suite # 302, Level-III, Afzal Appartement, Near Phase-III Chowk, Peshawar

Integrated Environment Laboratory

AMBIENT NOISE MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Project Name:	Local Government and Community Development (LG&CD).	Project Name:	Bahawalpur Landfill Site
Monitoring Date:	01-12-2022	Reporting Date:	13-12-2022
Source:	Ambient Noise	Monitoring Instrument:	Noise Meter-IEC651-Type-2
Location	Basti Yar Muhammad		

Sr. No.	Monitoring Time	Unit	Minimum	Maximum	Leq
Day Time			Day Time		
1.	09:00 A.M	dB(A)	49.3	50.6	49.9
2.	10:00 A.M		49.3	51.9	50.6
3.	11:00 A.M		47.3	48.5	47.9
4.	12:00 P.M		45.8	48.7	47.2
6.	01:00 P.M		50.7	54	52.3
6.	02:00 P.M		51.7	51.8	51.7
7.	03:00 P.M		47.1	48.7	47.9
8.	04:00 P.M		49.8	50.6	50.2
9.	05:00 P.M		52.7	52.9	52.8
10.	06:00 P.M		51.8	53.1	52.4
11.	07:00 P.M		54.3	57.1	55.7
12.	08:00 P.M		48.3	50.6	49.4
13.	09:00 P M		46.3	48.2	47.2
14.	10:00 P M		50.6	52.8	51.7
Night Time			Night Time		
16.	11:00 P M		48.3	49.9	49.1
16.	12:00 A M		50.6	51.5	51
17.	01:00 A M		52.3	54.1	53.2
18.	02:00 A M		46.7	47.2	46.9
19.	03:00 A M		50.2	52.1	51.1
20.	04:00 A M		48.5	51.3	49.9
21.	05:00 A M		47.3	48.7	48
22.	06:00 A M		46.8	48.1	47.4
Day Time			Day Time		
23.	07:00 A M		50.6	52.1	51.3
24.	08:00 A M		49.7	50.7	50.2

Day Time 06:00 AM – 10:00 PM
Night Time 10:00 PM – 06:00 AM
PEQS limit : 65 – 55 dB
WHO limit: 70 dB

PEQS: Punjab Environmental Quality Standards for Ambient Noise
WHO: World Health Organization Leq= Log Equivalent Continuous Sound Level

Note:

- Selected measurement units were dB(A) otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

HEAD OFFICE: 2nd Floor, Suite # 11, Anwar Tower, 99-Shadman, Lahore, Pakistan
PESHAWAR OFFICE: Suite # 302, Level-II, Afzal Appartement, Near Phase-II Chowk, Peshawar

Integrated Environment Laboratory

AMBIENT AIR GASES MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Client Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	30-11-2022	**Reporting Date:**	13-12-2022
Source	Ambient Air Gases	**Monitoring Instrument:**	AQMS 65
Location	Basti Rama		

Sr. No	Time	Parameters			
		CO	NO	NO_2	SO_2
		Units			
	Hours	(mg/m^3)	($\mu g/m^3$)	($\mu g/m^3$)	($\mu g/m^3$)
1.	09:00 A.M	0.34	5.46	8.06	7.28
2.	10:00 A.M	0.39	6.31	8.24	7.15
3.	11:00 A.M	0.31	6.38	8.51	6.42
4.	12:00 P.M	0.42	7.13	7.42	6.55
5.	01:00 P.M	0.45	6.53	7.29	6.7
6.	02:00 P.M	0.34	6.71	7.4	5.78
7.	03:00 P.M	0.32	7.25	7.75	6.4
8.	04:00 P.M	0.27	6.39	7.91	7.59
9.	05:00 P.M	0.23	5.55	7.43	5.42
10.	06:00 P.M	0.29	5.32	7.55	5.91
11.	07:00 P.M	0.15	6.1	8.13	7.34
12.	08:00 P.M	0.21	6.43	7.24	7.01
13.	09:00 P M	0.17	7.24	7.67	6.58
14.	10:00 P M	0.22	5.52	7.52	6.24
15.	11:00 P M	0.15	5.09	8.35	7.09
16.	12:00 A M	0.27	6.27	7.6	7.37
17.	01:00 A M	0.24	6.34	7.14	6.3
18.	02:00 A M	0.11	5.59	7.3	6.11
19.	03:00 A M	0.23	7.38	7.19	5.89
20.	04:00 A M	0.24	6.59	6.81	6.2
21.	05:00 A M	0.29	6.35	6.24	6.57
22.	06:00 A M	0.27	5.88	7.1	6.73
23.	07:00 A M	0.29	6.63	7.39	7.02
24.	08:00 A M	0.32	5.87	7.49	6.89
Average Concentration		0.27	6.28	7.63	6.60
PEQSAA		06	40	80	120
WHO		04	—	26	40

PEQSAA: Punjab Environmental Quality Standards for Ambient Air
WHO: World Health Organization $\mu g/m^3$= Micrograms per Cubic Meter

Note:

- Selected measurement units were $\mu g/m^3$ & mg/m^3 otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
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- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Annex-A-4-17

Integrated Environment Laboratory

AMBIENT NOISE MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Project Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	03-12-2022	**Reporting Date:**	13-12-2022
Source:	Ambient Noise	**Monitoring Instrument:**	Noise Meter-IEC651-Type-2
Location	Basti Menwala Khoon		

Sr. No.	Monitoring Time	Unit	Minimum	Maximum	Leq
Day Time			Day Time		
1.	09:00 A.M	dB(A)	48.3	49.7	49
2.	10:00 A.M		50.1	51.7	50.9
3.	11:00 A.M		49.8	52.7	51.2
4.	12:00 P.M		46.3	48.5	47.4
6.	01:00 P.M		52.5	53	52.7
6.	02:00 P.M		52.9	53.1	53
7.	03:00 P.M		51.7	53.8	52.7
8.	04:00 P.M		49.8	50.2	50
9.	05:00 P.M		45.8	47.6	46.7
10.	06:00 P.M		50.2	51.7	50.9
11.	07:00 P.M		48.6	50.2	49.4
12.	08:00 P.M		48.2	51.4	49.8
13.	09:00 P M		48.3	55.8	52
14.	10:00 P M		52.6	52.9	52.7
Night Time			Night Time		
16.	11:00 P M		50.3	54.5	52.4
16.	12:00 A M		52.6	57.1	54.8
17.	01:00 A M		48.5	49.8	49.1
18.	02:00 A M		48.7	55.1	51.9
19.	03:00 A M		52.2	54.3	53.2
20.	04:00 A M		50.5	51.7	51.1
21.	05:00 A M		49.3	51.1	50.2
22.	06:00 A M		48.8	55.1	51.9
Day Time			Day Time		
23.	07:00 A M		52.6	53.7	53.1
24.	08:00 A M		51.8	52.4	52.4

Day Time 06:00 AM – 10:00 PM
Night Time 10:00 PM – 06:00 AM
PEQS limit : 65 – 55 dB
WHO limit: 70 dB

PEQS: Punjab Environmental Quality Standards for Ambient Noise
WHO: World Health Organization **Leq**= Log Equivalent Continuous Sound Level

Note:

- Selected measurement units were dB(A) otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
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- The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring

Integrated Environment Laboratory

AMBIENT NOISE MONITORING REPORT

Reference Number	LG&CD/ENV/161-2022		
Project Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	04-12-2022	**Reporting Date:**	13-12-2022
Source:	Ambient Noise	**Monitoring Instrument:**	Noise Meter-IEC651-Type-2
Location	Basti Rasheedabad		

Sr. No.	Monitoring Time	Unit	Minimum	Maximum	Leq
Day Time			Day Time		
1.	09:00 A.M	dB(A)	50.4	53.3	51.9
2.	10:00 A.M		50.2	53.1	51.6
3.	11:00 A.M		50	52.9	51.4
4.	12:00 P.M		49.8	52.7	51.2
5.	01:00 P.M		49.6	52.4	51
6.	02:00 P.M		49.3	52.2	50.8
7.	03:00 P.M		49.1	52	50.6
8.	04:00 P.M		48.9	51.8	50.4
9.	05:00 P.M		48.7	51.6	50.1
10.	06:00 P.M		48.5	51.4	49.9
11.	07:00 P.M		48.3	51.1	49.7
12.	08:00 P.M		48	50.9	49.5
13.	09:00 P M		47.8	50.7	49.3
14.	10:00 P M		47.6	50.5	49.1
Night Time			Night Time		
15.	11:00 P M		47.4	50.3	48.8
16.	12:00 A M		47.2	50.1	48.6
17.	01:00 A M		47	49.9	48.4
18.	02:00 A M		46.8	49.7	48.2
19.	03:00 A M		46.6	49.5	48
20.	04:00 A M		46.4	49.2	47.8
21.	05:00 A M		46.1	49	47.5
22.	06:00 A M		45.9	48.8	47.3
Day Time			Day Time		
23.	07:00 A M		45.7	48.6	47.1
24.	08:00 A M		45.5	48.4	46.9

Day Time 06:00 AM – 10:00 PM
Night Time 10:00 PM – 06:00 AM
PEQS limit : 55 – 55 dB
WHO limit: 70 dB

PEQS: Punjab Environmental Quality Standards for Ambient Noise
WHO: World Health Organization Leq= Log Equivalent Continuous Sound Level

Note:

- Selected measurement units were dB(A) otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
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Signature of Analyst

Signature
Incharge Environmental Monitoring

AMBIENT NOISE MONITORING REPORT

Annex-A-4-19

Integrated Environment Laboratory

Reference Number	LG&CD/ENV/161-2022		
Project Name:	Local Government and Community Development (LG&CD).	**Project Name:**	Bahawalpur Landfill Site
Monitoring Date:	05-12-2022	**Reporting Date:**	13-12-2022
Source:	Ambient Noise	**Monitoring Instrument:**	Noise Meter-IEC651-Type-2
Location	Basti Chachran		

Sr. No.	Monitoring Time	Unit	Minimum	Maximum	Leq
	Day Time			Day Time	
1.	09:00 A.M	dB(A)	56.8	59.1	57.95
2.	10:00 A.M		57.9	60.1	59
3.	11:00 A.M		55.9	56.7	56.3
4.	12:00 P.M		55.8	58.4	57.1
5.	01:00 P.M		59.3	62.2	60.75
6.	02:00 P.M		59.3	60	59.65
7.	03:00 P.M		55.7	56.9	56.3
8.	04:00 P.M		58.4	58.8	58.6
9.	05:00 P.M		60.7	62.9	61.8
10.	06:00 P.M		60.4	61.3	60.85
11.	07:00 P.M		62.9	65.3	64.1
12.	08:00 P.M		56.9	58.8	57.85
13.	09:00 P M		54.9	56.4	55.65
14.	10:00 P M		59.2	61	60.1
	Night Time			Night Time	
15.	11:00 P M		56.9	58.1	57.5
16.	12:00 A M		59.2	59.7	59.45
17.	01:00 A M		60.9	62.3	61.6
18.	02:00 A M		56.4	57.8	57.1
19.	03:00 A M		58.8	60.3	59.55
20.	04:00 A M		57.1	59.5	58.3
21.	05:00 A M		55.9	56.9	56.4
22.	06:00 A M		55.4	56.3	55.85
	Day Time			Day Time	
23.	07:00 A M		59.2	60.3	59.75
24.	08:00 A M		59.7	62.4	61.05

Day Time 06:00 AM – 10:00 PM

Night Time 10:00 PM – 06:00 AM

PEQS limit : 65 – 55 dB

WHO limit: 70 dB

PEQS: Punjab Environmental Quality Standards for Ambient Noise

WHO: World Health Organization **Leq**= Log Equivalent Continuous Sound Level

Note:

- Selected measurement units were dB(A) otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst

Signature

Incharge Environmental Monitoring

Noise Level Monitoring at Existing Dumpsite

Integrated Environment Laboratory

EPA Accredited

NOISE LEVEL MONITORING REPORT

Reference Number	PICIIP/ENV/051-2023		
Project Name:	Punjab Intermediate Cities Improvement Investment Project	**Monitoring Location:**	Existing Transfer Station Band Road, TMA Office Opposite Model Bazar, Bahawalpur
Monitoring Date:	16-06-2023	**Source:**	Ambient Condition
GPS Coordinates:	29°23'58.0"N 71°41'06.4"E	**Monitoring Instrument:**	Noise Meter-IEC651-Type-2

Sr. No.	Monitoring Time	Unit	Minimum	Maximum	Leq
1.	08:00 AM		61.5	64.4	62.95
2.	09:00 AM		61.3	64.2	62.75
3.	10:00 AM		61.1	64	62.55
4.	11:00 AM		60.9	63.8	62.35
5.	12:00 PM		60.6	63.5	62.05
6.	01:00 PM		60.4	63.3	61.85
7.	02:00 PM		60.2	63.1	61.65
8.	03:00 PM		60	62.9	61.45
9.	04:00 PM		59.8	62.7	61.25
10.	05:00 PM		59.6	62.5	61.05
11.	06:00 PM		59.3	62.2	60.75
12.	07:00 PM	dB(A)	59.1	62	60.55
13.	08:00 PM		58.9	61.8	60.35
14.	09:00 PM		58.7	61.6	60.15
15.	10:00 PM		58.5	61.4	59.95
16.	11:00 PM		58.2	61.1	59.65
17.	12:00 AM		58	60.9	59.45
18.	01:00 AM		57.8	60.7	59.25
19.	02:00 AM		57.6	60.5	59.05
20.	03:00 AM		57.4	60.2	58.8
21.	04:00 AM		57.1	60	58.55
22.	05:00 AM		56.9	59.8	58.35
23.	06:00 AM		56.7	59.6	58.15
24.	07:00 AM		56.5	59.4	57.95

PEQS limit : 65 dB – 55 dB

WHO limit: 70 dB

PEQS: National Environmental Quality Standards
WHO: World Health Organization
Leq: Equivalent Continuous Sound Level
Note:

- Selected measurement units were dB (A) otherwise stated.
- Quality was assured through self calibration of the instrument.
- The values were representing of monitoring conditions prevailing during the monitoring hours.
- The measurements were carried out on client request.
- The client is responsible lawful usage of reported data in future.
- The report is not valid for court.

Signature of Analyst:

Signature of Chief Chemist

Integrated Environment Laboratory

Groundwater Quality Analysis Near the Proposed Landfill Site

Integrated Environment Laboratory

DRINKING WATER ANALYSIS REPORT

Reference Number	LG&CD/ENV/151-2022		
Client Name:	Local Government and Community Development (LG&CD)	**Project Name:**	Bahawalpur Landfill Site
Sampling Date:	05-12-2022	**Reporting Date:**	13-12-2022
Source	Tubewell	**Monitoring Instrument:**	APHA/USEPA Standard Methods
Location	Basti Chachran		

Sr. No.	Parameters	Analysis Method	Units	NEQS	Results
1	pH	APHA-4500H+ B	—	6.5-8.5	7.6
2	Taste & Odor	In-house	—	Non Objectionable	Non Objectionable
3	Color	APHA-2120 B/C	TCU	<15	5
4	Turbidity	APHA-2130 B	NTU	<5	3
5	Total Coliform	APHA:9222 B	Number/100 mL	0 Number/100 mL	0
6	E-Coli	APHA:9222 D	Number/100 mL	0 Number/100 mL	0
7	Total Dissolved Solids (TDS)	APHA-2540 C	mg/L	<1000	468
8	Total Hardness	APHA-2340 C	mg/L	<500	121
9	Nitrate	APHA-4500NO3 B	mg/L	≤50	4.9
10	Nitrite	APHA-4500NO2 B	mg/L	≤3	0.035
11	Ammonia	APHA-4500-NH3-B	mg/L	—	0.07
12	Arsenic	APHA-3500As B	mg/L	<0.05	N.D.
13	Antimony	APHA-3500Sb B	mg/L	<0.005	N.D.
14	Barium	APHA-3500Ba B	mg/L	0.7	N.D.
15	Chloride	APHA-4500Cl- B	mg/L	250	82
16	Fluoride	APHA-4500F- C	mg/L	<1.5	0.76

PDWQS: Punjab Drinking Water Quality Standards N.D = Not Detected

Note:

- Selected measurement units were mg/L otherwise stated.
- The measurements were carried out on client request. The client is responsible lawful usage of reported data in future. The report is not valid for court.

Signature of Analyst

Signature
Incharge Environmental Monitoring:

HEAD OFFICE: 2nd Floor, Suite # 11, Anwar Tower, 99-Shadman, Lahore, Pakistan

Groundwater Quality Analysis of the Legacy Landfill

Integrated Environment Laboratory

DRINKING WATER ANALYSIS REPORT

Reference Number	PICIIP/ENV/051-2023		
Project Name:	Punjab Intermediate Cities Improvement Investment Project	**Sampling Location:**	Existing Transfer Station Band Road, TMA Office Opposite Model Bazar, Bahawalpur
Sampling Date:	16-05-2023	**Source**	Drinking Water
GPS Coordinates:	29°23'58.0"N 71°41'06.4"E	**Monitoring Instrument:**	APHA/USEPA Standard Methods

Sr. No.	Parameters	Analysis Method	Units	PEQS	Results
1	pH	APHA-4500H+ B	--	6.5-8.5	7.8
2	Taste & Odor	In-house	--	Non Objectionable	Non Objectionable
3	Color	APHA-2120 B/C	TCU	<15	8
4	Turbidity	APHA-2130 B	NTU	<5	5
5	Total Coliform	APHA 9222 B	Number/100 mL	0 Number/100 mL	0
6	E-Coli	APHA 9222 D	Number/100 mL	0 Number/100 mL	0
7	Total Dissolved Solids (TDS)	APHA-2540 C	mg/L	<1000	384
8	Total Hardness	APHA-2340 C	mg/L	<500	129
9	Nitrate	APHA-4500NO3 B	mg/L	≤50	4.1
10	Nitrite	APHA-4500NO2 B	mg/L	≤3	0.24
11	Ammonia	APHA-4500-NH3-B	mg/L	---	N.D
12	Arsenic	APHA-3500As B	mg/L	<0.05	N.D.
13	Antimony	APHA-3500Sb B	mg/L	<0.005	N.D.
14	Barium	APHA-3500Ba B	mg/L	0.7	N.D.
15	Chloride	APHA 4500Cl- B	mg/L	250	137
16	Fluoride	APHA-4500F- C	mg/L	<1.5	0.86

PDWQS: Punjab Drinking Water Quality Standards N.D = Not Detected

Note:

- Selected measurement units were mg/L otherwise stated.
- The measurements were carried out on client request. The client is responsible lawful usage of reported data in future. The report is not valid for court.

Signature of Analyst

Signature of Chief Chemist

Integrated Environment Laboratory

FOR ENVIRONMENTAL MONITORING, ANALYSIS & SURVEYS

Street No. 09, Main Canal Road, Abshaar Colony Warsak Road, Peshawar, Pakistan

Soil Quality Analysis of the Legacy Landfill

Integrated Environment Laboratory

EPA Approved

SOIL ANALYSIS REPORT

Reference Number:	PICIIP/ENV/061-2023		
Project Name:	Punjab Intermediate Cities Improvement Investment Project	**Sampling Location:**	Existing Transfer Station Band Road, TMA Office Opposite Model Bazar, Bahawalpur
Source:	Soil Sample	**GPS Coordinates:**	29°23'58.0"N 71°41'06.4"E
Sampling Depth:	From Surface		

Sr. No.	Parameters		Results
1	Soil Texture	Sand %	15
		Silt%	46
		Clay %	39
		Texture Class	Sandy Clay Loam
2	pH		8.6
3	Electrical Conductivity EC (μSm^{-1})		231
4	Phosphorus ($mgkg^{-1}$)		3.2
5	Sodium Absorption Ratio		3.54
6	Oil & Grease ($mgkg^{-1}$)		1.03

μSm^{-1}: Micro siemens/meter

$mgkg^{-1}$: milligram per Kilogram

Signature of Analyst:

Signature of Chief Chemist

Integrated Environment Laboratory

Integrated Environment Laboratory

EPA Accredited

SOIL ANALYSIS REPORT

Reference Number:	PICIIP/ENV/001-2023		
Project Name:	Punjab Intermediate Cities Improvement Investment Project	Sampling Location:	Existing Transfer Station Band Road, TMA Office Opposite Model Bazar, Bahawalpur
Source:	Soil Sample	GPS Coordinates:	29°23'58.0"N 71°41'06.4"E
Sampling Depth:	3 Feet		

Sr. No.	Parameters		Results
1	Soil Texture	Sand %	23
		Silt%	41
		Clay %	36
		Texture Class	Sandy Clay Loam
2	pH		7.8
3	Electrical Conductivity EC (μSm^{-1})		236
4	Phosphorus ($mgkg^{-1}$)		3.5
5	Sodium Absorption Ratio		3.69
6	Oil & Grease ($mgkg^{-1}$)		0.67

μSm^{-1}: Micro siemens/meter

$mgkg^{-1}$: milligram per Kilogram

Signature of Analyst:

Signature of Chief Chemist

Integrated Environment Laboratory

FOR ENVIRONMENTAL MONITORING, ANALYSIS & SURVEYS

Appendix A.5 Occupational Health and Safety Plan

General

Occupational Health and Safety covers all personnel working under the project and will be in line with the World Bank/IFC EHS guidelines on health and safety.

The Occupational Health and Safety program will aim to ensure that the workplace is safe and healthy by: addressing the hazards and risks at the workplace; outlining the procedures and responsibilities for preventing, eliminating and minimizing the effects of those hazards and risks; identifying the emergency management plans; and, specifying how consultation, training and information are to be provided to employees at various workplaces.

Some of the risks/hazards associated with workplaces are due to working close to or at sites associated with the various project construction activities. Other risks associated with the project construction phase include risk of increase of vector borne and other different diseases.

The following sections will be implemented during the construction phase to address and ensure workers' health and safety.

a. Screening and regular unannounced checking of workers

As per the procedure for hiring workers, all contractors and labor agencies are required to make all prospective workers undergo medical tests to screen for diseases and sicknesses, prior to selection and employment of any worker. The contractor is also responsible for ensuring that no worker who has a criminal record is employed at the project site. It will be ensured that all workers undergo medical tests to screen diseases at source and at sites in consultation with the designated Health Officer.

In addition to this, the Project Management will also undertake sudden, unannounced checks on workers to look for diseases such as HIV, STDs, and hepatitis and take necessary steps as mandated by the Contractual agreement between the Contractor and the Worker(s).

b. Minimizing hazards and risks at the workplace.

To ensure safety at all work sites, the following will be carried out:

i. Installation of signboards and symbols in risky and hazardous areas, to inform workers to be careful.

ii. Construction of barricades around construction sites and deep excavated pits, to cordon off and deter entry of unauthorized personnel and workers into these areas.

iii. Providing a safe storage site/area for large equipment such as power tools and chains, to prevent misuse and loss.

iv. Proper Housekeeping: Ensuring that materials are all stacked, racked, blocked, interlocked, or otherwise secured to prevent sliding, falling, or collapse. Brick stacks will not be more than 7 feet in height and for concrete blocks they will not be more than 6 feet high.

v. Removing all scrap timber, waste material and rubbish from the immediate work area as the work progresses.

vi. Where scaffolds are required, ensuring that each scaffold or its components shall be capable of supporting its own weight and at least 4 times the maximum intended load applied or transmitted to it. The platform/scaffold plank shall be at least 15 inches wide and 1.5 inches thick. The rope should be capable of supporting at least 6 times the maximum intended load applied or transmitted to that rope. Pole scaffolds over 60 feet in height shall be designed by a registered professional engineer and shall be constructed and loaded in accordance with that design. Where scaffolds are not provided, safety belts/safety nets shall be provided;

vii. Ensure that all ramps or walkways are at least 6 feet wide, having slip resistance threads and not inclined at more than a slope of 1 vertical and 3 horizontals.

viii. Stacking away all excavated earth at least 2 feet from the pit to avoid material such as loose rocks from falling back into the excavated area and injuring those working inside excavated sites.

ix. Constructing support systems, such as bracing to adjoining structures that may be endangered by excavation works nearby.

x. Only a trained electrician to construct, install and repair all electrical equipment to prevent risks of electrical shocks and electrocution.

xi. Install fire extinguishers and/or other fire-fighting equipment at every work site to prepare for any accidental fire hazards.

c. Provision of Personal Protective Equipment

Risks to the health and safety of workers can be prevented by provision of Personal Protective Equipment (PPEs) to all workers. This will be included in the construction cost for each Contractor. Depending on the nature of work and the risks involved, contractors must provide without any cost to the workers, the following protective equipment:

i. High visibility clothing for all personnel during road works must be mandatory.

ii. Helmet shall be provided to all workers, or visitors visiting the site, for protection of the head against impact or penetration of falling or flying objects.

iii. Safety belt shall be provided to workers working at heights (more than 20 ft) such as roofing, painting, and plastering.

iv. Safety boots shall be provided to all workers for protection of feet from impact or penetration of falling objects on feet.

v. Ear protecting devices shall be provided to all workers and will be used during the occurrence of extensive noise.

vi. Eye and face protection equipment shall be provided to all welders to protect against sparks.

vii. Respiratory protection devices shall be provided to all workers during occurrence of fumes, dusts, or toxic gas/vapor.

viii. Safety nets shall be provided when worPunjablaces are more than 25 feet (7.5 m) above the ground or other surfaces where the use of ladders, scaffolds, catch platforms, temporary floors or safety belts is impractical.

The specific PPE requirements for each type of work are summarized below.

PPE Requirement List

Type of Work	PPE
Elevated work	Safety helmet, safety belt (height greater than 20 ft), footwear for elevated work.
Handling work safety	Helmet, leather safety shoes, work gloves.
Welding and cutting work	Eye protectors, shield and helmet, protective gloves.
Grinding work	Dust respirator, earplugs, eye protectors.

Work involving handling of chemical substances	Dust respirator, gas mask, chemical-proof gloves. Chemical proof clothing, air-lined mask, eye protectors.
Wood working	Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator.
Blasting	Hard hat, eye and hearing protection.
Concrete and masonry work	Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator.
Excavation, heavy equipment, motor graders, and bulldozer operation	Hard hat, safety boots, gloves, hearing protection.
Quarries	Hard hat, eye protectors, hearing protection, safety footwear, leather gloves and dust respirator.

d. Procedures to Deal with Emergencies such as Accidents, Sudden Illness and Death of Workers

First aid kits will be made available at all times throughout the entire construction period by the respective contractors. This is very important, because most work sites will be at some distance from the nearest hospital. In addition to the first aid kits, the following measures should be in place:

i. Provision of dispensaries by the individual EPC contractor.

ii. A vehicle shall be on standby from the Project Office so that emergency transportation can be arranged to take severely injured/sick workers to the nearest hospital for immediate medical attention.

iii. A designated Health Officer/worker for the Project will be identified as a focal person to attend to all health and safety related issues. This employee's contact number will be posted at all work sites for speedy delivery of emergency services. The focal person shall be well versed with the medical system and facilities available at the hospital.

iv. Communication arrangements, such a provision of radios or mobile communication for all work sites, for efficient handling of emergencies, will be made.

e. Record Maintenance and Remedial action

The Project Management will maintain a record of all accidents and injuries that occur at the work site. This work will be delegated by the contractor to the site supervisor and regularly reviewed every quarter by project management. Reports prepared by the contractor shall include information on the place, date and time of the incident, name of persons involved, cause of incident, witnesses present and their statements. Based on such reports, the management can jointly identify any unsafe conditions, acts or procedures and recommend for the contractor to undertake certain mitigative actions to change any unsafe or harmful conditions.

f. Compensation for Injuries and Death

Any casualty or injury resulting from occupational activities should be compensated as per the local labor laws. Where compensation is sought by the injured party, proper procedures for documentation of the case will be followed, including a detailed report on the accident, written reports from witnesses, report of the examining doctor and his/her recommendation for treatment. Each individual contractor will be responsible for ensuring compensation for the respective workers.

g. Awareness Programs

The Project management will undertake awareness programs through posters, talks, and meetings with the contractors to undertake the following activities:

i. Dissemination sessions will clarify the rights and responsibilities of the workers regarding interactions with local people (including communicable disease risks, such as HIV/AIDS), work site health and safety, waste management (waste separation, recycling, and composting), and the illegality of poaching.

ii. Make workers aware of procedures to be followed in case of emergencies such as informing the focal health person who in turn will arrange the necessary emergency transportation or treatment.

h. Nomination of a Health and Safety Focal Person

Within each site (especially if different sites are being implemented by different contractors), a Health and Safety Focal Person will be appointed. The Terms of Reference for the focal person will mainly be as follows:

i. Function as the focal person/representative for all health and safety matters at the workplace;

ii. Responsible for maintaining records of all accidents and all health and safety issues at each site, the number of accidents and its cause, actions taken and remedial measures undertaken in case of safety issues;

iii. Be the link between the contractor and all workers and submit grievances of the workers to the contractor and instructions/directives on proper health care and safety from the contractors back to the workers;

iv. Ensure that all workers are adequately informed on the requirement to use Personal Protective Equipment and its correct use;

v. Also responsible for the first aid kit and making sure that the basic immediate medicines are readily available.

Appendix A.6 Emergency Response Plan

PURPOSE

The purpose of this Emergency Response Procedure is to provide measures and guidance for the establishment and implementation of emergency preparedness plans for the project. The aim of the Emergency Response Procedure is to:

(i) Ensure all personnel and visitors to the office/job sites are given the maximum protection from unforeseen events.

(ii) Ensure all personnel are aware of the importance of this procedure to protection of life and property.

EMERGENCY PREPARATION AND RESPONSE MEASURE SCOPE

The emergency management program is applied to all Project elements and intended for use throughout the Project life cycle. The following are some emergencies that may require coordinated response.

(i) Construction Accident

(ii) Road & Traffic Accident

(iii) Hazardous material spills

(iv) Structure collapse or failure

(v) Trauma or serious illness

(vi) Sabotage

(vii) Fire

(viii) Environmental Pollution

(ix) Loss of person

(x) Community Accident

RESPONSIBILITIES

The detailed roles and responsibilities of certain key members of the Emergency Response team available to assist in emergency are provided in **Table G.1** below.

Emergency Response Team

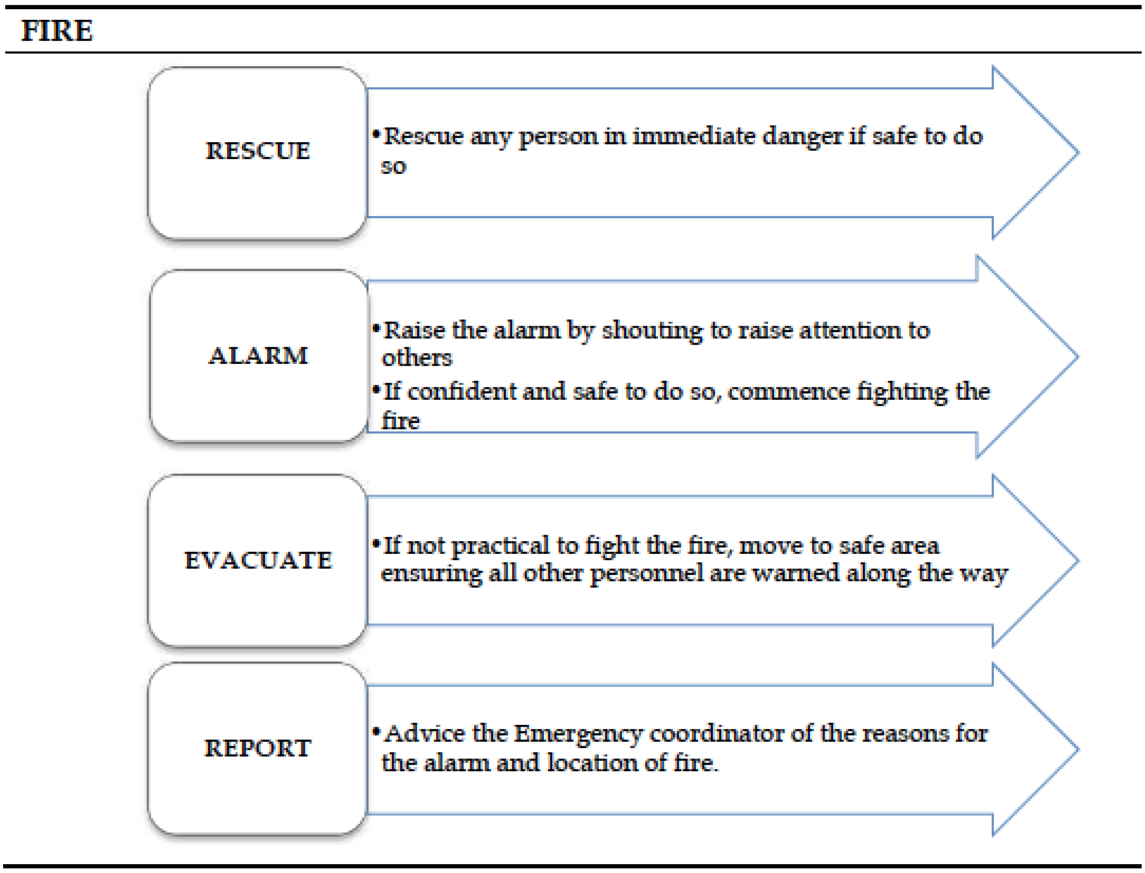
Action Group	Responsibility
Emergency Coordinator	Overall control of personnel and resources. The Emergency Coordinator will support and advise the Site Safety Supervision as necessary. Serves as public relations spokes persons, or delegates to some staff member the responsibility for working with news media regarding any disaster or emergency. Also assure proper coordination of news release with appropriate corporate staff or other designated people.
Site Safety Supervision (Emergency Commander)	Overall responsibility for activating emergency plan and for terminating emergency actions. Be alternative of emergency response chairpersons. Disseminates warnings and information as required to ensure all people in the immediate area have been warned and evacuated either by alarms or by word of mouth. Supervise the actions of the Emergency Response Team to ensure all persons are safe from the danger. Notify outside authorities if assistance is required. Carries the responsibility for coordinating actions including other organizations in accordance with the needs of the situation. Ensure maximum co-operation and assistance is provided to any outside groups called to respond to an emergency. Establish and appoint all emergency organization structure and team. Assures adequate delegation of responsibilities for all key positions of assistants on the Project to assist with any foreseeable emergency. Ensure resources available to purchase needed emergency response equipment and supplies. Assures that all persons on the Emergency Response Team aware and fully understand their individual responsibilities for implementing and supporting the emergency plan. Establish the emergency drill schedule of all identified emergency scenarios, track the status and evaluate the emergency. The Emergency Commander shall ensure that senior management personnel have been reported of the emergency as soon as practical after the event.
Security Team	Ensure that the exit route is regularly tested and maintained in good working order. Maintain station at the security gate or most suitable location to secure the area during any emergency such that only authorized

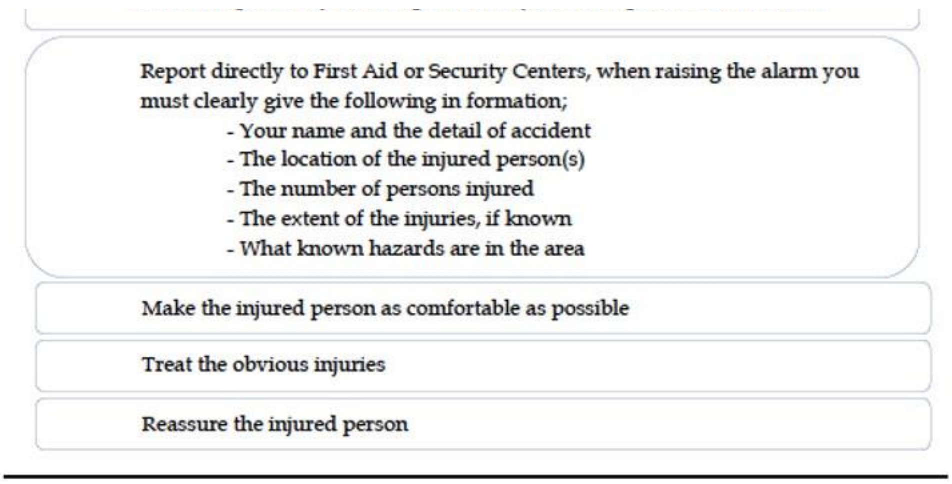
Action Group	Responsibility
	personnel and equipment may enter, prevent access to the site of unauthorized personnel. Assist with strong/activation of services during an emergency. Ensure vehicles and obstructions are moved to give incoming emergency vehicles access to the scene, if ambulance or emergency services are attending the site, ensure clear access and personnel are located to direct any incoming emergency service to the site of emergency.
Rescue & Medical Team	Protect the injured from further danger and weather. Provide treatment to the victim(s) to the best of their ability by first aid and then transfer to hospital. Remain familiar with the rescue activities and rescue apparatus. Assist outside medical services personnel when they arrive
General Administration Team	Response to support any requested general facilities for assisting Emergency Response Team in their work.
Government Relation Team	Coordinate with local government on a matter of concerned in the emergency response plan to liaise with local officers in their affair for support Emergency Response Team. Coordinate emergency plan with the government authorities, local community.
Environment Team	In case of emergency related to the environmental pollution such as the chemical spill, oil spill into the ambient, the environment team will support the technical advice to control and mitigate the pollution until return to the normal situation.
Department Heads	Call up of personnel into the safe location for protective life and property. Take immediate and appropriate action while Emergency Response Team is being mobilized. Keep in touch with the Emergency Commander Control and supervise operators and contractors on the implementation of this procedure, with consultation with Safety Team as necessary. Provide and maintain emergency equipment of their responsible areas.
Other Staff and Employees	All other staff and employees will remain at their workstations or assembly point unless directed otherwise from Emergency Response Team. Each supervisor will ensure that all members of his work group are accounted for and keep in touch with each of their Department Head.

PROCEDURE

Emergency situation and injuries to person can occur at any time or place either on Project site or elsewhere. The most two common types of emergencies on site are fire and serious accident.

Emergency Procedure for Fire





COMMUNICATION WITH AUTHORITIES / PRESS AT SITE

In the event of an accident or incident, only senior staff is permitted to give factual information to the authorities for resource of liability exposure. The press must be avoiding politely, at all costs, with the terse comment that “the matter is under investigation and relevant information when available will be provided by our Head Office” Do not ever give your opinion or story.

First Aid Persons

- Upon advice of medical emergency, make immediate assessment to response required and if necessary, advise security to summon ambulance or medical assistance, the qualified first aid attendant should also,
- Provide treatment to the victim(s) to the best of his/her ability.
- Ensure the safety of victims by ceasing any work activity in the area.
- Protect the injured from further danger and weather.
- Assist medical services personnel when they arrive.

General Administration Team

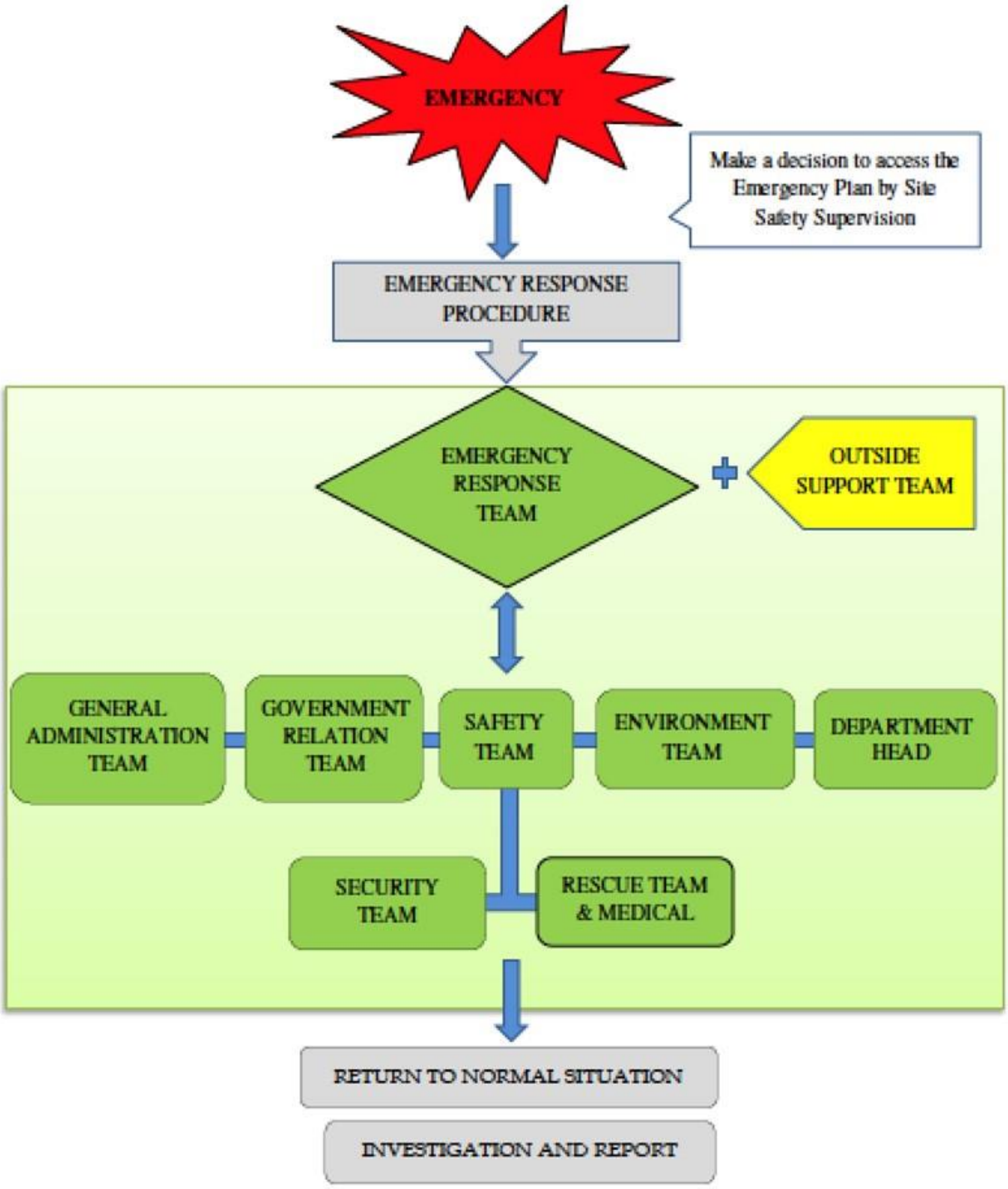
- Upon advice of medical emergency, maintain contact with first aid personnel and summon ambulance if required.

Security Team

- If ambulance or emergency services are attending the site, ensure clear access and personnel are located to direct vehicle closest to the scene.
- Prevent access to the site of unauthorized personnel (press, etc.).

Emergency Coordinator

- The Emergency Coordinator shall assist emergency personnel at the scene as required through allocation of company resources.
- The Emergency Coordinator shall ensure next-of-kin are properly notified as soon as possible and give whatever company support and assistance is necessary to assist them bundle the situation
- The Emergency Coordinator shall ensure that senior management personnel are advised of the emergency as soon as practical after the event.



Note: Name of contact person and call number from Owner/Contractor to be determined.

INCIDENT AND ACCIDENT REPORT

Section A: Identification Data

Report No:	Date of Reported:	Reporter:	Sign:
Job Title:		Company Name:	

Section B: Violence Rate

Accident Violence: ☐ 01-Death ☐ 02-Serious Injury ☐ 03-Lost Time Injury ☐ 04-First Aid ☐ 05- Not Injury ☐ 06-Near Miss

Property Damage Cost: ☐ 1-2,000 USD ☐ 2,001-10,000 USD ☐ 10,001-50,000 ☐ > 50,001

Section C: Environmental Impact

Affected area	☐ Construction area	☐ Public area	
Receptor	☐ None	☐ Workers	☐ Community
Type of pollution	☐ Physical	☐ Chemical	☐ Biological
Toxicity	☐ Non-toxic	☐ Low - toxic	☐ High - toxic
Return to Normal	☐ 1 day	☐ 1 day to 1 week	☐ ≥ 1 week
Cumulative impact	☐ Non-cumulative	☐ Cumulative	

Section D: Injured/Illness Employee

1.Name:	Sex:	Date of Birth:			Age:	Regular Job Title:	Experience:
	☐ Male ☐ Female	Month	Day	Year			In this job title: Years Weeks In this Project: Years Weeks

Site:	Company:	Reference:	Phone No:	Social Security Number

Part of Body Injured or Affected:

☐ Head ☐ Hands ☐ Face ☐ Nose
☐ Eyes ☐ Legs ☐ Teeth ☐ Neck
☐ Trunk ☐ Toes ☐ Elbow ☐ Shoulder
☐ Back ☐ Ankle ☐ Wrist ☐ Foot
☐ Arms ☐ Thump ☐ Fingers ☐ Internal

Remark: ....

Nature of Injury or Illness:

☐ Laceration ☐ Amputation ☐ Puncture ☐ Fracture
☐ Strain & Sprain ☐ Burns ☐ Contusion ☐ Dry Heat Friction
☐ Hernia ☐ Foreign Body ☐ Chemical ☐ Contamination
☐ Skin (Occupationnel) ☐ Rash ☐ Irritation

Remark: ....

2.Name:	Sex:	Date of Birth:			Age:	Regular Job Title:	Experience:
	☐ Male ☐ Female	Month	Day	Year			In this job title: Years Weeks In this Project: Years Weeks

Site:	Company:	Reference:	Phone No:	Social Security Number

Part of Body Injured or Affected:

☐ Head ☐ Hands ☐ Face ☐ Nose
☐ Eyes ☐ Legs ☐ Teeth ☐ Neck
☐ Trunk ☐ Toes ☐ Elbow ☐ Shoulder
☐ Back ☐ Ankle ☐ Wrist ☐ Foot
☐ Arms ☐ Thump ☐ Fingers ☐ Internal

Remark: ....

Nature of Injury or Illness:

☐ Laceration ☐ Amputation ☐ Puncture ☐ Fracture
☐ Strain & Sprain ☐ Burns ☐ Contusion ☐ Dry Heat Friction
☐ Hernia ☐ Foreign Body ☐ Contamination ☐ Chemical
☐ Skin (Occupationnel) ☐ Rash ☐ Irritation

Remark: ....

Section E: Accidents/incident Details

Date Accident/Incident Occurred:	Time Accident/Incident Occurred:	Exact Location of the Accident / Incident:

Details of the actual Job Being done at the time:
Details of Accident / Incident / What actually happened?

Section F: Accident Cause (Basic cause mark X / Contributing cause, if any mark O)

UNSAFE CONDITIONS		UNSAFE ACTS	
1	☐ Inadequately Guarded	1	☐ Operating Without Authority / Training
2	☐ Unguarded	2	☐ Operating at Unsafe Speed
3	☐ Defective Tools, Equipment, or Substance	3	☐ Marking SHE Device Inoperative
4	☐ Unsafe Design or Construction	4	☐ Using Unsafe Equipment or Equipment Unsafely
5	☐ Hazardous Arrangement	5	☐ Unsafe Loading, Placing, Mixing
6	☐ Unsafe Illumination	6	☐ Taking Unsafe Position
7	☐ Unsafe Ventilation	7	☐ Working on Moving or Dangerous Equipment
8	☐ Unsafe Clothing	8	☐ Distraction, Teasing, Horse Play
9	☐ Insufficient Instruction	9	☐ Failure to use Personal Protective Devices
10	☐ Lack of system of work	10	☐ Lack of effective instruction or supervision

Why was the unsafe act committed?____________ Why did the unsafe condition exist?____________

Section G: Guide to Corrective Action (Base on the cause checked above, I am taking the following corrective action)

UNSAFE ACT	UNSAFE CONDITION	If Supervisor can't handle, then recommend to
☐ Stop the Behaviour	☐ Remove	☐ Site Engineer, or
☐ Study the job	☐ Guard	☐ Site Manager, or
☐ Instruct (tell-show-try-check)	☐ Warn	☐ Project Manager, or
☐ Follow Up	☐ Supervisory Training	☐ Safety Committee
☐ Enforce		

Detail below any immediate remedial actions that have been taken:

Detail below any corrective and preventative actions that could be taken to prevent future re-occurrence:	Responsible	Completion Date

Section H: Witness Statement			
Witness Name		Interviewer Name	
Section I: Reviewed & Recommend by			
Recommendation:			
Reviewed By:	Position:	Signature:	Date:
Remarks : If Accident or Incident happened with lost time injury and affected to the publicity must further report to Safety Department; : First Aid Cases will not applicable to this form; : The accident report shall submit to Safety Department within 3 days : Attached the photograph or sketch the location of accident / incident;			

Appendix A.7 Archaeological 'Chance Find' procedure

Background

The purpose of this document is to address the possibility of archaeological deposits becoming exposed during ground altering activities within the project area and to provide protocols to follow in the case of a chance archaeological find to ensure that archaeological sites are documented and protected as required.

Archaeological sites are an important resource that is protected for their historical, cultural, scientific and educational value to the general public and local communities. Impacts to archaeological sites must be avoided or managed by development proponents. The objectives of this 'Archaeological Chance Find Procedure' are to promote preservation of archaeological data while minimizing disruption of construction scheduling/ It is recommended that due to the moderate to high archaeological potential of some areas within the project area, all on site personnel and contractors be informed of the Archaeological Chance Find Procedure and have access to a copy while on site.

Potential Impacts to Archaeological Sites

Developments that involve excavation, movement, or disturbance of soils have the potential to impact archaeological materials, if present. Activities such as road construction, land clearing, and excavation are all examples of activities that may adversely affect archaeological deposits.

Archaeological 'Chance Find' Procedure

If you believe that you may have encountered any archaeological materials, stop work in the area and follow the procedure below:

The following 'chance-find' principles will be implemented by the contractor throughout the construction works to account for any undiscovered items identified during construction works:

(i) Workers will be trained in the location of heritage zones within the construction area and in the identification of potential items of heritage significance.

(ii) Should any potential items be located, the site supervisor will be immediately contacted and work will be temporarily stopped in that area.

(iii) If the site supervisor determines that the item is of potential significance, an officer from the department of Archaeology (DoA) will be invited to inspect the site and work will be stopped until DoA has responded to this invitation.

(iv) Work will not re-commence in this location until agreement has been reached

between DoA and proponent as to any required mitigation measures, which may include excavation and recovery of the item.

(v) A precautionary approach will be adopted in the application of these procedures.

Detailed Procedural Steps

If the Director, department of Archaeology receives any information or otherwise has the knowledge of the discovery or existence of an antiquity of which there is no owner, he shall, after satisfying himself as to the correctness of the information or knowledge, take such steps with the approval of the Government, as he may consider necessary for the custody, preservation and protection of the antiquity.

Whoever discovers, or finds accidentally, any movable antiquity shall inform forth with the Directorate within seven days of its being discovered or found.

If, within seven days of his being informed, the Director decides to take over the antiquity for purposes of custody, preservation and protection, the person discovering or finding it shall hand it over to the Director or a person authorized by him in writing.

Where the Director decides to take over an antiquity, he may pay to the person by whom it is handed over to him such cash reward as may be decided in consultation with the Advisory Committee.

The Director or any officer authorized by him with police assistance may, after giving reasonable notice, enter into, inspect and examine any premises, place or area which or the sub-soil of which he may have reason to believe to be, or to contain an antiquity and may cause any site, building, object or any antiquity or the remains of any antiquity in such premises, place or area to be photographed, copied or reproduced by any process suitable for the purpose.

The owner or occupier of the premises, place or area shall afford all reasonable opportunity and assistance to the Director.

No photograph, copy of reproduction taken or made shall be sold or offered for sale except by or with the consent of the owner of the object of which the photograph, copy or the reproduction has been taken or made.

Where substantial damage is caused to any property as a result of the inspection, the Director shall pay to the owner thereof reasonable compensation for the damage in consultation with the Advisory Committee.

If the Director after conducting an inquiry, has reasonable grounds to believe that any land contains any antiquity, he may approach the Government to direct the Revenue Department to acquire such land or any part thereof and the Revenue Department shall thereupon acquire such land or part as for a public purpose.

Appendix A.8 Dust Management Plan

General

The purpose of this plan is to describe the measures that the project shall take to ensure that the risk of emissions from dust generated by site operations during construction are minimized and that best practice measures are implemented.

Dust emissions from construction can cause ill health effects to Contractor staff along with nuisance and annoyance to members of the local community. Dust will be controlled through:

- Elimination
- Reduction/Minimisation
- Control

This dust management plan shall be implemented based on the measures already provided in the Environmental Management Plan (EMP) relating to controlling dust emissions.

Methodology

The following methodology will be undertaken for each project section:

Step 1 – Identify the dust generating activities

Construction activities that are likely to produce dust will be identified. The activities that will be taken into account are:

- Haulage Routes, Vehicles and Asphalt/Concrete Batching Plant
- Roads, surfaces and public highways
- Static and mobile combustion plant emissions
- Tarmac laying, bitumen surfacing and coating
- Materials Handling, Storage, Spillage and Disposal
- Storage of material
- Stockpiles
- Spillages
- Storage of Waste
- Site Preparation and Restoration after Completion
- Earthworks, excavation and digging
- Storage of spoil and topsoil
- Demolition
- Construction and Fabrication Processes

Step 2 – Identify Sensitive Receptors

Sensitive receptors have already been identified. The nature and location of the sensitive receptors will be taken into account when implementing control measures.

Step 3 – Implement Best Practice Measures to Control

Based on the nature of the activity producing the dust, the likelihood of dust being produced and the possible consequence of dust based on the sensitive receptors, the most effective control measure will be identified and implemented.

Step 4 – Monitor effectiveness of control

Construction Supervision Staff (CSC) will have the responsibility to ensure that dust control measures are being implemented and are effective.

Step 5 – Record and report result of monitoring

All inspections, audits and results of monitoring will be recorded and kept as part of the site filing system.

Method Statements and Risk Assessments

The Contractor's Risk Assessments and Method Statements will be required to be approved by the CSC prior to commencing work and will be required to contain environmental aspects of the task, including dust control measures where required.

Where dust has been identified within the risk assessment as a significant issue, the method statement will be required to cover the following:

- Methods and materials that will be used to ensure that dust generation is minimized.
- The use of pre-fabricated materials where possible.
- Optimum site layout:
- Dust generating activities to be conducted away from sensitive receptors
- Supply of water for damping down.
- Good housekeeping and management
- All employees will be briefed on the Risk Assessment and Method Statement before starting work.

Training

All Contractor staff will be required to attend training seminars as already mentioned in the EMP document. A site-specific induction will also be required before being allowed to work on site. These will include site-specific sensitive receptors and details regarding dust control measures to be taken.

Toolbox talks on air pollution and minimizing dust emissions will be provided on a regular basis to Contractor staff.

Identification of Dust Generating Sources and Control Methods

Haulage Routes, Vehicles and Asphalt/Concrete Batching Plant

Dust Source	Dust Control Methods
Major haul roads and traffic routes	Haul roads will be dampened down via a mobile bowser, as required.
Public Roads	Road sweeper will be used to clean public roads as required.
Site traffic management	Site traffic will be restricted to constructed access roads as far as possible. Site speed limit will be set at 10 mph as this will minimize the production of dust.
Road Cleaning	A mechanical road sweeper will be readily available and used.
Handling, Storage, Stockpiling and Spillage of Dusty materials	
Material handling operations	The number of times a material will have to be handled will be kept to a minimum to prevent double handling and ensure dusty materials are not handled unnecessarily.
Transport of fine dusty materials and aggregates.	Closed tankers will be used or sheeted vehicles.
Vehicle loading/unloading materials on to vehicles and conveyors.	Dusty materials will be dampened down Drop heights will be kept to a minimum and enclosed where possible.
Storage of Materials	
Bulk cement, bentonite etc.	Bentonite will be delivered in tankers and stored in dedicated enclosed areas. Bulk cement will be transported through tractor trollies or trailers.
Fine dry materials	These will be protected from the weather and by storing in appropriate containers and indoors, where necessary.
Storage location	Material will be stored in dedicated lay-down areas.
Storage of Stockpiles	
Stockpile location	Stockpiles will be placed so as to minimize double handling and facilitate the site restoration.
Building stockpiles	Stockpiles, tips and mounds will not be stored at an angle greater than an angle of repose of the material.
Small and temporary stocPunjabiles	Where possible, stocPunjabiles will be placed under sheeting. Dusty material will be damped down.

Dust Source	Dust Control Methods
	Wind barriers (protective fences) of a similar height to the stocPunjabile will be erected, if required.
Large and long term stockpiles	Long-term stockpiles will be vegetated and stabilized as soon as possible. Stock plies will be dampened down until stabilized, where necessary. Wind barriers (protective fences) of a similar height to the stockpile will be erected, if required.
Waste Material from Construction	
Disposal method	A dedicated lay-down area will be available for waste. Waste will not be allowed to build up and will be disposed off at the designated locations as per EMP.
Site Preparation and Restoration	
Earthworks, excavation and digging	These activity areas will be kept damp where required and if possible, will be avoided during dry and windy periods.
Completed earthworks	Surfaces will be stabilized by re-vegetation as soon as possible, where applicable.
Construction and Fabrication Process	
Crushing of material for reuse, transportation and disposal	Authorization will be obtained from PMU and ADB before using any mobile plant on site for activities such as crushing and screening. Any crushing or screening activities will be located away from sensitive receptors.
Cutting, grinding, drilling, sawing, trimming, planning, sanding	These activities will be avoided wherever possible. Equipment and techniques that minimize dust will be implemented. Water will be used to minimize dust.
Cutting roadways, pavements, blocks	Water sprinkling to be used.
Angle grinders and disk cutters	Best practice measures will be used such as dust extraction

Monitoring Arrangements

Monitoring will be conducted at sensitive receptor locations in the project area as provided in the EMP. Furthermore, at locations where PM levels are exceeding applicable guidelines, additional stringent measures will be implemented at the respective location(s) in the project area to ensure dust levels are controlled as far as possible.

Appendix A.9 Site Specific EMP (SSEMP) Guide & Template for Guidance to Contractor

Guide for Development of SSEMP

Step 1: Define Boundaries

Step 2: Identify Sensitive Receptors

Step 3: Specify construction activities

Step 4: Conduct Risk Assessment

Step 5: Assign Environment Management measures

Step 6: Prepare Site Plans

Step 7: Prepare Environment Work Plans (if required)

Step 8: Monitoring

Step 1: The project area needs to be clearly defined.

Step 2: The mapping of sensitive receptors has already been conducted and needs to be presented clearly in a map.

Step 3: The tentative construction activities to be conducted are as follows:

Site Surveying and Vegetation (Trees and plants) Clearance

Establishment of Work Camp, Batching and Asphalt plant and access roads

Dismantling of Asphalt and existing structures including Utilities

Preparation of ground for Asphalting

Asphalting

Landscaping

Step 4: The Risk Assessment matrix template is provided in the table below.

Risk is assessed as the likelihood that the activity will have an effect on the environment as well as the consequence of the effect occurring. It is often described like this:

Risk = Likelihood × Consequence

Likelihood Scale

Likelihood	Definition	Scale
Certain	Will certainly occur during the activity at a frequency greater than every week if preventative measures are not applied	5
Likely	Will occur more than once or twice during the activity but less than weekly if preventative measures are not applied	3
Unlikely	May occur once or twice during the activity if preventative measures are not applied	2

Rare	Unlikely to occur during the project	1

Consequence Scale

Consequence	Definition	Score
Catastrophic	The action will cause unprecedented damage or impacts on the environment or surrounding community e.g. extreme loss of soil and water resources and quality from stormwater runoff extreme pollution of soil and water resources including major contamination from hazardous materials widespread effects on ecosystems with deaths of fauna/flora widespread community impacts resulting in illness, injury or inconvenience loss or destruction of archaeological or historical sites Occurrence will almost certainly result in the work being halted and a significant fine.	5
Major	The action will cause major adverse damage on the environment or surrounding communities' e.g. major loss of soil and water resources and quality from stormwater runoff major pollution of soil and water resources including contamination from hazardous materials significant effects on ecosystems with isolated deaths of non-vulnerable flora and fauna significant annoyance or nuisance to communities major damage to or movement required to archaeological or historical sites Occurrence may result in work being halted and a fine	3
Moderate	No or minimal adverse environmental or social impacts e.g. no measurable or noticeable changes in stormwater quality. Water quality remains within tolerable limits little noticeable effect on ecosystems no or isolated community complaints no or unlikely damage to archaeological or historical sites no likelihood of being fined	2
Minor	No or minimal adverse environmental or social impacts e.g. no measurable or noticeable changes in stormwater quality. Water quality remains within tolerable limits little noticeable effect on ecosystems	1

	no or isolated community complaints no or unlikely damage to archaeological or historical sites no likelihood of being fined	

Risk Score Table

Likelihood	Consequence				
		Catastrophic	Major	Moderate	Minor
	Certain	25	15	10	5
	Likely	15	9	6	3
	Unlikely	10	6	4	2
	Rare	5	3	2	1

Risk: Significant: 15-25

Medium: 6-10

Low 1-5

Any Medium to Significant risk requires an environmental management measure to manage the potential environmental risk. Judgement will be required concerning the application of an environmental management measure to mitigate low risk situations.

The higher the risk the more intensive the required mitigation measure will need to be; e.g. where site sedimentation is deemed to be low risk, then silt fences may be needed but as the risk increases, then sediment traps may be required. The selection of the appropriate mitigation measure will require judgement based on the level of risk and the specific site parameters.

Step 5: The Environmental Management measures are to be extracted from the IEE study for the project and should be added in the last column of the table below.

No.	Construction Activity	Hazards to Consider	Likelihood that the site or sensitive receptors will be affected?	Consequence of the site or sensitive receptors being affected?	Risk Score (consequence x likelihood)	Environmental Management Measures
i	Site Surveying & vegetation clearance	Damage to vegetation beyond project footprint				These can be taken from the EMP provided in the IEE report (If Risk Score is 6 or more)
		Erosion of exposed areas and sediment				
		Loss of topsoil				
		Dust generation				
		Noise				
ii	Establishment of Work Camp, Batching plant etc.	Soil deposited onto roads from tires				
		StocPunjabile erosion				
		Noise & Vibration				
		Traffic congestion				
		Fuel spills				

iii	Dismantling of Asphalt and existing structures including Utilities	Noise and vibration				
		Dust generation				
		Community safety				
		Worker safety				
		Traffic Congestion				
iv	Preparation of Sub-Base	Noise and vibration				
		Dust generation				
		Traffic Congestion				
v	Asphalting	Noise and vibration				
		Dust generation				
		Traffic Congestion				
		Community safety				

		Labor safety (PPEs)				
vi	Landscaping	Dust generation				
		Sediment runoff				
		Failure of vegetation to take root				

Step 6: The Site plans are a critical part of the SSEMP and will need to be prepared, otherwise the ADB will consider the document as incomplete.

The site plan will need to provide the following:

Indication of North and scale

Existing and planned supporting infrastructure (e.g. access roads, water supplies and electricity supplies)

Location of planned work

Contours

Drainage systems

Locations of sensitive receptors

Step 7 (if required)[32]: The completed SSEMP provides details of all the environmental management requirements for all stages of the construction process. For individual work teams who are responsible for only a small part of the overall construction works it can be confusing as to what is required for their particular work component. For example, the work team responsible for stripping soil for the construction areas are not going to be interested in the requirements for pouring concrete for footings and foundations. However, it is essential that the soil stripping team knows exactly what to clear and what to leave and where to put stocPunjabiles of soil for later use.

In situations where different work activities are required at different times or at different locations, environmental work plans can be prepared. These are similar to the work method statements that are often produced for major construction projects.

Step 8: A detailed monitoring plan will be provided along with frequency and responsibilities to ensure all key environmental parameters are monitored to ensure compliance with both national and ADB requirements.

Template for SSEMP

Introduction

Project Overview

Scope of SSEMP

Objectives of SSEMP

Map of Sensitive Receptors

Construction Activities

Risk Assessment

Risk Assessment Matrix & Mitigation Measures

Site Plan(s)

Environmental Monitoring Plan

Instrumental Monitoring of Environmental Parameters by Contractor as per EMP

In-house monitoring

Third Party environmental monitoring

[32] ADB, Safeguards Unit for Central & West Asia Department, *Environmental Management for Construction Handbook.*

Visual monitoring of Environmental Parameters by Contractor as per EMP
Responsibilities
Organizational Responsibilities and Communication
Responsibility of EA
Responsibility of Construction Supervision Consultant (CSC)
Responsibility of Contractor
Responsibility of EPA

Appendix A.10 Accident and Incident Investigation Procedure

INCIDENT / NEAR MISS REPORT	QUALITY RECORDS / FORMS	
	Doc. Level:	Doc. Version:1
	Doc. No	

HS.T.02	INCIDENT / NEAR MISS REPORT	
Title of Project:		
Location:		Date:

Objective(s)

To implement immediate and effective process in order to provide immediate treatment against any fatality, Injuries, Casualty.

SECTION A: TO BE COMPLETED BY PERSON INVOLVED (OR BY SUPERVISOR OR HEALTH AND SAFETY REPRESENTATIVE IF WORKER IS INCAPACITATED) AND BY THEIR SUPERVISOR

Details of the person involved in the incident/near miss

Employee #: .... **Site Address** .... **Work phone:** ....

Name: .... **Father Name:** ....

Position: .... **Date of birth:** .... ☐ **Male** ☐ **Female**

Please select one: ☐ Member ☐ Client Member ☐ Sub Contractor ☐ Visitor/Other

Details of the: ☐ Incident ☐ Near miss ☐ Medical

Date: .... **Time:** .... A.M /P.M

City: .... **Location:** ....

Was the incident/near miss reported to your supervisor, immediately: ☐ Yes ☐ No

Part of the body injured

Head	Trunk	Internal	Arm	Hand	Leg	Foot eye
☐ neck	☐ heart	☐ left	☐ left	☐ left	☐ left	☐ ear
☐ hip	☐ lungs	☐ right	☐ right	☐ right	☐ right	☐
☐ nose	☐ chest	☐ systemic	☐ shoulder	☐ thumb	☐ knee	☐ great toe
☐ mouth	☐ stomach		☐ upper arm	☐ fingers	☐ lower leg	☐ other toes
☐ teeth	☐ groin		☐ elbow	☐ palm	☐ ankle	
☐ face	☐ back		☐ forearm		☐ thigh	
☐ skull	☐ multiple		☐ wrist		☐ upper leg	☐ psychosocial

Nature of injury

☐ abrasion	☐ puncture	☐ heart attack	☐ sprain	☐ burn	☐ traumatic shock
☐ bruise	☐ laceration	☐ hearing loss	☐ strain	☐ scald	☐ electric shock
☐ fracture	☐ amputation	☐ foreign body	☐ hernia	☐ rash	☐ psychosocial
☐ concussion	☐ bite	☐ minor cuts		☐ allergy	☐ chemical

☐ aggravation of previous injury or medical condition *(please describe)*: ....

Type of incident which caused injury

☐ striking against	☐ stumbling	☐ lifting	☐ pushing	☐ ingestion
☐ struck by	☐ slipping	☐ bending	☐ pulling	☐ absorption
☐ caught in/on	☐ tripping	☐ twisting	☐ jumping	☐ inhalation
☐ stepping on	☐ falling	☐ stress	☐ vehicle	☐ needlestick

☐ other *(please describe)*: ....

Appendix A.11 Traffic Management Plan

Need for Plan

The construction of the Landfill will take over 24 months and in this period, huge vehicular movement carrying large amount of material and machinery is expected. This will definitely interrupt the local traffic and is therefore important to manage the traffic to avoid the nuisance to local residents in terms of noise, dust, congestion and inconvenience.

The plan

The Objective of Traffic Management Plan (TMP) is to define the requirements that should be implemented to mitigate any potential negative risks to the environment, workers or the community resulting from construction traffic.

The TMP will advise and inform site Contractors and external suppliers of equipment and materials of access and entry points along with other key information such tipping areas and wash-out areas. It is intended to compliment and work alongside relevant ESMMP. The TMP will be classed as "live" and therefore be subjected to updates as required.

Contractor, at the time of the execution of the project will prepare a comprehensive TMP in coordination with local traffic police department, PMU, emergency services and local administrative department. The PMU and CSC will review and approve contractors TMP. The contractor's TMP shall include following mitigation measures during its preparation:

- Undertake a road conditions assessment prior to and following the peak construction period, to assess any damage to road infrastructure that can be attributed to Project construction.
- Repair damage as appropriate or enter into a voluntary agreement with the relevant roads authority to reimburse the cost of any repairs required to the public road network as a result of the Project.
- Spoil dumpsites located close to Project site to minimise journey distance and limit movements to site access roads.
- Concrete mixing plant located at Project site limiting traffic movements associated with concrete delivery to site access roads
- Construction of worker accommodation on site to reduce light vehicle movements relating to travel to/ from the site
- Provision of bus/minibus services for personnel living in nearby settlements
- Movements of construction workers will be planned to avoid the busiest roads and times of day when traffic is at its greatest.
- Schedule deliveries and road movements to avoid peak periods
- Road maintenance fund to leave a useful asset for communities after the construction phase.

- Driver training for HGV drivers and refresher course every six months for Project drivers
- Speed restrictions for project traffic travelling through communities (to be agreed with Traffic Management Authority)
- Run a safety campaign to improve the people's knowledge of the traffic hazard on their roads, public information and other activities to address the issues.
- Run a pedestrian awareness programme
- Temporary signage
- The traffic management plan is provided below.

Other Recommendations

It is important to manage public access routes during construction because it can cause delay to local traffic and create a safety hazard both on and offsite. People working and living near the project site would be annoyed by the emissions, noise and visual intrusion of queuing vehicles. Some important factors involved in access routes and site traffic are as follows:

Public Access Routes

The use of public road for site access may be restricted in terms of:

- Vehicle size, width and type of load
- Time limits
- Parking
- Pedestrian conflicts

Contractor should have consultation with the local police or local authority to address these issues and to effectively manage them before the beginning of the construction.

Site Workers Traffic

Site personnel should not be permitted to park vehicles near the site boundary; this will lead to disruption in material deliveries. Designated parking area with appropriate parking space will be needed for this purpose; any plain area near construction site can be used for this purpose.

Site Rules

- Access to and from the site must be only via the specified entrance.
- On leaving the site, vehicles must be directed to follow the directions given.
- Drivers must adhere to the site speed limits.
- All material deliveries to site must keep allocated time limits.
- No material or rubbish should be left in the loading-unloading area.
- Develop a map for alternate routes showing material delivery services.

- Assign designated personnel on site to receive deliveries and to direct the vehicles.
- Monitor vehicle movement to reduce the likelihood of queuing or causing congestion in and around the area.
- Project vehicles should have a unanimous badge or logo on windscreen displaying that they belong to the project.

Contractor's Obligation

The traffic management plan of the Contractor should be safe enough and widening of access roads and construction of the detours must be completed before start of project construction activities so that heavy vehicular transportation for construction activities do not hinder the normal course of traffic lanes. While widening the access roads, the safe movement of the vehicles, people, animals and wildlife must be ensured. It will be sole responsibility of Contractor. The roads widening should be designed on the basis of the traffic survey, summarized and estimated site traffic. Contractor must ensure that road closures are carried out by a competent person. The Contractor obligation must include the display of traffic signs according to the need to divert the traffic volume and to guide the road users in advance. The traffic sign, traffic light should be placed from any diverting route or road marking.

The Contractor should consider the environmental and social impacts of the traffic during construction. It will be sole responsibility of the Contractor to implement a plan which produces minimum nuisance to the local people and to the environment. Safety of the people should be given due importance. It will be under Contractor obligation to notify the traffic management plan and its later changes to CSC, PMU, emergency services and Traffic Police, and also publish weekly programme in local newspapers.

Appendix A.12 PEQS Guidelines

Parameter	Unit	Standards (maximum allowable limit)
Temperature increase	°C	<3
pH value (acidity / basicity)	pH	6-9
5-day biochemical oxygen demand (BOD) AT 20 °C	mg/l	80
Chemical oxygen demand (COD)	mg/l	150
Total dissolved solids	mg/l	200
Total dissolved solids	mg/l	3,500
Grease and oil	mg/l	10
Phenolic compounds (as phenol)	mg/l	0.1
Chloride (as Cl)	mg/l	1.0
Fluoride (as F)	mg/l	10
Sulfate (SO_4)	mg/l	600
Ammonia (NH_3)	mg/l	40
Cadmium	mg/l	0.1
Chromium (trivalent and hexavalent)	mg/l	1.0
Copper	mg/l	1.0
Lead	mg/l	0.5
Mercury	mg/l	0.01
Selenium	mg/l	0.5
Nickel	mg/l	1.0
Silver	mg/l	1.0
Total toxic metals	mg/l	2.0
Zinc	mg/l	5
Arsenic	mg/l	1.0
Barium	mg/l	1.5
Iron	mg/l	8.0
Manganese	mg/l	1.5
Boron	mg/l	6.0
Chlorine	mg/l	1.0

Notes:

1. The standard assumes that dilution of 1:10 on discharge is available. That is, for each cubic meter of treated effluent, the recipient water body should have 10 m^3 of water for dilution of this effluent.

2. Toxic metals include cadmium, chromium, copper, lead, mercury, selenium, nickel and silver. The effluent should meet the individual standards for these metals as well as the standard for total toxic metal concentration.

Source: Government of Pakistan (2000) (SRO 549(I)/2000).

Pollutants	Time-Weighted Average	Concentration in Ambient Air		Method of Measurement
		Effective from 1st July 2010	Effective from 1st January 2013	
Sulfur Dioxide (SO_2)	Annual Average *	80 µg/m3	80 µg/m3	Ultraviolet Fluorescence
	24 hours**	120 µg/m3	120 µg/m3	
Oxides of Nitrogen as (NO)	Annual Average*	40 µg/m3	40 µg/m3	Gas Phase Chemiluminescence
	24 hours**	80 µg/m3	80 µg/m3	
Ozone (O_3)	1 hour	180 µg/m3	130 µg/m3	Non dispersive UV absorption
Suspended Particulate Matter (SPM)	Annual Average*	400 µg/m3	360 µg/m3	High Volume Sampling, (Average flow rate not less than 1.1 m3/minute).
	1 hour	180 µg/m3	130 µg/m3	
Respirable Particulate Matter. PM_{10}	Annual Average*	200 µg/m3	120 µg/m3	β Ray absorption
	24 hours**	250 µg/m3	150 µg/m3	
Respirable Particulate Matter. $PM_{2.5}$	Annual Average*	25 µg/m3	15 µg/m3	β Ray absorption
	24 hours**	40 µg/m3	35 µg/m3	
	1 hour	25 µg/m3	15 µg/m3	
Lead (Pb)	Annual Average*	1.5 µg/m3	1.0 µg/m3	ASS Method after sampling using EPM 2000 or equivalent Filter paper
	24 hours**	2.0 µg/m3	1.5 µg/m3	
Carbon Monoxide (CO)	8 hours**	5 µg/m3	5 µg/m3	Non dispersive Infra-Red (NDIR)
	1 hour	10 µg/m3	10 µg/m3	

* Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

24 hourly / 8 hourly values should be met 98% of the in a year. 20% of the time, it may exceed but not on two consecutive days.

Source: Government of Pakistan (2010) (SRO 1062 (I)/ 2010).

Punjab Environmental Quality Standards for Noise[1]

S/No.	Category of Area/Zone	Limit in dB(A) Leq	
		Day Time	Night Time
1	Residential area (A)	55	45
2	Commercial area (B)	65	55
3	Industrial area (C)	75	65
4	Silence zone (D)	50	45

1: Effective from 1st July, 2012.

Note: 1. Day time hours: 6 am to 10 pm

2. Night time hours: 10 pm to 6 am

3. Silence zone: Zones that are declared as such by the competent authority. An area comprising not less than 100 meters around hospitals, educational institutions and courts.

4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

Punjab Environmental Quality Standards for Motor Vehicle Exhaust and Noise

(A) For In-use Vehicles

Sr. No.	Parameter	Standard (Maximum permissible Limit)	Measuring Method	Applicability
1	Smoke	40% or 2 on the Ringlemann Scale during engine acceleration mode	To be compared with Ringlemann Chart at a distance 6 or more.	Immediate effect
2	Carbon Monoxide	6%	Under idling conditions: Non-dispersive infrared detection through gas analyzer.	
3	Noise	85 db (A).	Sound meter at 7.5 meters from the source.	

Punjab Standards for Drinking Water Quality

Parameter	Unit	PEQS
E-Coli	numbers/ml	Must not be detectable in any 100 ml sample
Total Coliform	numbers/ml	Must not be detectable in any 100 ml sample
Color	TCU	≤ 15 TCU
Taste	No objectionable/Acceptable	-
Odor	No objectionable/Acceptable	-
Turbidity	NTU	< 5 NTU
Total Hardness	mg/l	< 500 mg/l
TDS	mg/l	< 1000
pH		6.5-8.5
Aluminum	mg/l	≤0.2
Antimony	mg/l	≤0.005 (P)
Arsenic	mg/l	≤0.005 (P)
Barium	mg/l	0.7
Boron	mg/l	0.3
Cadmium	mg/l	0.01
Chloride	mg/l	<250
Chromium	mg/l	≤0.05
Copper	mg/l	2
Cyanide	mg/l	≤0.05
Fluoride	mg/l	<1.5
Lead	mg/l	≤0.05
Manganese	mg/l	≤0.5
Mercury	mg/l	≤0.0001
Nickel	mg/l	≤0.02
Nitrate	mg/l	≤50
Nitrite	mg/l	≤3
Selenium	mg/l	0.01
Residual Chlorine	mg/l	0.2-0.5 at consumer end
Zinc	mg/l	5

Appendix A.13 Solid Waste Management Framework

INTRODUCTION

Framework Solid Waste Management Plan for the development of Bahawalpur Landfill is provided. Construction contractors may use this framework as guiding document for preparation of site specific solid waste management plan. The purpose of this Framework Solid Waste Management Plan is to ensure that wastes arising from the proposed construction works at Bahawalpur Landfill are managed, reused, recovered or disposed of by a method that ensures the provisions of the Punjab Environmental Protection, 1997 (Amended 2017) and ADB SPS, 2009. It also ensures that the optimum levels of waste reduction, re-use and recycling are achieved.

Waste management priorities for project are based following waste management hierarchy.

- Prevent material wastage
- Minimise the quantity of waste
- Reuse of site materials
- Recycling of waste
- Energy recovery
- Disposal

WASTE MANAGEMENT AT BAHAWALPUR LANDFILL

National Level

Waste management of the project will be carried as per national rules including:

- Solid Waste Management Policy, 2000
- Requirements of Punjab Environmental Protection Act, 1997 (Amended 2017)
- Draft Guidelines on Solid Waste Management, 2005.
- Section 11 of PEPA, 1997 prohibits discharge of waste in amount that violates the NEQS.
- Draft Hazardous Substances rule of 1999
- Section 132 of Cantonment Act, 1942
- Provision Contains in the Local Government Ordinance, 2001

Regional Level

- Asian Development Bank (ADB) SPS, 2009
- IFC guidelines for Solid Waste Management
- Best practices of waste management on construction sites

DESCRIPTION OF THE PROJECT

The proposed LANDFILL will be developed at Mari Sheikh Shijra, located approximately 11 km away from Bahawalpur city in Punjab province of Pakistan at an elevation of 392 ft (119 m) above mean sea level (AMSL). The proposed landfill will be developed on 110 acres of vacant land with the proposed site being accessible through a metalled road.

The development of the proposed LANDFILL is designed to support the BWMC and other involved agencies, so as to completely transform the SWM system in Bahawalpur. Complete with institutional strengthening, recycling and other support initiatives, the project includes the installation of primary and secondary Municipal Solid Waste (MSW) collection systems and the development of an international standard MSW management facility that will accommodate Bahawalpur’s residual MSW for at least 20 years.

Details of the wastes to be produced

During construction/civil works potential sources of waste will include spoils generated during excavation, concrete and construction waste, domestic wastes (solid & wastewater), fuel or oil leakages or spills, onsite effluents from vehicle wash & cleaning, and cement spills. It is the responsibility of all personnel on site including Contractors, Sub-Contractors and their Employees to ensure compliance with this Waste Management Plan.

Main Waste Categories

Contractors are required to develop inventory of main waste categories that will be generated during construction phase of the project. Anticipated main waste categories include construction debris, concrete waste, scrap wood, bricks, concrete, asphalt, plumping fixtures, piping, insulation (asbestos and non-asbestos), metal scraps, oil, electrical wiring and components, chemicals, paints, solvents.

Anticipated Hazardous Waste Arising

Fuels stored on site that will be used during the construction phase are classed as hazardous. There will be fuel stored on site for machinery and construction vehicles. All fuel tanks and draw off points will be bunded. If the fuel is correctly contained and bunded, it is not expected that there will be any fuel wastage at the site. Other sources of hazardous waste include used paints, used oil/lubricants, electrical waste and chemicals. Project contractors are required to develop SOPs for handling, storage and disposal of hazardous waste arising from the project.

ESTIMATED WASTE GENERATION

Construction Waste Generation

Project contractors are required to develop and maintain waste inventory clearly showing the type, amount and location of waste generated from different activities at the site. Waste record keeping is key to successful implementation of waste management plan.

Proposed Waste Management Options

Waste will be segregated on site. Contractor will ensure that sufficient number of waste drums are placed at site with appropriate color coding. All recyclable waste will be handed over to recycling contractor. The appointed waste contractor will collect and transfer the recyclable wastes as receptacles are filled. The non-recyclable waste will be transferred by an authorized waste collector to an appropriate facility. Project contractors will identify both recycling and non-recycling contractor working in the project area. Contractors through bidding documents will be bound to hire such waste contractors for efficient waste management at project sites. A successful Waste Management Plan is largely dependent on how readily it can be changed in to normal site operations by the person responsible. It is recognized that the plan should not be obstructive to site operations and the construction program by placing the responsibility of construction waste management with the Manager, all reuse, recycling, wastage and necessary disposal can be monitored as close to the source as possible. An Environmental Representative from each Works Sub-Contractor will also be nominated responsible for all waste management in their own operations. In this way, it is possible to identify where the greatest material wastage occurs, with a view to implementing better management.

The site Construction Manager will be designated as the Responsible Person and have overall responsibility for the implementation of the on-site Waste Management Plan. The Responsible Person will be assigned the authority to instruct all site personnel to comply with the specific provisions of the plan. At the operational level, a nominated Environmental Representative from each sub-contractor company on the site shall be assigned the direct responsibility to ensure that the discrete operations stated in this framework for solid waste management are performed on an on-going basis.

Tracking and documentation procedures for off-site waste

The site construction Manager will maintain a copy of all waste collection permits. If waste (soil & stone) is being accepted on-site, a waste docket must be issued to the collector. If the waste is being transported to another site, a copy of the waste permit for that site must be provided to the manager. Record of waste collection docket, a receipt from the final destination of the material will be kept as part of the on-site waste management records. All information will be entered in a waste management system to be maintained on-site.

Disposal Waste

Contractors are required to develop SOP for disposal of recyclable, non-recyclable and hazardous waste generated at site. Food waste will be disposed at food waste pit which will be fenced. Recycling waste will be handed over to recycling waste contractor. Hazardous waste will be disposed through incineration facility available in close proximity of the project area. Workers on the site will be encouraged to recycle as much municipal waste as possible i.e. cardboard, plastic, metals and glass. Prior to removal, the municipal waste will be examined to determine if recyclable materials have been placed in other containers. If this is the case, effort will be made to determine the cause of the waste not being segregated correctly.

ESTIMATED COST OF WASTE MANAGEMENT

Contractors are required to estimate and budget cost for waste management through BOQ items. Such waste management cost should include cost of waste drums, cost of waste handling crew, cost of waste transportation, cost of EPA approved waste contractor services and associated incineration costs if any. By reusing materials on site, there will be reduction in transport and disposal costs for a waste contractor taking the material away.

TRAINING PROVISIONS FOR WASTE MANAGER AND SITE CREW

A waste manager will be appointed or designated by construction contractors to ensure commitment, operational efficiency and accountability during the project execution.

Site Manager Training and Responsibility

The waste manager will be given responsibility and authority to select a waste team if required i.e. members of the site crew that will aid him in the organization, operation and recording the waste management system implemented on-site. The waste manager will have overall responsibility to oversee record and provide feedback to the CSC on everyday waste management at the site. Authority will be given to the waste manager to delegate responsibility to sub-contractors where necessary and to co-ordinate with suppliers, service providers and sub-contractors to prioritize waste prevention and salvage. The waste manager will be trained in how to set up and maintain a record keeping system, how to perform an audit and how to establish targets for waste management on-site. He will also be trained in the best method for segregation and storage of recyclable materials, have information on the materials that can be reused on-site and know how to implement this Framework for Solid Waste Management.

Site Crew Waste Management Training

Training of the site crew is the responsibility of the waste manager and as such, a waste training program should be organized. A basic awareness course will be held for all crew to outline the construction waste management plan and to detail the segregation of waste at source. This may be incorporated with other training needs (e.g. general site induction, safety training etc.). This basic course will describe the materials to be segregated, the storage methods and the location of the waste storage areas. A subsection on hazardous wastes will be incorporated and the particular dangers of each hazardous waste will be explained.

RECORD KEEPING

Records will be kept for each waste material which leaves the site, either for reuse on another site, recovery, recycling or disposal. A system will be put in place to record the construction waste arising on-site. The waste manager or delegate will record the following:

- Waste taken off-site for reuse
- Waste taken off-site for recovery
- Waste taken off-site for recycling
- Waste taken off-site for disposal
- Waste (soil & stone) accepted on-site for recovery

For each movement of waste off-site, a signed waste collection docket will be obtained by the waste manager (or delegate) from the contractor. This will be carried out for each material type. This system will also be linked with the delivery records. A signed waste acceptance docket will be issued for each movement of waste on-site.

OUTLINE WASTE AUDIT PROCEDURE

Contractors are required to develop SOP for waste auditing at the construction sites. Such SOP should reflect frequency and types of waste audits, audit criteria and way forward to close non-compliances.

Responsibility for Waste Audit

The appointed waste manager will be responsible for conducting a waste audit at the site during project execution.

Review of Records and Identification of Corrective Actions

A review of all the records for the waste generated and transported off-site, as well as waste accepted, should be undertaken. If waste movements are not accounted for, the reasons for this should be established in order to see if and why the record keeping system has not been maintained. Each material type will be examined in order to see where the largest percentage waste generation is occurring. The waste management methods for each material type will be reviewed in order to highlight how the targets can be achieved. Waste management costs will also be reviewed. Upon completion of the construction phase a final report will be prepared summarizing the outcomes of waste management processes adopted and the total recycling/reuse/recovery figures for the development.

CONSULTATION WITH RELEVANT BODIES

Local Authority

Project contractors are required to maintain close coordination with PMU, BWMC and PUNJAB EPA to ensure that all available waste reduction, re-use and recycling opportunities are identified and utilized.

EPA Approved Waste Contractors

Companies that specialize waste management will be contacted to determine their suitability for engagement. If used, each company will be audited in order to ensure that relevant and up-to-date waste collection permits and/or license are held. In addition, information regarding individual materials will be obtained including the feasibility of recycling each material, the costs of recycling/reclamation and the means by which the wastes will be collected and transported off-site, and the recycling/reclamation process each material will undergo off-site.

Appendix A.14 NOC from Punjab EPA for Site in 2018

ENVIRONMENT PROTECTION DEPARTMENT
Government of the Punjab
National Hocky Stadium, Lahore.

NO. DD (EIA)/EPA/116(EIA)/2017/1808/554
Dated: 7 / 9 /2018

To,

Managing Director,
Bahawalpur Waste Management Company,
2-B Ghaznavi Road, Model Town A,
Near Al-Farooq School,
District Bahawalpur.

Subject: **DECISION OF EPA PUNJAB REGARDING THE PROJECT "CONSTRUCTION OF A LANDFILL SITE BY BAHAWALPUR WASTE MANAGEMENT COMPANY AT MOUZA NOABAD, DIISTRICT BAHAWALPUR."**

1. **Description of Project:** Construction of a landfill site
2. **Location of Project:** Mouza Noabad, Tehsil Bahawalpur, District Bahawalpur
3. **Date of filing:** 22.11.2017
4. EPA Punjab has reviewed the Environmental Impact Assessment (EIA) Report and considered Site Inspection Reports received from Deputy Director (Environment), Bahawalpur vide letter No. F-BWMC/2018/EPA/BWP/158 dated 14.02.2018. EPA Punjab has also considered the recommendations of **Committee of Experts** (Meeting dated 18.08.2018) & other relevant record to take a lawful decision.
5. **EPA, Punjab accords Environmental Approval under Section 12 of Punjab Environmental Protection Act 1997 for construction of aforesaid project subject to the following conditions**

   i. The Proponent shall ensure compliance of Punjab Environmental Quality Standards (PEQS) during construction and operational phase w.r.t noise, waste water and gaseous emissions.
   ii. Mitigation Measures suggested in the Environmental Impact Assessment report and Environmental Management Plan (EMP) shall be strictly adhered to minimize any negative impacts on soil, ground water, air and biological resources of the project area. The proponent will depute staff to monitor the compliance of EMP.
   iii. The Proponent shall maintain the record of auditable measures taken for implementation of Environmental Management Plan for verification by EPA, Punjab.
   iv. Monitoring shall be carried out during the entire period of the project activities. Monitoring reports shall be submitted to EPA Field office on quarterly basis.
   v. Proponent must not pollute or over use any surface water body in the vicinity of the project.
   vi. The Proponent shall ensure that strict and efficient health and safety measures are in place for protection of workers backed by a comprehensive emergency response system.
   vii. The Proponent shall redress the objections / concerns of neighbours / stakeholder on priority basis (if any at any stage).
   viii. The Proponent shall obtain NOCs/ clearance of all other concerned departments before commencement of work.
   ix. The Proponent shall plant 5,000 trees of 6-7 feet height of indigenous species in consultation with EPA Field office within six months. The Proponent shall also take measures for protection and maintenance of these trees and maintain their proper record for verification by EPA.
   x. The Proponent shall follow building by laws and the construction plan approved by the competent authority including seismic, structural and geotechnical analysis.
   xi. The Proponent shall avoid the disturbance of the traffic flow due to heavy traffic during construction and operation phase
   xii. The Proponent shall make proper parking arrangements as per approved plan and shall not convert the parking area to other use.
   xiii. Camping sites by the contractor shall be located at suitable distance away from any settlement to avoid disturbance to the local people and he will ensure restoration of camping site to its original condition as well.
   xiv. The Proponent shall not place the construction material openly.
   xv. The construction material shall be piled / stored in such a way that it shall not destroy the flora / environment of the locality.

xvi. The Proponent shall do landscaping and restore the environment after completion of the construction work.

xvii. The Proponent will install standby power generator (if required) adopting sound proofing techniques and it shall be equipped with chimney with proper height to discharge the hot gases / smoke and the proponent will not install the generator on residential area side.

xviii. Proponent shall submit undertaking that no interim injunction has been issued by any court of law against said project as of date of issuance and receiving of this approval and in case any such injunction this approval shall stand cancelled.

xix. Arrangements shall be made for safe disposal of sanitary and solid waste. The solid waste shall be retained within the unit boundary/premises and will be disposed off in an environment friendly way at a suitable disposal facility. Toilet/washrooms will be maintained in an orderly and hygienic manner for public use.

xx. Compensation shall be provided to the inhabitants in case of loss of agricultural land, crop, property, etc. in accordance with the rates that are agreed upon. All conflicting issues regarding compensation, etc. should be settled amicably before the start of the project activities.

xxi. The proponent shall take all necessary measure to safeguard the social and economic conditions affecting the community life.

xxii. The Proponent shall provide latest, according to international best practices the PPEs to the workers.

xxiii. There must be a proper leachate collection system.

xxiv. The proponent must install effective odour control system/measures/ odour control system to be properly adopted.

xxv. The Proponent shall follow the SOPs regarding dengue larvae eradication and shall ensure removal of stagnant water on daily basis.

6. The Proponent shall, before commencing construction of the project, acknowledge acceptance of the stipulated conditions by executing an Undertaking in the form prescribed in Schedule VII of Review of IEE/EIA Regulations 2000.

7. The Proponent shall be liable for correctness and validity of information supplied to this department directly or through the environmental consultant.

8. This approval is accorded only for the construction phase of the project. The Proponent shall apply for confirmation of compliance under Regulation 14 of IEE / EIA Regulation, 2000 by submitting Environmental Management Plan for operational phase along with compliance status report of the Environmental Approval of the construction phase of the project.

9. The Proponent shall be liable for compliance of Regulations 13, 14, 18 and 19 of IEE/EIA Regulations, 2000, regarding approval, confirmation of compliance, entry, inspections and monitoring.

10. EPA reserves the right to impose any other condition based on its monitoring.

11. Any change in the approved project shall be communicated to EPA, Punjab and shall be commenced after obtaining the approval.

12. This approval shall be treated as null and void if all or any of the conditions mentioned above, is/are not complied with and in case of any interim injunction by any court of law against said project.

13. This approval shall be valid (for commencement of construction) for a period of three years from the date of issue under Regulation 17 of IEE / EIA Regulations, 2000.

14. This approval can be withdrawn at anytime without any prior notice if deemed necessary in the public / national interest.

15. This decision is issued with approval of Director General, EPA Punjab.

ASSISTANT DIRECTOR (EIA)

NO. & DATE EVEN.

A copy is forwarded to the Assistant Director (Environment) Bahawalpur w.r.t letter No. F-BWMC/2018/EPA/BWP/158 dated 14.02.2018. He is requested to:

i. Obtain undertaking from the project proponent mentioned at para 6 for the record of EPA Headquarter and Field Office.

ii. Ensure compliance of the conditions mentioned in the Environmental Approval and maintain the file / record of correspondence with the project proponent properly.

ASSISTANT DIRECTOR (EIA)

Appendix A.15 IBAT Proximity Report of Bahawalpur LFS

Integrated Biodiversity Assessment Tool

PROXIMITY REPORT

LFS BAWAWALPUR

Country: Pakistan

Location: [29.3, 71.6]

Date of analysis: 16 January 2023 (GMT)

Size of site: 0 km^2

Buffers applied: 1 km | 3 km | 5 km

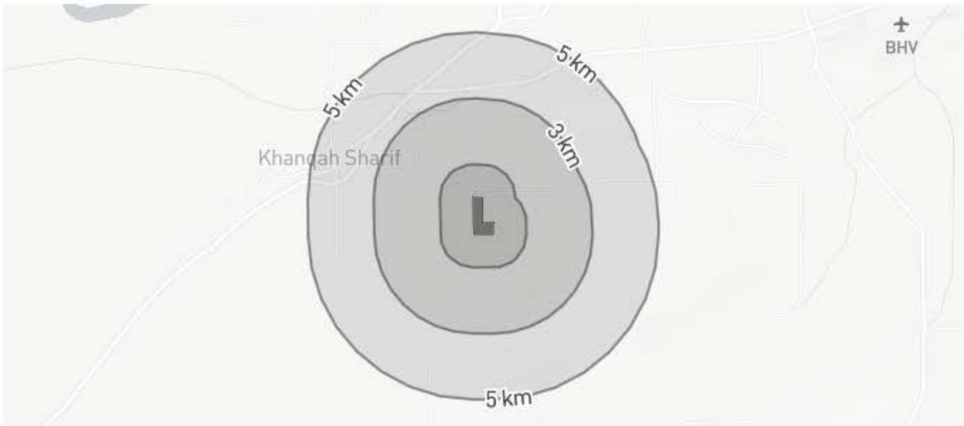
IUCN Red List Biomes: Freshwater, Terrestrial

Generated by: Aziz Karim

Organisation: ADB

Overlaps with:

Protected Areas	0
Key Biodiversity Areas	0
IUCN Red List	36



Displaying project location and buffers: 1 km, 3 km, 5 km

About this report

This report presents the results of [29905-38691] proximity analysis to identify the biodiversity features and species which are located within the following buffers: 1 km, 3 km, 5 km.

This report is one part of a package generated by IBAT on 16 January 2023 (GMT) that includes full list of all species, protected areas, Key Biodiversity Areas in CSV format, maps showing the area of interest in relation to these features, and a 'How to read IBAT reports' document.

WARNING: IBAT aims to provide the most up-to-date and accurate information available at the time of analysis. There is however a possibility of incomplete, incorrect or out-of-date information. All findings in this report must be supported by further desktop review, consultation with experts and/or on-the-ground field assessment. Please consult IBAT for any additional disclaimers or recommendations applicable to the information used to generate this report.

Please note, sensitive species data are currently not included in IBAT reports in line with the Sensitive Data Access Restrictions Policy for the IUCN Red List. This relates to sensitive Threatened species and KBAs triggered by sensitive species.

Data used to generate this report

- UNEP-WCMC and IUCN, 2023. Protected Planet: The World Database on Protected Areas (WDPA)[On-line], Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net - January 2023.
- BirdLife International (on behalf of the KBA Partnership), 2022. Key Biodiversity Areas - November 2022.
- IUCN, 2022. IUCN Red List of Threatened Species - December 2022.
- IUCN. The IUCN Red List of Threatened Species. Version 2019-3. (2019). https://www.iucnredlist.org
- IUCN. Threats Classification Scheme (Version 3.2). (2019)
- Strassburg, B.B.N., Iribarrem, A., Beyer, H.L. et al. Global priority areas for ecosystem restoration. Nature 586, 724–729 (2020). https://doi.org/10.1038/s41586-020-2784-9

Protected Areas

The following protected areas are found within 1 km, 3 km, 5 km of the area of interest.
For further details please refer to the associated csv file in the report folder.

No protected areas within buffer distance

Key Biodiversity Areas

The following key biodiversity areas are found within 1 km, 3 km, 5 km of the area of interest.
For further details please refer to the associated csv file in the report folder.

No KBAs within buffer distance

IUCN Red List of Threatened Species

The following threatened species are potentially found within 50km of the area of interest.

For the full IUCN Red List please refer to the associated csv in the report folder.

Species Name	Common Name	Taxonomic Group	IUCN Category	Population Trend	Biome
Vanellus gregarius	Sociable Lapwing	AVES	CR	Decreasing	Terrestrial
Gyps bengalensis	White-rumped Vulture	AVES	CR	Decreasing	Terrestrial
Geoclemys hamiltonii	Spotted Pond Turtle	REPTILIA	EN	Decreasing	Terrestrial, Freshwater
Hardella thurjii	Crowned River Turtle	REPTILIA	EN	Decreasing	Terrestrial, Freshwater
Nilssonia gangetica	Indian Softshell Turtle	REPTILIA	EN	Decreasing	Terrestrial, Freshwater
Nilssonia hurum	Indian Peacock Softshell Turtle	REPTILIA	EN	Decreasing	Terrestrial, Freshwater

Species Name	Common Name	Taxonomic Group	IUCN Category	Population Trend	Biome
Platanista minor	Indus River Dolphin	MAMMALIA	EN	Increasing	Freshwater
Axis porcinus	Hog Deer	MAMMALIA	EN	Decreasing	Terrestrial, Freshwater
Oxyura leucocephala	White-headed Duck	AVES	EN	Decreasing	Terrestrial, Freshwater
Rynchops albicollis	Indian Skimmer	AVES	EN	Decreasing	Terrestrial, Freshwater
Haliaeetus leucoryphus	Pallas's Fish-eagle	AVES	EN	Decreasing	Terrestrial, Freshwater
Neophron percnopterus	Egyptian Vulture	AVES	EN	Decreasing	Terrestrial, Freshwater
Falco cherrug	Saker Falcon	AVES	EN	Decreasing	Terrestrial, Marine, Freshwater
Leptoptilos dubius	Greater Adjutant	AVES	EN	Decreasing	Terrestrial, Freshwater
Glyptothorax punjabensis		ACTINOPTERYGII	EN	Decreasing	Freshwater
Panthera tigris	Tiger	MAMMALIA	EN	Decreasing	Terrestrial
Varanus flavescens	Yellow Monitor	REPTILIA	EN	Decreasing	Terrestrial
Aquila nipalensis	Steppe Eagle	AVES	EN	Decreasing	Terrestrial
Crocodylus palustris	Mugger	REPTILIA	VU	Stable	Terrestrial, Freshwater

IBAT

Species Name	Common Name	Taxonomic Group	IUCN Category	Population Trend	Biome
Pangshura tecta	Indian Roofed Turtle	REPTILIA	VU	Decreasing	Terrestrial, Freshwater
Wallago attu		ACTINOPTERYGII	VU	Decreasing	Freshwater
Aythya ferina	Common Pochard	AVES	VU	Decreasing	Terrestrial, Marine, Freshwater
Columba eversmanni	Yellow-eyed Pigeon	AVES	VU	Decreasing	Terrestrial, Freshwater
Sterna aurantia	River Tern	AVES	VU	Decreasing	Terrestrial, Marine, Freshwater
Clanga clanga	Greater Spotted Eagle	AVES	VU	Decreasing	Terrestrial, Freshwater
Aquila rapax	Tawny Eagle	AVES	VU	Decreasing	Terrestrial, Freshwater
Aquila heliaca	Eastern Imperial Eagle	AVES	VU	Decreasing	Terrestrial, Freshwater
Chrysomma altirostre	Jerdon's Babbler	AVES	VU	Decreasing	Terrestrial, Freshwater
Lissemys punctata	Indian Flapshell Turtle	REPTILIA	VU	Decreasing	Terrestrial, Freshwater
Schizothorax plagiostomus	Snow Trout	ACTINOPTERYGII	VU	Decreasing	Freshwater
Bagarius bagarius		ACTINOPTERYGII	VU	Decreasing	Freshwater
Acinonyx jubatus	Cheetah	MAMMALIA	VU	Decreasing	Terrestrial

Species Name	Common Name	Taxonomic Group	IUCN Category	Population Trend	Biome
Panthera pardus	Leopard	MAMMALIA	VU	Decreasing	Terrestrial
Saara hardwickii	Indian Spiny-tailed Lizard	REPTILIA	VU	Decreasing	Terrestrial
Saxicola macrorhynchus	White-browed Bushchat	AVES	VU	Decreasing	Terrestrial
Chlamydotis macqueenii	Asian Houbara	AVES	VU	Decreasing	Terrestrial

Recommended citation

IBAT Proximity Report. Generated under licence 29905-38691 from the Integrated Biodiversity Assessment Tool on 16 January 2023 (GMT). www.ibat-alliance.org

How to use this report

This report provides an indication of the potential biodiversity-related features - protected areas, key biodiversity areas and species - close to the specified location. It provides an early indication of potential biodiversity concerns, and can provide valuable guidance in making decisions. For example, this information can be helpful when assessing the potential environmental risk and impact of a site, categorising investments/projects, preparing the terms of reference for an impact assessment, focusing attention on key species of conservation concern and sites of known conservation value, and reviewing the results of an impact assessment.

The report does not provide details of potential indirect, downstream or cumulative impacts. Furthermore, the report should be regarded as a "first-step", providing a set of conservation values sourced from global data sets, and is not a substitute for further investigation and due diligence, especially concerning national and/or local conservation priorities.

Appendix A.16 Urdu Project Summary

Urdu Summary

مختصر خلاصہ برائے ماحولیاتی اثرات کی تشخیص

پنجاب کے وسطی شہرونکی بہتر سرمایہ کاری کامنصوبہ

پاکستان : بہاولپور میں کچرا کنڈی کے قیام کا منصوبہ

ماحولیاتی اثرات کے اقدامات کا خلاصہ

منصوبے کا جائزہ

1. حکومت پنجاب ایشیائی ترقیاتی بینک (اے ڈی بی) کے مالی تعاون سے وسطی اضلاع میں پنجاب انٹرمیڈیٹ سٹیز امپرووومنٹ انویسٹمنٹ پراجیکٹ (پی آئی سی آئی آئی پی) پر عملدرآمد کر رہی ہے۔ پی آئی سی آئی آئی پی پنجاب کے مختلف شہروں میں شہری انتظام کے بنیادی ڈھانچے اور خدمات میں سرمایہ کاری کا ہدف رکھتا ہے۔
2. شہروں میں کھلے عام کچرا پھینکنے کی وجہ سے کچرے کی گندگی اور بدبو لوگوں کو پریشان کر رہی ہے اور ماحول کو آلودہ کر رہی ہے۔ بہاولپور ویسٹ مینجمنٹ کمپنی (بی ڈبلیو ایم سی) کا مقصد ان طریقوں کا مقابلہ کرنا ہے لیکن موجودہ سالڈ ویسٹ مینجمنٹ سسٹم اور (بی ڈبلیو ایم سی) جدید طرز، ضروری آلات، لینڈ فل اور افرادی قوت سے مکمل طور پر لیس نہیں ہے۔
3. بہاولپور لینڈ فل کو ایک مربوط سہولت کے طور پر ڈیزائن کیا گیا ہےیہ 150 میٹر x 200 میٹر کے 4 خلیات پر مشتمل ہے جسے ترتیب وار تیار کیا جائے گا۔ سال 2024 میں سیل ون تیار کیا جائے گا اور جنوری 2025 تک کچرا وصول کرنے کے لئے تیار ہوجائے گا۔ بائیو ری ایکٹر کو لینڈ فل گیس ریکوری سسٹم، لینڈ فل گیس فلرنگ اور میتھین اجزاء کو سی این جی میں تبدیل کرنے کے ساتھ مربوط کیا گیا ہے۔ جگہ کے تصوراتی خاکہ کی بندش اور بندش کے بعد کا استعمال شامل ہے جس میں ترمیم کرنا پڑسکتی ہے کیونکہ خلیوں کی بندش سالوں میں آگے بڑھتی ہے۔ مزید برآں علاج شدہ طبی کچرا کو ٹھکانے لگانے کے لئے سیل کا ایک حصہ لینڈ فل سائٹ پر زیر غور ہے۔

منصوبے کی جگہ کا مقام

4. مجوزہ لینڈ فل سکی جگہ ماڑی شیخ شجرہ کے مقام پر تیار کی جائے گی، جو بہاولپور شہر کے مرکز سے تقریبا 11 کلومیٹر دور سطح سمندر (اے ایم ایس ایل) سے 392 فٹ (119 میٹر) کی بلندی پر واقع ہے۔ یہ جگہ بستی یار محمد روڈ کے ذریعے قابل رسائی ہے ، تاہم ایل ایف ایس (تقریبا 2.5 کلومیٹر لمبائی) کی طرف جانے والی رسائی سڑک ابھی تک تعمیر نہیں کی گئی ہے اور اس کی تعمیر منصوبے کے فزیبلٹی ڈیزائن میں شامل ہے۔ تقریبا ۱۰ کلومیٹر مرکزی سڑک کی بہتری بھی منصوبے کا حصہ ہے۔
5. خانووالا میں واقع موجودہ ڈمپنگ سائٹ پر ایک چھوٹے پیمانے پر کمپوسٹ پلانٹ قائم کیا جائے گا جس میں تجارتی کچرا سے الگ نامیاتی کچرا استعمال کیا جائے گا۔ لکڑی کا کچرا، سبزیوں اور فروٹ مارکیٹ کے کچرے، ریستورانوں اور ہوٹلوں سے پکا ہوا کھانا اور دکانوں سے زائد المیعاد کھانا ملایا جائے گا۔ موجودہ ڈمپ سائٹ بنیادی کچرا جمع کرنے والے علاقوں سے اوسطا تقریبا ۱۰ کلومیٹر پر واقع ہے۔ (قریب ترین آبادی کے مرکز سے 5.8 کلومیٹر اور دور ترین علاقے سے 15 کلومیٹر)۔ یہ کسی بھی ماحولیاتی کنٹرول کے بغیر ایک کھلی ڈمپ سائٹ ہے جو نیچے یا سائیڈ وال لائنر سسٹم ہے ، کوئی لیچیٹ کلیکشن اور ٹریٹمنٹ سسٹم یا لینڈ فل گیس ریکوری سسٹم نہیں ہے۔ جمع شدہ کچرا روزانہ ڈھانپنے والی مٹی سے ڈھکا ہوا نہیں ہے۔
6. مجوزہ ایم آر ایف مقام ایک پرانی ڈمپ سائٹ اور گندے پانی کے کھلے تالابوں سے متصل ہے۔ ایم آر ایف قومی شاہراہ سے حاصل پور روڈ تک بائی پاس پر واقع ہے۔ 10 ایکڑ اراضی پر اس سائٹ پر ایم آر ایف کے قیام سے اخراج میں کمی کرکے سائٹ کے مجموعی کاربن فٹ پرنٹ کو کم کیا جاسکے گا۔ بی ڈبلیو ایم سی ایم آر ایف چلائے گی. شہر کی مغربی طرف سے آنے والی سڑک کو بہتری کی ضرورت ہوگی جو سڑک کو دو طرفہ سڑک میں تبدیل کر رہی ہے۔ سڑک کی بہتری کی لمبائی کا تخمینہ تقریبا 5کلومیٹر ہے۔ اس میں سے 2.5 کلومیٹر سنگل روڈ کو ڈبل لین تک توسیع دی جائے گی اور 2.5 کلومیٹر نئی دو طرفہ سڑک ہوگی۔ منصوبے میں مخصوص سی اینڈ ڈی ویسٹ کنٹریکٹر کے ذریعے تعمیراتی اور انہدام (سی اینڈ ڈی) کچرے کی ری سائیکلنگ کی بھی تجویز دی گئی ہے۔

Appendix A.17 Public Hearing Proceedings

OFFICE OF THE ASSISTANT DIRECTOR ENVIRONMENT
BAHAWALPUR
313-C, SATELLITE TOWN.

To,

The Assistant Director (EIA),
EPA, Govt. of Punjab, Lahore.

No. EIA/EPA/BWP/2023/598 Dated: 26.10.2023

Subject: **PARTICIPATION OF STAKEHOLDERS IN PUBLIC HEARING AND COMPILATION OF PROCEEDINGS OF THE EVENT "ESTABLISHMENT OF INTEGRATED SOLID WASTE MANAGEMENT SYSTEM (ISWM) LAND FILL SITE AT BASTI CHACHRAN ROAD, NEAR NOUABAD DISTRICT BAHAWALPUR"**

Please refer to your office letter No. AD(EIA)/EPA/F-172(EIA)/2023/4904 dated. 27-09-2023 on the subject noted above.

Find enclosed herewith the proceedings of the public hearing for information and further necessary action in accordance with IEE/EIA Regulations, 2022.

Assistant Director Environment
Bahawalpur

C.C.

The Project Director, Punjab Intermediate Cities, Improvement Program (PICIIP) 40-B-1, Gulberg-III Road, Lahore.

Subject:- **PROCEEDINGS OF PUBLIC HEARING OF THE PROJECT "ESTABLISHMENT OF INTEGRATED SOLID WASTE MANAGEMENT SYSTEM (ISWM) LAND FILL SITE AT BASTI CHACHRAN ROAD, NEAR NOUABAD DISTRICT BAHAWALPUR"**

Reference: EIA Section letter No. AD(EIA)/EPA/F-172(EIA)/2023/4904 dated. 27-09-2023

Venue: Punjab Council of the Art, Rasheedia Auditorium, Muhammad Bin Qasim Road, Model Town-A, Bahawalpur.

Date & time: 10-10-2023 at 11.00AM

Participants

83 participants from general public and govt. offices attended the hearing proceedings. The attendance sheet of participants is enclosed at **Annex-A**.

Proceedings:

1. The proceedings started with few verses from Holy Quran.
2. Mr. Osama, Assistant Director (Environment) PICIIP, extended a warm welcome to the participants and introduced the esteemed guests.
3. The Assistant Director Environment Bahawalpur briefed the participants about lawful provision of section 12 of Punjab Environmental Protection Act-1997(amended 2012) and highlighted the significance of public participation in the project.
4. Mr. Ahtasham consultant of the firm presented a comprehensive overview of the entire ISWM project and the whole system planned for execution in Bahawalpur. He also included all the technical, financial, environmental and social aspects in the presentation and briefed the participants. He also briefed about the environmental impacts and its mitigations. He added that public hearing/stakeholder consultation provides a platform for discussing the proposed project in detail, addressing community concerns, and gaining support for the initiative aimed at improving solid waste management and the overall environment in the district Bahawalpur.
5. Mr. Waqas, Deputy Director (Environment & Social Safeguards) PICIIP, provided an insightful overview of the session's purpose. He elaborated on the critical need and significance of the project for the city of Bahawalpur. He informed the participants

and briefed that ISWM system, aimed at creating a cleaner city by scientifically processing solid waste and disposing it at a sanitary engineered landfill site.

6. Mr. Muhammad Naeem (CEO-BWMC) elaborated on the funding source, noting that the ADB-funded project would create employment opportunities in Bahawalpur while ensuring a healthy environment. The project, including Door-to-Door (D2D) collection, Material Recovery Facilities (MRF), landfill site management, recycling facilities, and composting, aims to establish Bahawalpur as a model of cleanliness and effective waste management.

7. Mr. Muhammad Irfan, Technical Manager (BWMC) briefed the participants on the current solid waste management practices in the city.

Stakeholders Discussions, Comments and Concerns:

Immediately after the presentation, the house was opened for having concerns, suggestions and recommendations from the participants. Participants were encouraged to make their contribution. The consultant replied all the questions of the participants according to their satisfaction. No participant opposed the development of project.

Sr. No.	Queries from Audience	Responses
1	Concerns about leachate and toxins resulting from landfill dumping and their treatment	The participants were informed that leachate collection and treatment system is part of the landfill project, moreover, to control the leaching process an engineered design having high density polyethylene) geo-membrane, gravels etc will be developed for landfill site.
2	Details regarding tree plantation on the landfill site.	It was briefed by the consultant that tree plantation is also been included in the project. Massive plantation shall be ensured in and around the project.
3	The number of employment opportunities that would be generated for the community through project	It was briefed that around 400-500 (direct and indirect) jobs will be created during construction phase while during operation phase around 200

Sr. No.	Queries from Audience	Responses
	implementation	jobs (direct and indirect) will be created. It was added that locals will be preferred for these jobs.
4	A question was raised about the impact of project on air.	All the impacts related with air during the construction and operation of the project were satisfactory briefed to the participants.
5	A question was raised about the impact of noise generation.	All the impacts related with noise during the construction and operation of the project were satisfactory briefed to the participants.

Photographs

The photographs depicting different parts and persons of public hearing are enclosed at **(Annex-B)**.

The proceedings ended with the vote of thanks.

Assistant Director Environment
Bahawalpur

Appendix-A

Attendance Sheet of the Participants

PUBLIC HEARING
ATTENDANCE SHEET

Project Name: Punjab Urban Development Projects: Integrated Solid Waste Management System (ISWM), Bahawalpur (DREAMS-I)

Dated: October 10, 2023.

Sr. No.	Name	Address	Contact No.	Signature
1.	Naeem	B.W.M.C	-	
2.	Abdurrehman Raza	ES-EDCH	03028462412	
3.	M. Waqas Afzal	DD (Safeguards) PICIIP	0346-3501477	
4.	Syed Osama Faheem Rizvi	AD - PRF PMU	0344-4000357	
5.	Imran Mehmood	Manager MIS BWMC	0345-9634444	
6.	Rizwan Jabbar	Infrastructure Engr.	0321-6974585	
7.	Aamir Ismail	BWMC	03458671444	
8.	[illegible]	Bahawal Pur	0302(65-7388	
9.	ASAD AHMAD	BAHAWALPUR	0301-7791766	
10.	Abbas	BWMC	0300-7804877	
11.	Khadim Hussain	BWMC	0302-7705321	خادم
12.	Nadeem Baig	BWMC	0300-3083013	
13.	RIZWAN	BWMC	03017769101	
14.	DILSHAD	BWMC	03077288884	دلشاد
15.	ADNAN	BWMC	0304 8341615	
16.	MoMiN Abbas	BWMC چیرآباد	0304 2335176	Momin Abbas
17.	SHAMSHEER	BWMC	03249920416	شمشیر حیدر
18.	ارشد	BWP	03078863861	
19.	Bilal Ahmad	BWP	0303-6730604	Bilal Ahmed
20.	AbdulLatif	BWP	03082048364	
21.	[illegible]	BWP	0307-8670628	

Sr. No.	Name	Address	Contact No.	Signature
22.	ADNAN	BWP	0345-5555005	Adnan
23.	اشفاق	لودھراں	0302-2887003	اشفاق
24.	ثنا اللہ	احمد پور شرقیہ	0305 7876199	[illegible]
25.	محمد بلال	لال سوہانرا	0307-5432833	محمد بلال
26.	شاہد علی	عباس کالونی	0301-7475996	[illegible]
27.	عثمان غفار	حاصل پور چوک	0305-7500584	[illegible]
28.	محمد نذیر	ڈیرہ نواب	0303 6445983	محمد نذیر
29.	نذیر احمد	دلاور کالونی	0308 7749289	نذیر احمد
30.	یعقوب	چوک بہادر	0340-6000230	یعقوب
31.	عبدالرحمن	ون یونٹ چوک	0301-2177230	[illegible]
32.	محمد طاہر	منڈی بلی بہاولپور	0306 7673048	[illegible]
33.	آصف	بہاولپور	0304-8602853	Asif
34.	[illegible]	بہاولپور	0303367140	[illegible]
35.	شہزاد افضل	محلہ عام خاص	0300-2647984	Shahzad
36.	[illegible]	احمد پور	03002939586	[illegible]
37.	اعجاز	لوڑکوٹ	0302 7491360	اعجاز
38.	لیاقت اللہ	فوجی بستی	03065026071	لیاقت
39.	Syed Ahsan Raza	AM Comm Bazar	0345-8676444	[illegible]
40.	[illegible]	سرائیکی چوک	0304-7662401	شہزاد دلبر
41.	Muhammad Kashif	شاہدرہ	0302-2206228	[illegible]
42.	Muhammad umar	دلاور کالونی BWMC	03036478857	M. umar
43.	Atif Ejaz	[illegible] BWMC	03077457729	[illegible]
44.	Fahad	Bahawalpur.	0300-6881924	[illegible]
45.	M [illegible]		03017741975	M [illegible]
46.	NADEEM FAISAL	B.W.M.C	03016215879	N Faisal

Annex-A-17-6

Sr. No.	Name	Address	Contact No.	Signature
47.	Baloon		03055562378	[illegible]
48.	آصف	[illegible]	03200651634	آصف
49.	[illegible]	[illegible]	03046808429	[illegible]
50.	[illegible]	[illegible]	0305-7579800	[illegible]
51.	افضل خان [illegible]	[illegible]	03006804628	[illegible]
52.	Farhan Mustafa	[illegible]	0301-7986465	[illegible]
53.	محمد اظہر علی [illegible]	سیٹلائٹ ٹاؤن	0333-636-4423	[illegible]
54.	محمد کاشف [illegible]	BWP	03044536844	[illegible]
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PUBLIC HEARING
ATTANDANCE SHEET

Project Name: Punjab Urban Development Projects: Integrated Solid Waste Management System (ISWM), Bahawalpur (DREAMS-I)

Dated: October 10, 2023.

Sr. No.	Name	Address	Contact No.	Signature
1.	Shahnaz Kousar Khan	PMU-PICIIP	—	[illegible]
2.	Syeda Farhat Abbas	CIU-PRF Bahawalpur	-	Farhat Abbas
3.	Zareena	Bwp		[illegible]
4.	[illegible]	Bwp		[illegible]
5.	Aasa Khan	Bwp		[illegible]
6.	Sana Kanwal	Bwp		[illegible]
7.	Sana Saif	BwP		[illegible]
8.	Syra Yaseen	Bwp		[illegible]
9.	Nazia Sultan	Bwp		[illegible]
10.	Kiran Shazadi	EDCM Coordinator		Kiran
11.	M. Junaid	B.W.P	0355-4105843	M. Junaid
12.	MUNAWAR-HUSSAIN	B.W.P	0304-9640408	[illegible]
13.	M.AZHAR	B.W.P	0300 6857380	M. Azhar
14.	توقیر شاہ	B.W.P	03005507595	توقیر شاہ
15.	مشتاق احمد	B.W.P	0300-9889654	[illegible]
16.	SaJid Nazeer	B.W.P	03006825424	[illegible]
17.	[illegible]	BWP	03468815063	[illegible]
18.	ضیاء الحق	BWP	03457061259	
19.	M. Asif Saeed	BWP	0335-0848990	[illegible]
20.	Hafiz M Talha	Bwp	0308-5098805	[illegible]
21.	Syed Ali Hasnain	Bwp	03458600532	[illegible]

Sr. No.	Name	Address	Contact No.	Signature
22.	Ahmad Ateeb ullah	BWP	03458600813	[signature]
23.	Ahmad Aslam	Yousf town.	03074485041	[signature]
24.	Shoukat Masih	Yousf twon	0301-7740591	[signature]
25.	Shahzaib Masih	Yousf twon	0301-3276107	شاہزیب
26.	Mastaq Masih	Yousf Islamicoly	0300-7806467	[signature]
27.	Irfan Masih	Yousf twon	0308-8533406	[signature]
28.	ANSAR ABBAS	AD (Env)	—	[signature]
29.	Nadeem	EP A BWP	0334 8689595	[signature]
30.				
31.				
32.				
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Appendix -B

Glimpse of Consultation Session Event

Recitation of the Verses of Holy Quran

Presentation of the EDCM Environment Expert

Briefing of Deputy Director (Env /Social) PMU

Response to the Public Queries

Briefing of CEO BWMC

Response to the Public Queries by CEO BWMC


Participants of the Public Hearing


Participants of the Public Hearing


Participants of the Public Hearing


Participants of the Public Hearing


Participants of the Public Hearing


Participants of the Public Hearing


A Query from a Participant

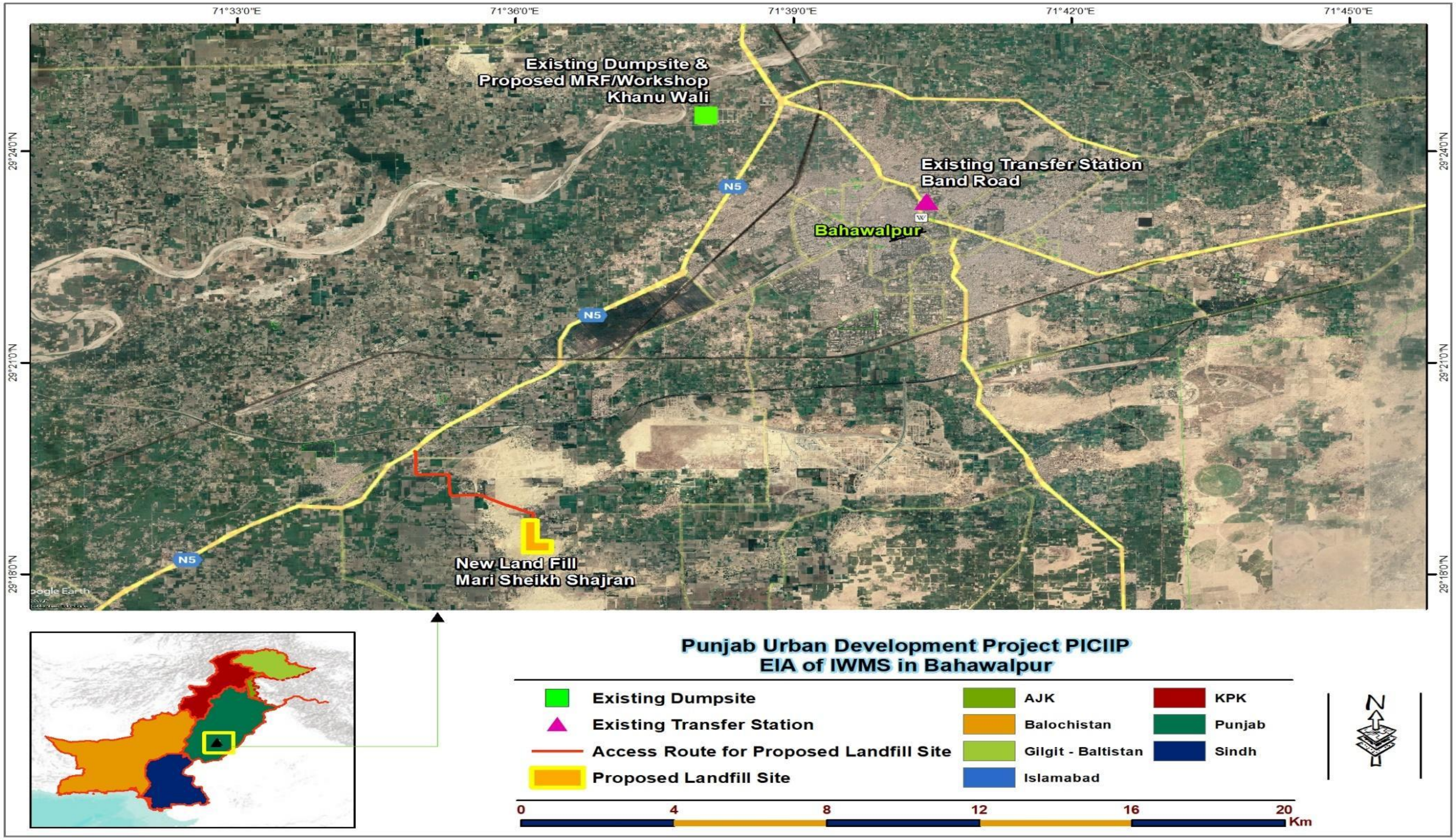

A Query from a Participant


A Query from a Participant


A Query from a Participant


A Query from a Participant


Vote of Acceptance for the Project by General Public


71°33'0"E
71°36'0"E
71°39'0"E
71°42'0"E
71°45'0"E
29°24'0"N
29°21'0"N
29°18'0"N
Existing Dumpsite &
Proposed MRF/Workshop
Khanu Wali
Existing Transfer Station
Band Road
Bahawalpur
N5
New Land Fill
Mari Sheikh Shajran
Punjab Urban Development Project PICIIP
EIA of IWMS in Bahawalpur
Existing Dumpsite
Existing Transfer Station
Access Route for Proposed Landfill Site
Proposed Landfill Site
AJK
Balochistan
Gilgit - Baltistan
Islamabad
KPK
Punjab
Sindh
N
0
4
8
12
16
20
Km

منصوبے کی ضرورت ہے۔

7. ٹھوس کچرےکو ٹھکانے لگانا ماحولیاتی صحت کے بنیادی اشارے میں سے ایک ہےٹھوس کچرےکو غلط طریقے سے ٹھکانے لگانے اور ویکٹر سے پیدا ہونے والی بیماریوں کے واقعات کے درمیان گہرا تعلق ہے۔ لہذا، ٹھوس فضلے کو ٹھکانے لگانے کا موثر نظام علاقے کی ایک اہم ضرورت ہے تاکہ اس طرح کے کچرے کی وجہ سے صحت کے خطرات کو کم سے کم کیا جاسکے۔ بہاولپور شہر میں ٹھوس کچرے کو ٹھکانے لگانے کی موجودہ صورتحال ماحولیاتی صحت کے خطرے کے دیگر اشاریوں کے مقابلے میں زیادہ تشویشناک ہے۔
8. پورے شہر میں میونسپل فضلہ جمع کرنا اور ٹھکانے لگانا بھی مناسب حد تک مناسب نہیں ہے۔ جمع شدہ کچرااکثر سڑک کے کنارے کھلی جگہوں میں پھینک دیا جاتا ہے اور مسافروں اور آس پاس کے علاقوں کے رہائشیوں کے لئے انتہائی تکلیف دہ ہوجاتا ہے۔ یہ عمل ان کی کمی اور قابو کے بجائے ماحولیاتی صحت کے خطرات کی ایک اور سنگین وجہ ہے۔ فی الحال بہاولپور میں کوئی سائنسی اور انجینئرڈ لینڈ فل سائٹ دستیاب نہیں ہے۔ کھلی ڈمپنگ کے ساتھ صرف محدود گھریلو فضلہ جمع کرنے کی جگہ ہے۔
9. مجوزہ بہاولپور آئی ایس ڈبلیو ایم ایس بہاولپور ویسٹ مینجمنٹ کمپنی (بی ڈبلیو ایم سی) اور پنجاب ایل جی اینڈ سی ڈی ڈی کو شہر میں ایس ڈبلیو ایم سسٹم کو مکمل طور پر تبدیل کرنے میں مدد فراہم کرے گا۔ اس منصوبے میں پرائمری اور سیکنڈری میونسپل سالڈ ویسٹ (ایم ایس ڈبلیو) جمع کرنے کے نظام کی تنصیب اور بین الاقوامی معیار کے بائیو ریایکٹر لینڈ فل بشمول ایم آر ایف اور کمپوسٹنگ پلانٹ کی ترقی بھی شامل ہے تاکہ بہاولپور سے میونسپل ٹھوس کچرے کو کم از کم 20 سال تک ذخیرہ کیا جاسکے۔

عوامی مشاورت کا عمل

10. مجموعی طور پر 160 سے زائد مختلف افراد سے جامع ء مشاورت کے دو دور منعقد کیے گئے۔ عوامی مشاورت کا پہلا دور نومبر 2022 کے پہلے ہفتے میں منعقد ہوا تھا جبکہ عوامی مشاورت کا دوسرا دور دسمبر 2022 کے مہینے میں مکمل ہوا تھا۔ ان مشاورتوں میں تعمیراتی اور آپریشنل مرحلے سے وابستہ مثبت اور منفی اثرات اور منفی اثرات کو مناسب طور پر کم کرنے کے بارے میں معلومات کا تبادلہ کیا گیا۔

متبادل کا تجزیہ

11. کچرے کو ٹھکانے لگانے کا موجودہ نظام غیر کنٹرول ڈمپ سائٹس کے ذریعے کیا گیا ہے۔ ان ڈمپ سائٹس کو اکثر ایک ایسے علاقے کی خصوصیت دی جاتی ہے جہاں کچرا آسانی سے لے جایا جاتا ہے، اتارا جاتا ہے، اور بعض اوقات بلڈوزر کے ذریعہ برابر کیا جاتا ہے۔ تقریبا یہ تمام مقامات مٹی اور زیر زمین پانی کی آلودگی کے خلاف کوئی تحفظ کے بغیر کام کرتے ہیں۔
12. زمین بھرنے کی ترقی کے لئے تین مختلف مقامات درج ذیل تھے:

یزمان - مالوٹ مشینری اسٹور کے بغل میں ماروٹ یزمان روڈ بہاولپور میں واقع ہے۔

خانو ولی - یہ مقام دریائے ستلج سے 0.5 کلومیٹر کے فاصلے پر واقع ہے اور قریب ترین انسانی بستی منصوبےکی جگہ سے 350-400 میٹر کے دائرے میں واقع ہے۔ مجوزہ جگہ کا علاقہ 25 سال کی قابل استعمال زندگی کے لئے کافی ہے۔

ماڑی شیخ شجرہ - بستی یار محمد، بہاولپور کے قریب واقع ہے۔ جگہ کا کل رقبہ 110 ایکڑ ہے۔ مجوزہ جگہزیادہ تر زرعی کھیتوں سے گھری ہوئی ہے اور قریبی انسانی بستیوں سے محفوظ فاصلے پر واقع ہے۔

13. ماڑی شیخ شجرہ کی جگہ کچرا کنڈی کے انتخاب کے لئے درکار زیادہ تر معیار کو پورا کرتی ہے۔ یہ شہر سے کافی دور ہے۔ آبادی بہت کم ہے اور اگرچہ کچھ حساس ریسیپٹرز موجود ہیں ، لیکن مناسب ماحولیاتی جائزے کیے جارہے ہیں اور ماحولیاتی اور سماجی اقتصادی اثرات دونوں کو کم سے کم کرنے کے لئے بازآبادکاری کے منصوبے تیار کیے جارہے ہیں۔ آس پاس کا زیادہ تر علاقہ بنجر اور زرعی ہے۔ دیگر متبادل مقامات کو دیکھتے ہوئے ، تمام یا تو زرعی یا نیم شہری علاقے تھے ، جو کم از کم اس جگہ کو باقی میں سب سے زیادہ مثالی رکھتے ہیں۔
14. کسی اضافی اراضی کے حصول کی ضرورت نہیں ہے کیونکہ 110 ایکڑ اراضی کا رقبہ پہلے ہی بی ڈبلیو ایم سی کی ملکیت ہے اور سیل کے مقامات بفر زون کی ضروریات کو پورا کرتے ہیں جو اس بات کو یقینی بناتا ہے کہ لینڈ فلنگ آپریشن کے ممکنہ اثرات کے باہر کسی ناقابل قبول اثر کا سبب نہ بنیں۔ قریبی آبادی کو بائیو ری

ایکٹر لینڈ فل کی خوبیوں کے بارے میں تعلیم دے کر اس منصوبے کی سماجی قبولیت میں اضافہ کیا گیا ہے۔ اس منصوبے میں کوئی نجی اراضی کا حصول شامل نہیں ہے۔

15. دیگر قسم کے متبادل جن پر غور کیا گیا ان میں اینروبک نظام ہضم کے لئے تکنیکی متبادل، مواد کی بازیابی کی سہولت کے لئے تکنیکی متبادل، کچرے کو ٹھکانے لگانے کے متبادل کے ساتھ ساتھ ممکنہ علاج کے اختیارات کا موازنہ کرنے کے ساتھ ساتھ مختلف قسم کی لینڈ فلنگ طریقہ کار کا اقتصادی پہلو تجزیہ شامل تھا۔

ممکنہ بڑے اثرات

تعمیر سے پہلے / ڈیزائن کا مرحلہ: اہم ممکنہ اثرات جن کا جائزہ لیا گیا ہے اور جن کے لئے ضروری تخفیف کے اقدامات بھی تجویز کیے گئے ہیں، حسب ذیل ہیں:

- کچراکنڈی کی نامناسب ڈیزائننگ مختلف اثرات کا باعث بنتا ہے.
- آئی ایف سی گائیڈ لائنز پر عمل نہ کرنے کی وجہ سے لینڈ فل سائٹ کا نامناسب انتخاب.
- زمین کے استعمال میں تبدیلی,

تعمیر کا مرحلہ: اہم ممکنہ اثرات جن کا جائزہ لیا گیا ہے اور جن کے لئے ضروری تخفیف کے اقدامات بھی تجویز کیے گئے ہیں، حسب ذیل ہیں:

- لینڈ فل کی نامناسب تعمیر حتمی ڈیزائن کے مطابق نہیں.
- مقامی افراد کی صحت اور حفاظت کے مسائل.
- پیشہ ورانہ صحت اور حفاظت کے مسائل.
- خطرناک اور غیر خطرناک کچرے کی نامناسب طریقے ٹھکانے لگانا.
- ایم آر ایف اور لینڈ فل سائٹ تک رسائی کے لئے سڑکوں کی تعمیر سے وابستہ اثرات.

آپریشن کا مرحلہ: اہم ممکنہ اثرات جن کا جائزہ لیا گیا ہے اور جن کے لئے ضروری تخفیف کے اقدامات بھی تجویز کیے گئے ہیں، حسب ذیل ہیں:

- لیچیٹ کی نسل
- مٹی اور زیر زمین پانی کی ممکنہ آلودگی
- لینڈ فل گیس کی پیداوار
- قابل اعتراض بدبو کی پیداوار اور ہوا کے معیار پر اثرات
- ورمن اور بیماری ویکٹر کی پیداوار کی کشش
- پیشہ ورانہ صحت اور حفاظت
- کچرا جمع کرنے اور اٹھانے کے اثرات
- ہوا سے بھرا ہوا کچرا
- بندش اور بندش کے بعد کے اثرات

تخفیف کے اقدامات

16. ای آئی اے رپورٹ میں تعمیر سے قبل، ڈیزائن، آپریشن، بندش اور بندش کے بعد کے مراحل سے متعلق تخفیف کے اقدامات کی تفصیل دی گئی ہے۔ لیچیٹ جمع کرنے اور علاج، لینڈ فل گیس مینجمنٹ، بدبو اور ویکٹر کنٹرول کے لئے ضروری ڈیزائن پر غور شامل کیا گیا ہے. ای آئی اے رپورٹ میں مٹی اور زمین / سطحی پانی کی آلودگی ، او ایچ ایس کے مسائل ، معاشرتی تنازعات ، پودوں کے نقصان اور متعدی بیماریوں سے بچنے کے لئے تعمیراتی مرحلے سے وابستہ تخفیف کی تفصیل دی گئی ہے۔

17. آپریشن کے مرحلے کے لئے تخفیف فراہم کی جاتی ہے تاکہ اس بات کو یقینی بنایا جاسکے کہ لیچیٹ اور لینڈ فل گیس کا مناسب انتظام کیا جائے ، کچرا اٹھانے کے اثرات ، ٹریفک کے مسائل ، ہوا سے اڑنے والا کچرا ، ویکٹر اسپریڈ اور ہوا کے معیار کے مسائل نہ ہوں۔ بدبو اور کوڑے کے مسائل سے بچنے کے لئے روزانہ کور کا استعمال کیا جائے گا۔ علاقے کی جمالیاتی کشش کو بہتر بنانے کے لئے ضروری شجرکاری کے ذریعے بفر زون تیار کیا جائے گا اس منصوبے کے نتیجے میں کچرے کے انتظام کی بہتر خدمات، صحت عامہ میں بہتری اور علاقے کی جمالیاتی حسن میں بہتری آئے گی۔

مجموعی اثرات:

18. لینڈ فل منصوبے کے علاقے میں کوئی دوسرا بنیادی ڈھانچہ کام کرنے کا منصوبہ نہیں ہے جبکہ یہ منصوبے کے کام ۲۰۲۵ تک انجام دیئے جائیں گے۔ اس طرح، کسی مجموعی اثرات کی توقع نہیں ہے.

بالواسطہ اور متاثرکن اثرات:

19. مجوزہ بہاولپور ایس ڈبلیو ایم سہولت کے ہر مرحلے کے ممکنہ اثرات کی نشاندہی کی گئی ہے اور فیلڈ ڈیٹا، ثانوی اعداد و شمار، ماہرین کی رائے اور تحقیق کا استعمال کرتے ہوئے پاکستان میں پہلے کے تقابلی منصوبوں کا جائزہ لیا گیا ہے۔ ان میں جسمانی، حیاتیاتی اور سماجی و اقتصادی ماحول پر اثرات شامل ہیں. ہوا کے اخراج، ٹریفک اور شور سے ماحول پر پڑنے والے اثرات کا بھی جائزہ لیا گیا ہے اور یہ قابل قبول اور ماحول کی گنجائش کے اندر پایا گیا ہے۔

20. اس طرح، مجوزہ لینڈ فل کاموں سے منفی بالواسطہ اور متاثر کن اثرات کی توقع نہیں ہے.

نتیجہ اور سفارشات

21. رپورٹ میں زمہ داران کے واضح کردار اور ذمہ داریوں کے ساتھ ایک ایکشن پلان فراہم کیا گیا ہے۔ پی ایم یو، کنٹریکٹرز اور کنسٹرکشن سپرویژن کنسلٹنٹ اس ایکشن پلان کے بڑے اسٹیک ہولڈرز ہیں۔ تعمیراتی کام شروع ہونے سے پہلے ایکشن پلان پر عمل درآمد ہونا ضروری ہے۔

22. تخفیف کے اقدامات کو تعمیر اور آپریشن کے دوران ماحولیاتی نگرانی کے ایک پروگرام کے ذریعہ یقینی بنایا جائے گا تاکہ اس بات کو یقینی بنایا جاسکے کہ ای ایم پی میں تمام اقدامات پر عمل درآمد کیا جاتا ہے اور اس بات کا تعین کیا جاتا ہے کہ آیا ماحول کو ارادے کے مطابق محفوظ کیا گیا ہے یا نہیں۔ اس میں سائٹ پر اور باہر مشاہدات، دستاویزات کی جانچ پڑتال، اور کارکنوں اور فائدہ اٹھانے والوں کے ساتھ انٹرویو شامل ہوں گے، اور اصلاحی کارروائی کے لئے کسی بھی ضروریات کی اطلاع دی جائے گی۔

23. ڈیزائن ، تعمیر اور آپریشن سے وابستہ ممکنہ منفی اثرات کو مناسب انجینئرنگ ڈیزائن اور تجویز کردہ تخفیف اقدامات اور طریقہ کار کی شمولیت یا اطلاق کے ذریعہ بغیر کسی مشکل کے معیاری سطح تک کم کیا جاسکتا ہے۔ یہ نتیجہ اخذ کیا گیا ہے کہ مجوزہ منصوبے کو ای آئی اے مطالعہ میں نشاندہی کردہ مناسب تخفیف اقدامات اور نگرانی کے پروگراموں کے ساتھ آگے بڑھنا چاہئے۔

Appendix A.18 NOC from Wildlife Department for Site

PUNJAB WILDLIFE & PARKS DEPARTMENT

OFFICE OF THE DEPUTY DIRECTOR WILDLIFE
BAHAWALPUR REGION, BAHAWALPUR
Ph No.062-9255189 Email:ddwbwp1@gmail.com

No. 545/DDW-BWP/2023 Dated Bahawalpur, the 21/02/2023

To,

The Infrastructure Engineer
PMU, PICIIP LG&CD Department
Bahawalpur

SUBJECT:- **REQUEST FOR NO OBJECTION CERTIFICATE (NOC) CONFORMING NO ENDANGERED SPECIES IN THE PROJECT AREA**

Reference: Letter No. LG&CD/PICIIP/PRF-PUDP/CIU-PWP/22-55 Dated: 20.02.2023

It is apprised that Assistant Director Wildlife Protection Force, Bahawalpur has reported vide letter No. 11/AD-WPF-BWO/2023 Dated: 21.02.2023 that there is no disturbance for wildlife is observed in the area of the project and most of species red listed by IUCN are not native to the said area. Furthermore, in case the project is extended beyond the boundary limits a comprehensive study of such area would be required.

2. Hence, this department has no objection to the execution of the said projection at proposed site.

(SYED ALI USMAN BUKHARI)
DEPUTY DIRECTOR WILDLIFE
BAHAWALPUR REGION
BAHAWALPUR

Appendix A.19 Hydrogeological Assessment Report

Estimation of Leachate Leaking Effect on Ground Water Quality (Bahawalpur Landfill site)

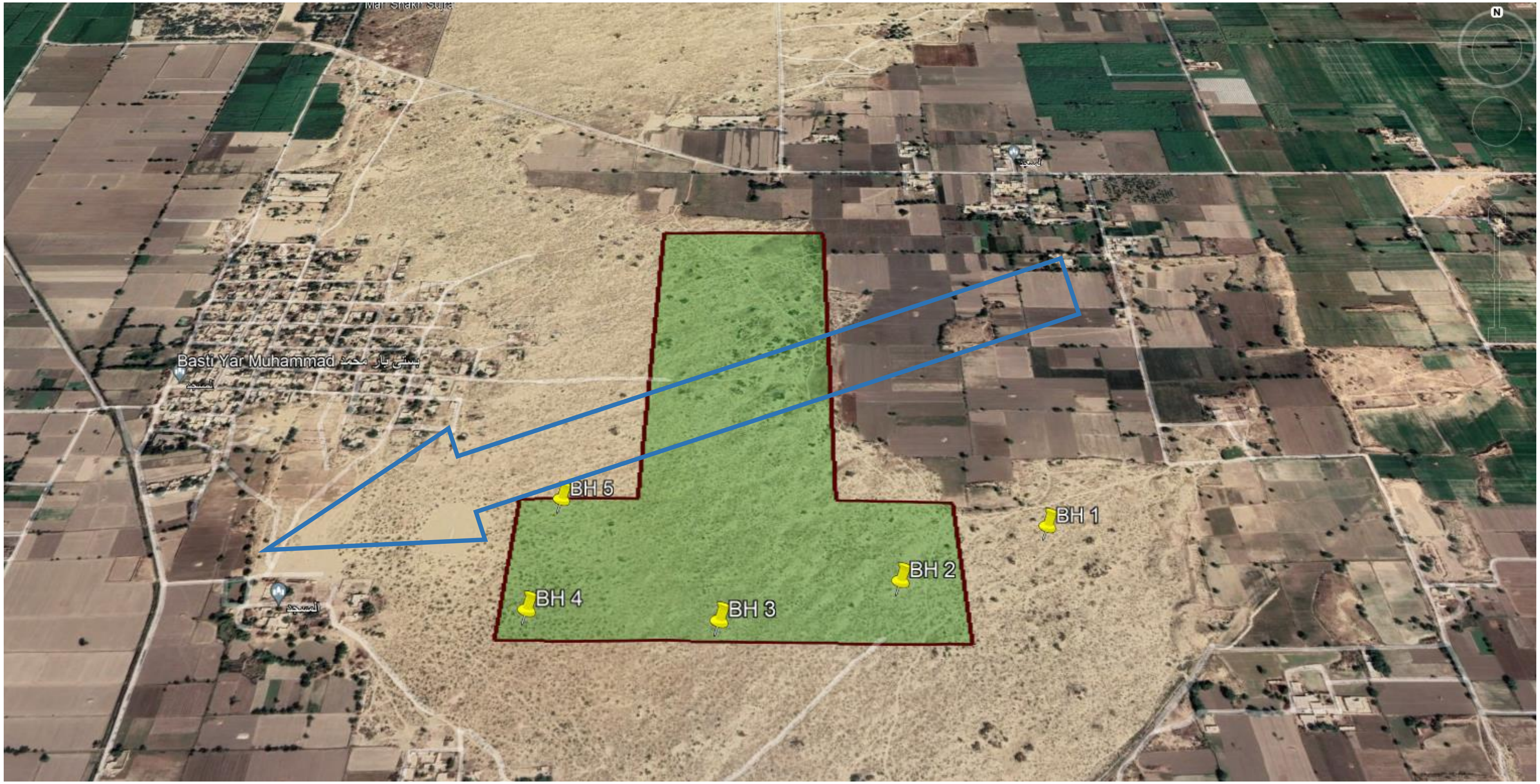
Part 1: Problem statement

Sanitary landfills generally are constructed by placing wastes in excavations and covering the material daily with soil--thus the term "sanitary" to indicate that garbage and other materials are not left exposed to produce odours or smoke or attract vermin and insects. Even though a landfill is covered, leachate may be generated by the infiltration of precipitation and surface runoff. Fortunately, many substances are removed from the leachate as it filters through the unsaturated zone, but leachate may contaminate groundwater and even streams if it discharges at the surface as springs and seeps.

In Bahawalpur Landfill site (LFS), as per geotechnical investigation, the ground comprises of Silty Sand (SM / SP) dominates up to 4-6m depth afterward 2-3m Silty Clay/Lean Clay and Sandy Strata (SP-SM)/Silty Sand (SM) is observed till borehole termination depth. A Silty Clay (CL-ML)/Lean Clay (CL) layer of 1-2m is observed at varying depth of 12-14m in all boreholes except BH-03. However in all four excavated test pits, Silty Sand (SM) is dominant up to termination depth. The groundwater table was encountered in boreholes at depths 14 to 16.5m.

The ground condition reveals mostly Sandy silty with occasional bands of Lean Clay and Silty Clay. Overall the soil can be considered as Silty Sand (SM), as a conservative estimate of Geology. Soil profile for different boreholes carried out during the geotechnical investigation is provided in Geotechnical Investigation Report.

A leachate leak from any of the storage cells may result in the contamination of the water table below the LFS. The geology of the site is Sandy Silt (considered for modelling purposes to be of Moderately High Permeability) with occasional bands of Lean Clay of low permeability. The water table, based on actual data from site as well as the surroundings of LFS, shows that the water table is sloping towards nearby mosque and a few households. **Figure 2** below shows the community location and the ground water flow from North-East towards South West in the surrounding of the LFS.



Location of tube wells and groundwater levels showing underground flow direction

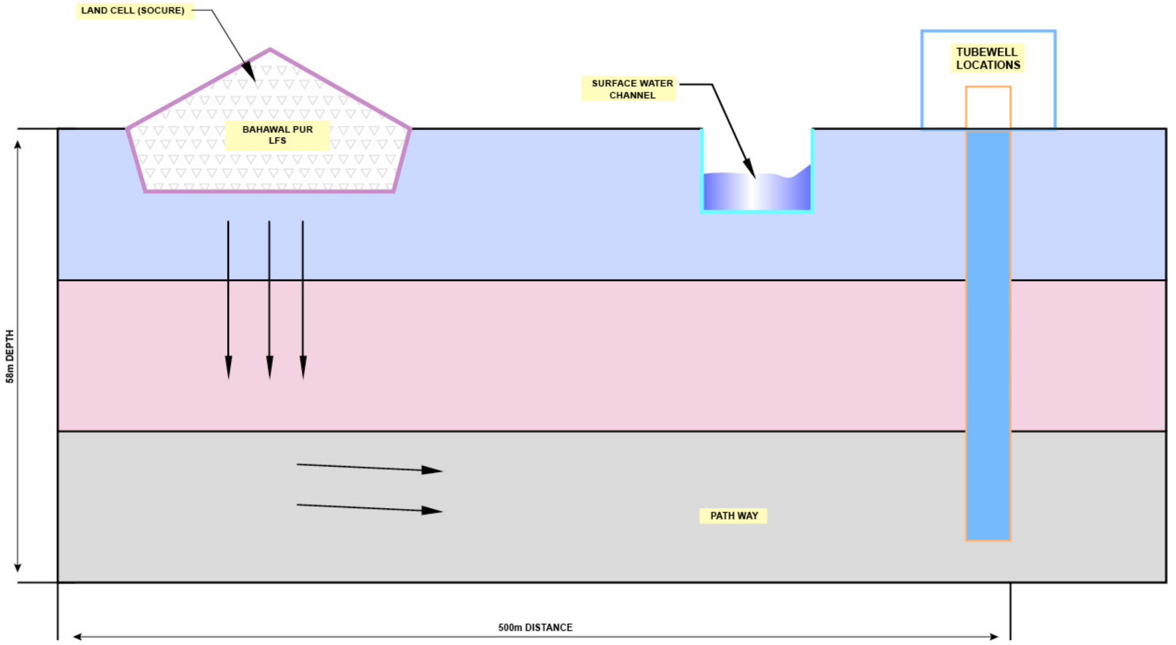
Sr.No.	Bore No.	Coordinates		Drilling Depth (m)	GWT (m)
		N	E		
1	**BH-01**	3243377	752238	**15 m**	**14 m**
2	**BH-02**	3243267	751984	**18 m**	**16 m**
3	**BH-03**	3243229	751750	**20 m**	**N/A**
4	**BH-04**	3243218	751460	**16 m**	**14.80 m**
5	**BH-05**	3243357	751471	**18 m**	**16.5 m**

Depth of water table from boreholes

As per **Figure 2** above, the nearest communities with respect to the proposed LFS is at risk in the direction of the flow are Residential houses (Distance 340m), and a Mosque (Distance 320m). The conceptual model as well as the pathway of the groundwater flow is shown below in **Figure 3**.

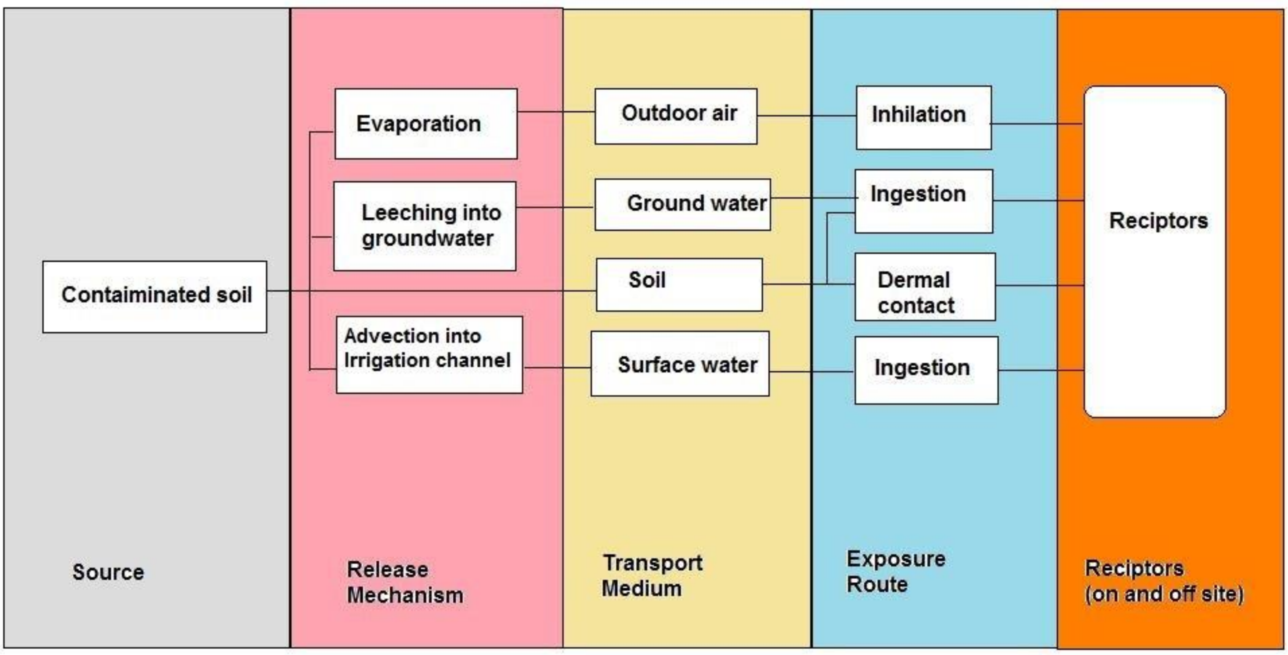
This report focuses on checking the source, identify transport mechanisms and potential targets affected by the contamination using a qualitative and quantitative risk assessment of the problem. The involve computation of contaminant concentration at the targets identified in a conceptual model, estimating the concentration at various target points. In the end, the remedial measures will be advised based on the analyses and any further data required will be identified.

Part 2: Conceptual model



Conceptual model showing source, pathway, and targets

Part 3: Sources pathways and targets



Transport and fate mechanisms for contaminant movement

Part 4: Qualitative risk assessment

The qualitative risk assessment for the study is described in the following steps:

- Step 1: Identification of Key Risks based on the data collection
- Step 2: Establishment of PI matrix to categorize different risks

- Step 3: Assigning PI to the agreed risks to calculate risk score from PI matrix
- Step 4: Ranking the risk scores to create a severity table and finalize ranks for different key risks

Step 1 Identification of Key Risks

Risk No	Description
1	Contamination of groundwater from leachate leaking cell
2	Contamination of surface water in the irrigation channel
3	Contamination uptake in drinking water by the local community
4	Evaporation of contaminant in the air to reduce air quality
5	Dermal contact while using water for washing and cleaning
6	Danger to the aquatic life in the area
7	Contamination uptake in vegetation and subsequent ingestion (eating)

Step 2 PI Matrix

Impact ↓					
Very High	Med. Risk	Med. Risk	High risk	High risk	High risk
Serious	Med. Risk	Med. Risk	Med. Risk	High risk	High risk
Moderate	Low risk	Med. Risk	Med. Risk	Med. Risk	High risk
Minor	Low risk	Low risk	Low risk	Med. Risk	Med. Risk
Insignificant	Low risk	Low risk	Low risk	Med. Risk	Med. Risk
Probability→	Very Low	Low	Medium	High	Very High

Step 3 Assigning PI to the agreed risks to calculate risk score from PI matrix

Risk No	Description	Impact	Probability	Risk score
1	Contamination of groundwater from leachate leaking cell	Serious	High	High
2	Contamination of surface water in the irrigation channel	Serious	Low	Low
3	Contamination uptake in drinking water by the local community	Very High	High	High
4	Evaporation of contaminant in the air to reduce air quality	Minor	Low	Low
5	Dermal contact while using water for washing and cleaning	Moderate	Medium	Medium
6	Danger to the aquatic life in the area	Minor	Low	Low

7	Contamination uptake in vegetation and subsequent ingestion (eating)	Insignificant	Low	Low

Step 4 Ranking the risk scores to create a severity table

Risk No	Description	Impact	Probability	Risk score	Rank
1	Contamination of groundwater from the leaking tank	Serious	High	High	1
3	Contamination uptake in drinking water by the local community	Very High	Very High	High	1
5	Dermal contact while using water for washing and cleaning	Serious	Medium	Medium	2
2	Contamination of surface water in the irrigation channel	Moderate	Medium	Low	3
4	Evaporation of contaminant in the air to reduce air quality	Minor	Low	Low	3
6	Danger to the aquatic life in the area	Minor	Medium	Low	3
7	Contamination uptake in vegetation and subsequent ingestion (eating)	Insignificant	Low	Low	3

The above risk analysis indicates that the contamination of groundwater from possible leakage of a storage cell may result in the uptake of contamination by the nearby community. Therefore, the possibility of contamination reaching the community, time taken to reach the community and the concentration at the target needs further investigation.

Part 5: Estimates of likely range of contamination at targets

The calculations for the estimates of likely range of contamination at targets and time travel are provided below:

i. Available data:

Soil conditions:

Sandy Silt (SM): 0 to 18m

Permeability K = 5 x 10^{-6} m/sec or 4.3 x 10^{-1} m/day,

Porosity n = 0.33 (Terzaghi, K., Peck, R., and Mesri, G., Soil Mechanics in Engineering Practice. Wiley, New York, 1996.)

Thickness = 18m from three boreholes

Aquifer:

Material Type = Sandy Gravel

Permeability K = between 30 m/day, (Estimated)

Porosity n = 0.23

Thickness = Not determined (assumed to be greater than mixing depth on the conservative side)

Groundwater:

Water table elevations:

Name of TW	Depth of Water Table (m)
BH 1	14
BH 2	16
BH 4	14.8
BH 5	16.5

Landfill Cell:

Cell Area = 103600 m^2

The base of contaminant tank = 10m below ground level

Water supplies:

By Tube well at local community

Population = 2000 people (Estimated) Community of about 200 Homes.

Flow rate = 0.5 m^3/sec (Estimated)

Distance from landfill site =340m

Water consumption = 200 litres/person/day (includes, washing, drinking, cooking, toilets etc)

Water drinking = UNKNOWN

Calculating containment concentration at source Co:

Rate of leakage = 2211 Kg/year

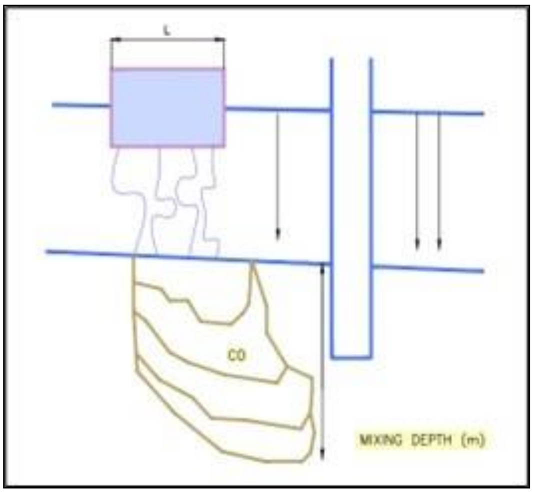
Permeability = 0.43 m/day

Slope of water table

dh/dx = 2/280 m/m

Ground water flow rate Vd = -K * dh/dx = 30 * 0.03 = 0.21 m/day

Mixing depth Z = $(0.0112 * L^2)^{0.5}$ + b (1 – exp[(-L * inf) /(K * dh/dx *b)]   (equation 1)



Where

L = source length parallel to ground water flow = 200m

b = Aquifer thickness = 100m

inf = infiltration rate of rain = 0.0038 m/day

K = Hydraulic conductivity (taking minimum) = 30 m/day

dh/dx = hydraulic gradient of water table = 2/280 m/m

Putting the values in equation 1 we get

Z = 27.5 m, Near 20m which is maximum usual thickness

Flow rate below the Cell $Q = V_d * Z * Y$ m^3/day

Where Y is width of the tank

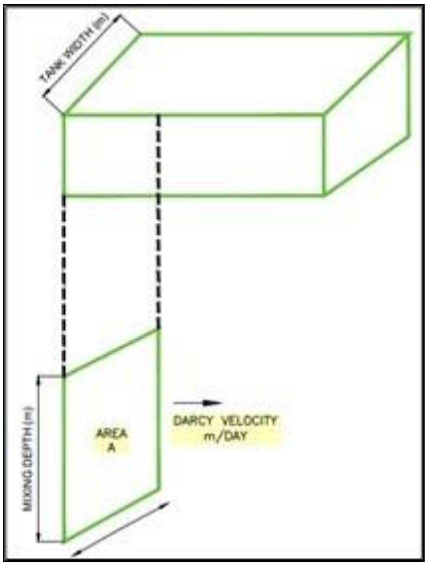
Q = 0.9 * 22.02 * 10

Q = 59.081 m^3/day

Q = 21564 m^3/year

Contamination at source Co = amount lost per year / flow rate

Co = 0.12 Kg/m^3 Contamination per m^3 in water table just below source



ii. Using Ogata and banks equation to calculate contaminant concentration at various targets identified;

$C/Co = ½ \times ERFC [(x – (v/R_f)t)/(4(D/R_f)t)^{1/2}]$ → Ogata and banks equation with no biodecay

Note: error check was made for $[(x – vt)/(4Dt)^{1/2}]$ < 0, and for negative values

ERFC (fx) = 1 + ERF (-fx) is used

Targets point identified for Ogata and banks equation is Tube wells at nearest community 340m away from Landfill

First calculating dispersion coefficient for the contaminant

$D = \alpha_L \times v + D^*$

Where D* = diffusivity of Leachate

D* = 0 m^2/day (Assuming no diffusion is taking place – conservative estimate)

Flow path length L = True velocity × time

Time = 365 × 1 = 365 days

True velocity v = K × (dh/dx)/n

V = 0.64 m/day

L = 0.64 x 365 = 219 m

Therefore using equation

$\alpha_L = 0.83 (\log L)^{2.414}$

$\alpha_L = 23.7$ m

As

$D = \alpha_L \times v + D^*$

Putting the values we get

D = 15.3 m^2/day

Using Excel to solve Ogata and banks equation

Input data for Otaga and Banks equation

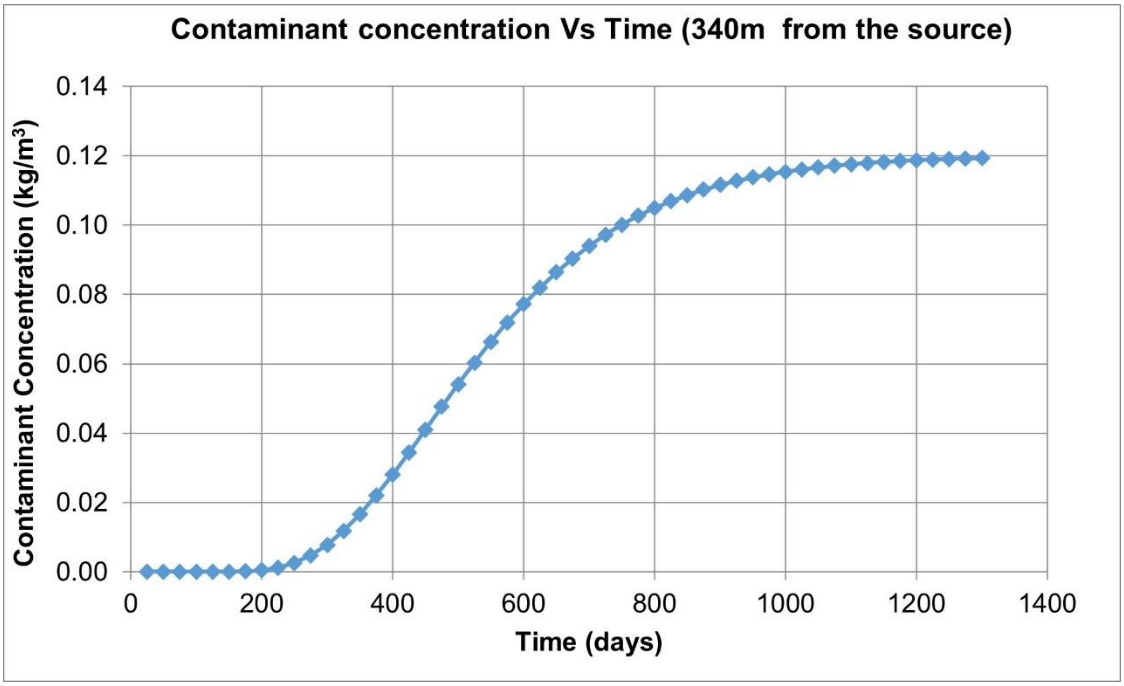
Using excel to calculate the expected concentration of a contaminant 340m from a source Vs time after the source started emitting contamination based on the following data			
Inputs	Co	0.12	kg/m3
	K	30	m/day
	dh	2	m
	dx	280	m
	porosity	0.33	
	D, Dispersion Coefficient	15.3	
	x, Distance from Source	340	m
Calculations			
	Darcy Velocity	0.214285714	m/day
	v, True Velocity	0.649350649	m/day

Contaminant concentration at the tube well location at 340m from the landfill site

Time t (days)	Contaminant concentration C, (kg/m3)
25	0.00
50	0.00
75	0.00
100	0.00
125	0.00
150	0.00
175	0.00
200	0.00
225	0.00
250	0.00
275	0.00
300	0.01
325	0.01
350	0.02
375	0.02
400	0.03
425	0.03

Time t (days)	Contaminant concentration C, (kg/m3)
450	0.04
475	0.05
500	0.05
525	0.06
550	0.07
575	0.07
600	0.08
625	0.08
650	0.09
675	0.09
700	0.09
725	0.10
750	0.10
775	0.10
800	0.10
825	0.11
850	0.11
875	0.11
900	0.11
925	0.11
950	0.11
975	0.11
1000	0.12
1025	0.12
1050	0.12
1075	0.12
1100	0.12
1125	0.12
1150	0.12
1175	0.12
1200	0.12
1225	0.12
1250	0.12
1275	0.12

Time t (days)	Contaminant concentration C, (kg/m3)
1300	0.12



Breakthrough curve Contaminant concentration at local community location Vs time in days

Time taken by the contamination to appearing in the local community water supply after cell breach at the LFS = 4/0.432 + 300 = **310 Days**

Time required to reach the full concentration of 0.12 kg/m^3 will be 1010 days

Part 6: Conclusions.

- The hydrogeological analysis was based on a very conservative estimate of contaminant movement through strata considering no bio decay, diffusion or retardation is occurring to model worst-case scenario.
- Based on analysis, it will take a total of **310 Days** for contamination to start appearing at the nearest tube well located in the direction of flow at the local community 340m away from the landfill site.
- Once the contamination start appearing in the water supply from the tube well it will take about 700 more days to reach full concentration.
- Under part 2a of section 57 (Environmental Protection Act 1990, UK Guidance) as the amount of contamination is below the guidelines values for contamination the part of the land cannot be described as contaminated land here.

- However, there is a significant chance of harm if the amount of groundwater flow reduces or the contamination level increases above the current levels. Therefore it is recommended to use observation boreholes to monitor groundwater quality and also additional checks should be made on monthly basis by collecting water samples from the nearest tube well for detection of any contamination. If any contamination is detected then the necessary action to plug the breach should be completed with 310 days.

- The leachate discharge should be measured on regular basis to indicate barrier breach from loss of leachate.

Appendix A.20 Air Dispersion Modelling Report

General:

This document deals with the quantitative and qualitative estimates of criterial pollutants i.e., Particulate Matter (PM_{10}), Carbon Monoxide (CO) and Oxides of Nitrogen (NO_x) to be emitted through the flare stack of proposed landfill site located at mouza Nouabad, District Bahawalpur, Punjab.

1. Location:

The proposed landfill site will be developed at Mari Sheikh Shijra, located approximately 11km away from Bahawalpur city center at an elevation of 392 ft (119 m) above mean sea level (AMSL).

The google coordinates of the proposed site are given **Table -1** below.

Bahawalpur Solid Waste Management Facility Locations

Site Name	Latitude	Longitude
Proposed Landfill Site (LFS)	29°17'46.46"N	71°35'26.70"E

2. Methodology:

Lakes Environmental Software[33], “AERMOD view” was adapted to predict the downwind transportation or dispersion of criteria pollutants emission from the operation of the flare stack of landfill site.

AERMOD View is our most commonly used air dispersion model and is applicable to a wide range of buoyant or neutrally buoyant emissions up to a range of 50km.

3.1 AERMOD View:

The AERMOD view air pollution dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 kilometers) dispersion of air pollutant emissions from stationary sources.

[33] https://www.weblakes.com/software/air-dispersion/aermod-view/

- A meteorological data pre-processor (AERMET) that accepts surface meteorological data, upper air soundings, and the inbuilt data from the model backups. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain preprocessor (AIRMAP) whose main purpose is to provide a physical relationship between terrain features and the behavior of air pollution plumes. It generates location and height data for each receptor location.

Specific electronic file formats on the meteorological conditions and terrain were used to form input in the model sub-preprocessors to successfully run the program.

- **Mixing Height:** The mixing height (or depth) can be described as "the height above the surface through which relatively vigorous vertical mixing occurs". The mixing height is therefore well defined under neutral or unstable conditions and is undefined in stable conditions. A mixing height of 50 and 150 meters was assumed for neutral and unstable conditions respectively.
- **Stability:** The atmospheric stability category associated with maximum concentrations varies depending on the dispersion coefficient and the source height. The maximum concentration of pollutant generally increases with decreasing wind speeds. Wind stability D (neutral) was used.

3.2 Main Assumptions:

The following assumptions were made for the air dispersion model:

- The plume spread has a Gaussian distribution in both the horizontal and vertical planes;
- The mean wind speed; (a) is high enough to ignore the diffusion effect in the lee-ward direction; (b) is constant throughout the layer where the plume is being transported; and (c) the wind speed remains constant during travel and for that particular time;
- The Pasquill Stability Categories considered are B & D, (B: representing semi-turbulent conditions in summer within the transporting wind field, which is more appropriate for the meteorological conditions and D: representing neutral conditions which prevail during winter months in the area.
- Turbulence is assumed same everywhere during the period under consideration;

3.3 Key Inputs:

The key inputs required by the model were; Number, height, inner diameter, velocity, emission rate of pollutants and temperature of stack. The pollutant concentrations and other related data obtained from the Designer of landfill Project.

Inputs data

Sr. No.	Stack Parameter	Values
Technical Inputs / Specification of Stacks		
1	Stack height	42.50 m
2	Stack diameter	0.85 m
3	Δh (Gas Enthalpy)	1.94 j
4	Stack Gas exit Velocity or Gas Flow Rate	1.15 m
5	Down wind speed (u)	1.27m/s
6	Stability class	D (Neutral)
7	Ambient Temperature	24.5^{o}C
8	Stack Temperature	24.5^{o}C
9	Urban /Rural Class Option	Rural
10	Total number of stacks	01
11	Gas Emission rate	0.0561g/s
Pollutants Specifications		
The concentration of pollutants as percentage ratio of the total pollutant concentration was estimated at "15% oxygen normalization" as below: **Exhaust Analysis % Vol.** • Nitrogen 74.51% • Oxygen 13.15 % • Carbon Dioxide 3.47% • Water 6.99% • Particulates 1.88 %		

3.4 Modeling Outputs

Downwind model summaries of overall 24-hourly levels at receptors distanced at 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1500, 2000, 2500, 3000, 4000 and 5000 meters from the stack along 16 radial directions 22.5^{o} apart from each. The stack was treated as point source for modeling the plume dispersion.

Modeling levels have been compared to verify compliance with the allowable ambient levels. Comparison of levels has been made with WHO allowable atmospheric (ambient) concentration for CO, NOx, & PM_{10} for 24-hours mg/m^3.

The dispersion and ground level concentrations of emissions were determined by the interaction of the following variables:

a) Flare Stack characteristics

b) Physical and chemical characteristics of the emissions

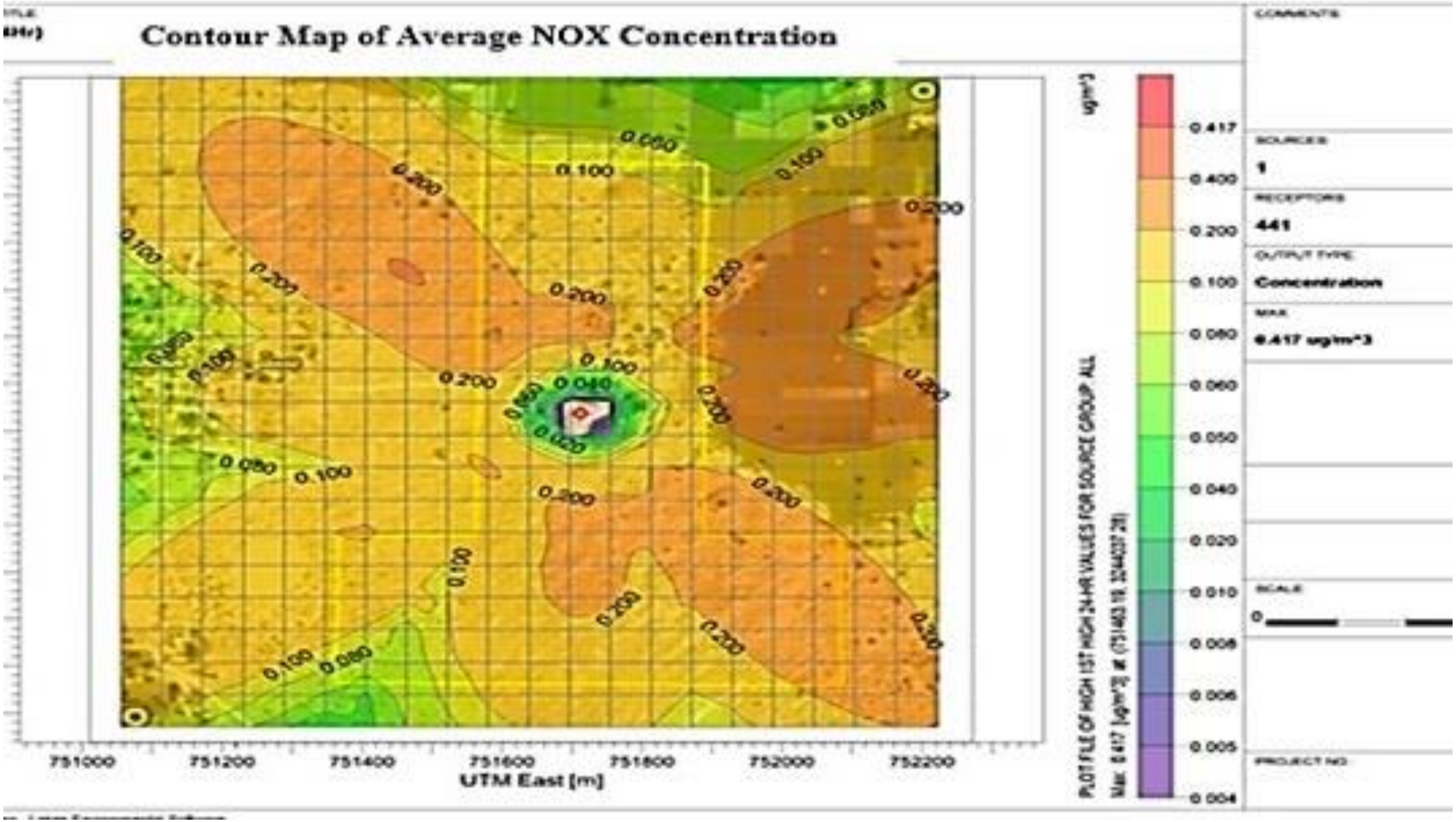
c) Meteorological conditions near the site during the time the emissions traveled from the stack to the ground level receptor

d) Topographical conditions of the site and surrounding areas

The special dispersion of the pollution levels around the project site was modeled for ground level concentration. Dispersion of maximum pollutants is found in the north east direction driven by the south-westerly wind. Models for dispersion of NO_x, and PM based 24-Hour Averages for proposed facilities have been recorded in Air Quality Modelling Tables below.

24hs Average NOx Concentration (μg/m3)

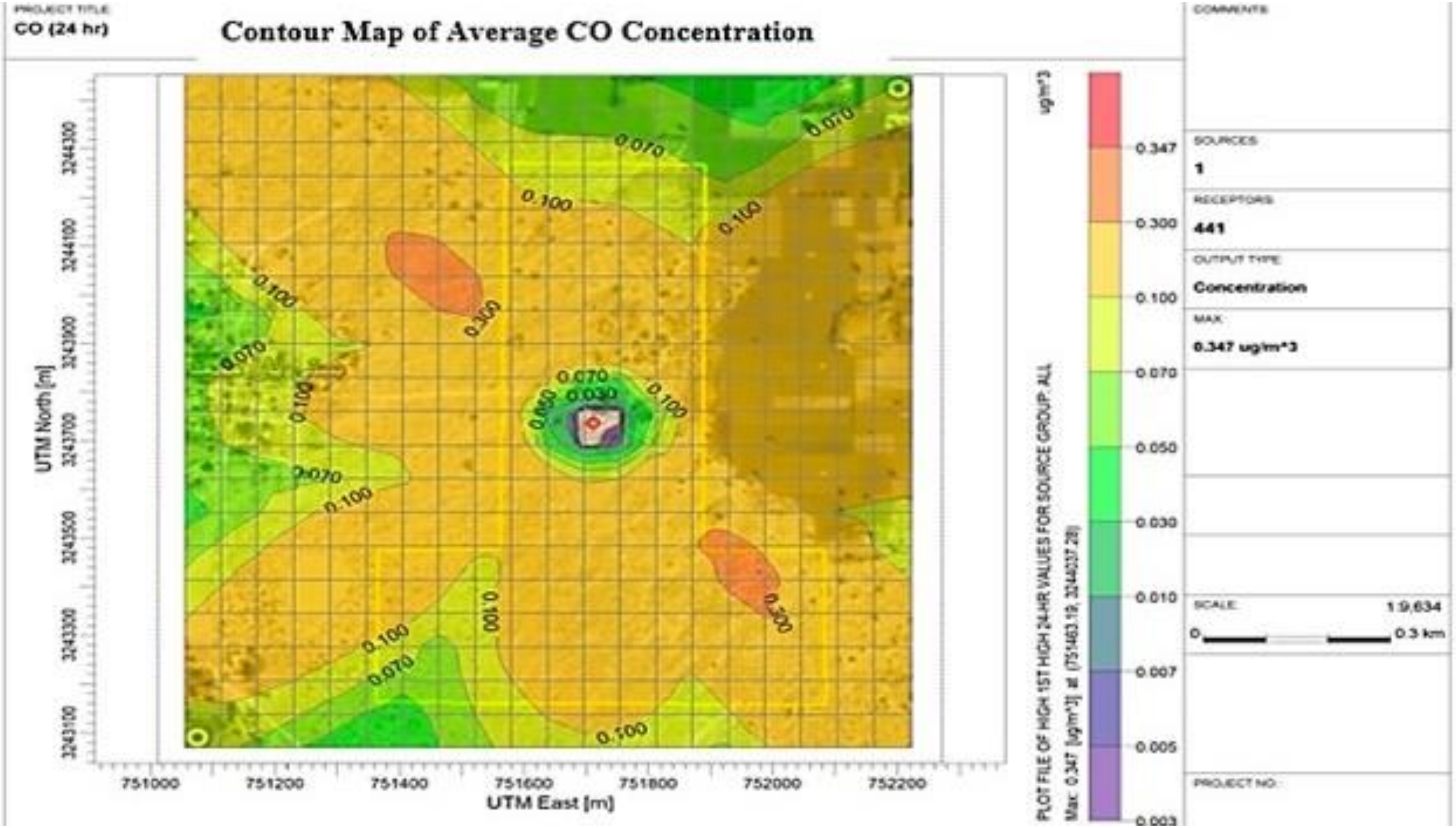
Direction (Degrees)	Distance (Meters)															
	100	200	300	400	500	600	700	800	900	1000	1500	2000	2500	3000	4000	5000
22.5	0.00	0.09	0.05	0.22	0.14	0.19	0.28	0.29	0.36	**0.41**	0.33	0.33	0.36	0.34	0.15	0.08
45	0.00	0.13	0.07	0.17	0.15	0.14	0.15	0.11	0.14	0.13	0.12	0.13	0.11	0.10	0.08	0.06
67.5	0.00	0.08	0.16	0.19	0.16	0.17	0.16	0.14	0.12	0.11	0.10	0.12	0.14	0.40	0.16	0.15
90	0.00	0.03	0.17	0.16	0.15	0.13	0.14	0.12	0.11	0.10	0.11	0.08	0.06	0.04	0.00	0.00
112.5	0.00	0.09	0.18	0.19	0.17	0.16	0.14	0.12	0.10	0.11	0.10	0.12	0.14	0.40	0.16	0.15
135	0.00	0.07	0.07	0.17	0.15	0.14	0.13	0.11	0.14	0.13	0.12	0.10	0.11	0.10	0.07	0.04
157.5	0.00	0.06	0.09	0.16	0.14	0.13	0.12	0.10	0.11	0.10	0.09	0.08	0.06	0.04	0.03	0.00
180	0.00	0.05	0.08	0.15	0.13	0.14	0.15	0.13	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.02
202.5	0.00	0.07	0.10	0.17	0.15	0.14	0.13	0.11	0.14	0.13	0.12	0.10	0.11	0.10	0.07	0.04
225	0.00	0.04	0.17	0.16	0.15	0.13	0.14	0.12	0.11	0.10	0.11	0.08	0.06	0.04	0.00	0.00
247.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
270	0.00	0.00	0.00	0.00	0.01	0.05	0.14	0.15	0.13	0.14	0.12	0.11	0.10	0.05	0.03	0.04
292.5	0.00	0.00	0.00	0.02	0.14	0.11	0.14	0.13	0.12	0.10	0.11	0.10	0.07	0.04	0.03	0.01
315	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.11	0.18	0.20	0.18	0.17	0.15	0.13	0.20	0.00
337.5	0.00	0.00	0.00	0.06	0.40	0.39	0.18	0.20	0.18	0.17	0.15	0.13	0.2	0.01	0.00	0.00
360	0.00	0.06	0.09	0.16	0.14	0.13	0.12	0.10	0.11	0.10	0.09	0.08	0.06	0.04	0.03	0.00



Contour Map Showing 24hs Average NOx Concentration (µg/m^3)

Table 13.7: 24-HR Average CO Concentration (μg/m³)

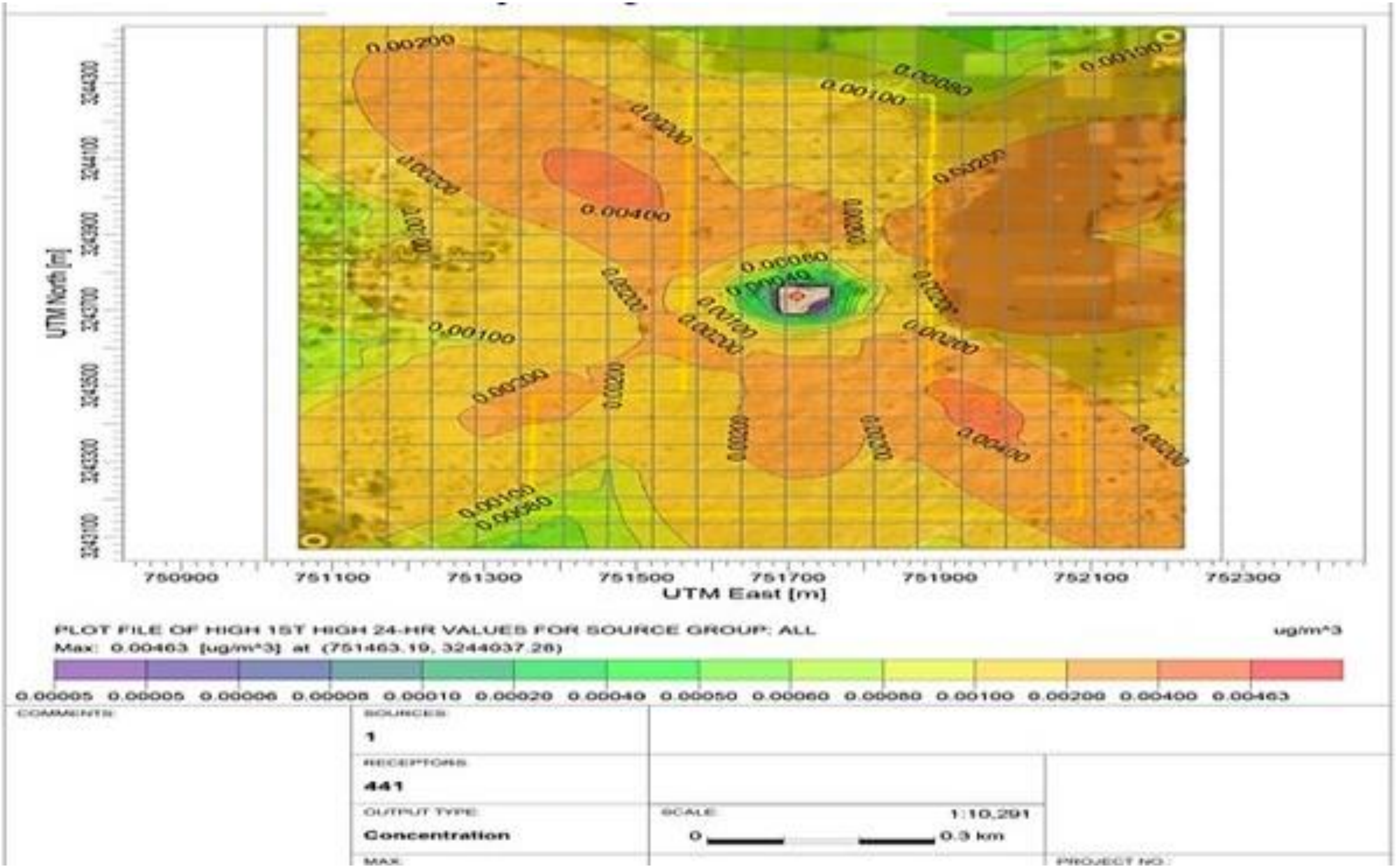
Direction (Degrees)	Distance (Meters)															
	100	200	300	400	500	600	700	800	900	1000	1500	2000	2500	3000	4000	5000
22.5	0.00	0.09	0.05	0.22	0.14	0.19	0.28	0.29	0.32	**0.34**	0.31	0.31	0.30	0.24	0.15	0.08
45	0.00	0.08	0.16	0.19	0.16	0.17	0.16	0.14	0.12	0.11	0.10	0.12	0.14	0.40	0.16	0.15
67.5	0.00	0.03	0.17	0.16	0.15	0.13	0.14	0.12	0.11	0.10	0.11	0.08	0.06	0.04	0.00	0.00
90	0.00	0.02	0.11	0.10	0.08	0.07	0.06	0.05	0.11	0.10	0.11	0.08	0.06	0.04	0.00	0.00
112.5	0.00	0.07	0.07	0.17	0.15	0.14	0.13	0.11	0.14	0.13	0.12	0.10	0.11	0.10	0.07	0.04
135	0.00	0.06	0.09	0.16	0.14	0.13	0.12	0.10	0.11	0.10	0.09	0.08	0.06	0.04	0.03	0.00
157.5	0.00	0.05	0.08	0.15	0.13	0.14	0.15	0.13	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.02
180	0.00	0.07	0.10	0.17	0.15	0.14	0.13	0.11	0.14	0.13	0.12	0.10	0.11	0.10	0.07	0.04
202.5	0.00	0.04	0.17	0.16	0.15	0.13	0.14	0.12	0.11	0.10	0.11	0.08	0.06	0.04	0.00	0.00
225	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
247.5	0.00	0.00	0.00	0.00	0.01	0.05	0.14	0.15	0.13	0.14	0.12	0.11	0.10	0.05	0.03	0.04
270	0.00	0.00	0.00	0.02	0.14	0.11	0.14	0.13	0.12	0.10	0.11	0.10	0.07	0.04	0.03	0.01
292.5	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.11	0.18	0.20	0.18	0.17	0.15	0.13	0.20	0.00
315	0.00	0.00	0.00	0.06	0.40	0.39	0.18	0.20	0.18	0.17	0.15	0.13	0.2	0.01	0.00	0.00
337.5	0.00	0.06	0.09	0.16	0.14	0.13	0.12	0.10	0.11	0.10	0.09	0.08	0.06	0.04	0.03	0.00
360	0.00	0.03	0.06	0.18	0.16	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.06	0.04	0.03	0.00



Contour Map Showing 24hs Average CO Concentration (µg/m^3)

24-HR Average PM10 Concentration (μg/m³)

Direction (Degrees)	Distance (Meters)															
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1500**	**2000**	**2500**	**3000**	**4000**	**5000**
22.5	0.000	0.002	0.002	0.002	0.0014	0.0019	0.0028	0.0029	**0.0026**	0.0046	0. 003	0. 003	0. 003	0. 002	0. 001	0.0009
45	0.000	0.0008	0.002	0.002	0.002	0.0014	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.0011	0.001
67.5	0.000	0.000	0.000	0.000	0.000	0.0014	0.0013	0.0012	0.0011	0.10	0.0011	0.0008	0.0006	0.0004	0.000	0.000
90	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.003	0.001	0.001	0.001	0.0008	0.0006	0.0004	0.000	0.000
112.5	0.000	0.0007	0.0007	0.0017	0.0015	0.0014	0.0013	0.0011	0.0014	0.0013	0.0012	0.0010	0.0011	0.0010	0.0007	0.0004
135	0.000	0.0006	0.0009	0.0016	0.0014	0.0013	0.0012	0.0010	0.0011	0.0010	0.0009	0.0007	0.0006	0.0004	0.0003	0.0000
157.5	0.000	0.0005	0.0008	0.0015	0.0013	0.0014	0.0015	0.0012	0.0011	0.0010	0.0009	0.0008	0.0007	0.0006	0.0003	0.0001
180	0.000	0.0007	0.0010	0.0017	0.0015	0.0014	0.0013	0.0011	0.0014	0.0013	0.0012	0.0010	0.0011	0.0010	0.0008	0.0005
202.5	0.000	0.0004	0.0017	0.0016	0.0014	0.0013	0.0014	0.0012	0.0011	0.0010	0.0011	0.0008	0.0006	0.0004	0.0000	0.0000
225	0.000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
247.5	0.000	0.0000	0.0000	0.0000	0.0001	0.0005	0.0014	0.0015	0.0013	0.0014	0.0012	0.0011	0.0010	0.0005	0.0003	0.0002
270	0.000	0.0000	0.0000	0.0002	0.0014	0.0011	0.0014	0.0013	0.0012	0.0010	0.0011	0.0010	0.0007	0.0004	0.0003	0.0001
292.5	0.000	0.0000	0.000	0.0010	0.0006	0.002	0.0007	0.0011	0.0018	0.0021	0.0018	0.0017	0.0016	0.0014	0.0020	0.0002
315	0.000	0.0000	0.000	0.006	0.0040	0.0036	0.0018	0.0020	0.0018	0.0017	0.0015	0.0013	0.002	0.0001	0.0000	0.0000
337.5	0.000	0.0006	0.009	0.006	0.0014	0.0013	0.0012	0.0010	0.0011	0.0010	0.0009	0.0008	0.0006	0.0004	0.0003	0.0000
360	0.000	0.003	0.06	0.0018	0.0017	0.0015	0.0014	0.0012	0.0011	0.0010	0.0009	0.0008	0.0006	0.0004	0.003	0.0000



Contour Map Showing 24hs Average PM10 Concentration (µg/m^3)

Table 13.9: Airshed Classification with Model Outputs

Target Analyet	Avg. Time	Standard	Avg. Time	Standard		Location					
						Basti Rama	Basti Yar Muhama	Basti Karim	Basti Meriwala	Basti Rasheed	Basti Chachra
CO	24hr	04 mg/m³	8 hrs	5 mg/m³	0.347	0.617	0.837	1.077	0.737	0.727	0.647
NO_2	24hr	25 ug/m³	24 hrs	80 ug/m³	0.417	7.947	12.817	14.757	8.857	10.657	10.837
PM_{10}	24hr	45 ug/m³	24 hrs	150 ug/m³	0.00463	64.03463	59.37463	68.36463	52.93463	57.95463	54.49463

3.5. Conclusion

The color contours maps plotted by the model for the proposed emissions effect of the proposed flare display the extent of dispersion of the pollutants. The dispersion plumes shown in above figures show that the plant is located at 1000 meters from the origin set at top left corner of the map. Contours maps expand to 5000 meters from the flare site. The contours show that the emissions disperse in north-east-north direction.

Airshed classification results of monitored location based on modelled incremental values shows that cumulative values of CO and NO_2 are well within the stringent WHO guidelines however PM_{10} values are exceeding WHO guidelines Cumulative values of CO, NO_2 and PM_{10} are well within PEQS which shows that air quality impact will be low when flare operating at its normal conditions provided good air to landfill gas ratio is maintained during combustion.

Appendix A.21 Landfill Gas/Fire Emergency Response Plan

Landfill Gas/Fire Accident and Emergency Plan

a) General

A Landfill Gas Accident and Emergency Plan will detail how potential accidents and failure scenarios that might lead to:

• migration or other uncontrolled emission of landfill gas,

• an impact on local air quality,

• release of odorants; and

• harm to human health, will be managed.

b) Potential Failure Scenarios

The Plan will identify failure scenarios for each component of the landfill gas management system and must assign appropriate actions for elements of the landfill gas control system at specific locations. Failure scenarios and appropriate actions include:

- Compliance criteria requirements such as emissions standards,
- Assessment and action criteria – these are derived values based on compliance and emission limit criteria which form an early warning or may trigger additional monitoring or emergency procedures,
- Systems failure criteria, for example failure of the landfill gas plant or accidental disconnection of landfill gas collection wells,
- Timescales for replacing critical equipment,
- Incident/event report criteria, such as odour reported beyond the authorised place boundary,
- Emergency actions – immediate measures, for example evacuating buildings,
- Changes to landfill gas management techniques and other operational control measures required to control landfill gas on-site, for example installing additional landfill gas collection wells; and
- Changes to the strategy for routine monitoring to provide improved data to evaluate the event, for example increased perimeter monitoring.

A Landfill Gas Management Plan must detail what will be done when the following are encountered:

- Abnormal results in monitoring data,
- Operational problems or failure of the landfill gas control system during routine inspections or maintenance; and
- Reported event, for example an odour complaint. Where remedial action will be needed, expected implementation timescales should be included in the plan, e.g. start enhanced monitoring protocols within 24 hours or incorporate additional collection wells within 7 days (in the case of sacrificial pin wells).

c) Procedure to Cope with Landfill Fire

In case of emergency gas leakage leading to fire, following emergency procedure will be adopted.

1. The weighbridge should be notified immediately of the fire (type, location and size), and the Landfill Manager will then be notified by weighbridge
2. Emergency Coordinator (Weighbridge) will then contact emergency services and start recording events.
3. Stop all operations, stop trucks at the weighbridge, and assess the situation, only attempt to control fire if it is safe to do so.
4. Make sure all personnel on site are accounted for.
5. Emergency Coordinator must then evacuate all staff and visitors not involved in fighting the fire.
6. Emergency Coordinator to notify emergency services if require.

The BWMC will ensure following fire protection facilities on site in case of a fire:

- Maintain a stockpile of cover near the tipping area that is designated for fire-fighting purposes.
- A fire-fighting water tank will be installed at the infrastructure area. The tank will be equipped with standard Coupling outlets, compatible with Local Fire Brigade equipment.
- A stand pipe and pump for refilling water trucks will be located adjacent to the tank.
- 50 mm of daily cover and 300mm of intermediate cover.
- Fire extinguisher on all landfill equipment and selected site utilities.
- Additional water supply shall be available
- All site personnel will be trained in the most efficient fire-fighting procedures.
- BWMC landfill Operations staff involved in fighting the fire should consider the following guidelines:
- Use personal protective clothing or equipment, especially considering the use of a respirator fitted with a vapour filter. Many substances produce toxic fumes when ignited (e.g. plastics, solvents, industrial wastes).
- Consider the quickest method of attacking the fire taking into consideration the prevailing wind or air currents, the nature of the fire and the combustible materials.
- If not safe to fight the fire, try to prevent it spreading through the use of fire breaks or wetting down the surrounding areas.
- On the arrival of the Fire Brigade, hand over the responsibility for the fire-fighting effort to the Fire Brigade’s Site Controller. Offer assistance, if required.
- After the fire has been extinguished, monitor the area to ensure it does not reignite.
- If the fire is amongst the waste rather than on top consider the use of an excavator to distribute the waste so that fire-fighting measures are more effective
- Extreme care must be taken when fighting a landfill fire as smoke and fumes may be toxic.
- Use a dry powder or CO_2 extinguishers in the first instance.
- Apply and compact (if possible) thick layer of cover to prevent oxygen from reaching the burning area.

- Seek advice from the BWMC Landfill Operations Manager before using water (some materials are not compatible with water).
- If the above is not sufficient to extinguish the fire.
- Systematically dig out the affected area.
- Extinguish the fire in the excavated material using one of the methods above.
- If deep landfill fire is detected the area must be isolated in case of a surface collapse resulting from the fire burning out a subsurface cavity.
- Deep landfill fires can be extinguished by systematically digging out the affected area and extinguishing the fire in the excavated material.
- Capping the area to minimise oxygen ingress.
- Displacing oxygen by injecting an inert gas, such as nitrogen, into the fire

Emergency Response Team

Personnel present on the premises of BWMC landfill will be responsible for the initial control of the emergency, until relieved designated the Emergency Controller. All personnel must follow the directions of the emergency controller at the site of the emergency.

Roles shall be assumed in the following order:

- Landfill Manager
- Emergency Controller
- Emergency Coordinator

Other ERT team members may consist of

- Person (Operations Supervisor)
- Person (Contractor Supervisor)
- Person (Contractor Second in Command)
- Person (Weighbridge Operator)
- Weighbridge Attendant (Causal/Part-time staff)

Role of Landfill Manager:

- Assist with accounting for personnel and locating missing persons (if approved by emergency controller).
- Collects visitors sign in book and proceeds to the emergency evacuation point during an evacuation.
- Ensure all personnel are accounted for.
- Liaise with other ERT memebers regarding missing persons.
- Notify emergency controller of situation, i.e all people accounted/not accounted for.
- Take names and contact numbers of any emergency services personnel accessing the site.
- Stop any trucks, public or media from entering site.

Role of the Emergency Controller:

The Emergency Controller will proceed directly to the site of the emergency if safe to do so and take control of the emergency situation.

The responsibilities of the Emergency Controller include:

- Go to the site of the emergency, if possible, and assess the situation - act accordingly. i.e. how best to deal with emergency and any special requirements needed including PPE.

- Maintain or establish communications with emergency services on site and the weighbridge office.
- Carry a mobile phone and UHF radio at all times.
- Appoint an Emergency Co-ordinator to stand by and operate the telephone system (normally the weighbridge operator).
- Advise the Emergency Co-ordinator of the details of the situation and nominate the emergency services, subcontractors and consultants to be notified.
- Notify neighbours of incident if applicable.
- Complete a Corrective and Preventive Action report describing circumstances and the action taken immediately after the emergency has passed.
- Liaise with Landfill Manager to establish the level of alert required.
- Brief and Coordinate with emergency services such as fire brigade, rescue etc.

Role of the Emergency Coordinator

The Emergency coordinator (generally the Weighbridge Operator) is responsible for providing:

- Co-ordinate communications between site and emergency services
- Advice the emergency services of pertinent details including the location, type of emergency, injuries and the assistance required.
- Co-ordinate communication with other parties (e.g. contractors, customers and consultants); as directed by the Emergency Controller.
- The Emergency Coordinator is required to operate the telephone system and UHF Radio or other communication gadgets.
- If the emergency situation is located in the Weighbridge/Site Office (e.g. a fire) then mobile telephones or portable radios may be used.
- Ensure communications are established with the Emergency Controller
- Contact the Landfill Manager and advise him/her of the details of the emergency.
- Direct any media inquiries to the CEO BWMC or GM Operations/Media communication
- Record events on the site emergency forms.

Appendix A.22 Draft Framework Management Plan

Framework Management Plant for Landfill Operations

a) General

Landfill operators (DBO Contractor) must manage their operations to minimize the risk of pollution from the activities and must have methods in place that ensure compliance with IEE requirements, ADB SPS, 2009 and Punjab EPA, 2012 and best international practices. DBO contractor will ensure that:

- Systems and procedures are in place that ensure compliance with all conditions,
- Compliance is monitored and reviewed,
- Systems and procedures are audited, and corrective action taken where the systems are not shown to ensure compliance.

b) Scope

Management Plans set out define procedures to operate their site to minimize risks to the environment and ensure compliance. Management Plans shall be developed by DBO contractor that cover specific risk areas, risk assessment and mitigation adopted to manage the risks. These management plans will be periodically reviewed with updated information and shall be maintained by the DBO contractor through project operation phase. DBO contractor will prepare the following management plans before start of operations at Landfill site.

- Landfill Gas Management Plan
- Water Management Plan;
- Leachate Management Plan;
- Waste Acceptance Management Plan;
- Capping Management Plan;
- Nuisance Management Plan (including odour, noise (and vibration), dust (and mud), litter, aerosols vermin and landfill cover);
- Monitoring Management Plan

All the management plans provided in this document shall be prepared by DBO contractor in IEE requirements, ADB SPS, 2009 and Punjab EPA, 2012 and best international practices.

c) Landfill Gas Management Plan

The Landfill Gas Management Plan should refer to a landfill gas management system, which means the combination of infrastructure required for landfill gas monitoring, collection, extraction, flaring and/or utilisation, and the management philosophies, techniques and practices designed and adopted to ensure optimal landfill gas recovery. The Landfill Gas Management Plan must describe how landfill gas will be controlled, including details of containment and phasing of landfill development, stated emission standards, collection procedure of landfill gas, gas collection layout plan, gas processing and treatment, gas flaring and gas conversion to CNG. Landfill gas management plan must contain landfill gas accident and emergency plan and provisions for its periodic revisions and updating.

d) Water Management Plan

A site specific water management plan will be prepared by the DBO contractor to define procedure that how rainwater, surface water and groundwater will be managed. It must account for local weather, hydrology and hydrogeology, be part of the engineering design, and must also link to the Restoration Plan. The water management plan must detail storm water pathways around LFS, water balance calculations, rainwater management, temporary capping on non-operational areas and storm water management within and around the facility. The plan shall take into account the any hydrological risk assessment required and surface water discharges (if required) from the landfill.

e) Leachate Management Plan

DBO contractor will prepare leachate management plan in line with the requirements of IEE, ADB SPS, 2009, Punjab EPA Act, 2012 and best international practices. The plan shall detail the procedures and responsibilities to install, operate, maintain and monitor the leachate control measures, water balance study, site specific action levels, procedures to inspect, maintain and service each element of the leachate collection, control and discharge system, including supplementary processing and treatment equipment, procedures for extreme weather events such as rainfall. The plan shall also detail the treated leachate disposal procedure and subsequent reporting to PMU and Punjab EPA.

f) Waste Acceptance Management Plan

The Waste Acceptance Management Plan (WAMP) must detail how the DBO contractor will comply with the Criteria and Procedures for the Acceptance of Waste at Bahawalpur

LFS. No hazardous or medical waste shall be accepted at the landfill site. Waste acceptance management plan shall contain details on amount and type of waste accepted and defined waste acceptance criteria. Waste acceptance procedure include visual inspection of every waste load, waste documents review and inspection and checks on credentials of waste carrier.

g) Capping Management Plan

Capping of filled waste cells is fundamental to the control of landfill gas emissions and odour as well as to the minimization of infiltration of rainwater into the waste mass. When one landfill cells is filled it will be permanently capped. DBO contractor is expected to cap the landfill cells in accordance to the detailed design requirements. DPO contractor will prepare method statement and necessary drawings as part of the capping management plan. A capping management plan shall detail the area which are permanently capped, partially capped or to be capped in near future.

h) Nuisance Management Plan

The plan will detail all the nuisance impacts that landfill will pose on the environment and community and measure that need to be undertaken to mitigate such impacts. The plan shall detail the impacts and mitigation measures for odour, dust, noise and vibration, litter, aerosols and vermin controls. DBO contractor will prepare nuisance plan keeping in consideration the impact assessment carried out in the project IEE and mitigation measures provided in the EMP.

i) Monitoring Management Plan

DBO contractor will prepare monitoring management plan to illustrate monitoring requirements, additional monitoring requirements, to demonstrate performance of environment critical equipment, landfill gas and leachate monitoring requirements. The plan shall detail landfill gas and leachate monitoring plan including schedule and frequency of monitoring, layout drawing showing construction and location of monitoring points, location of perimeter boreholes, sampling and measurement technique, analysis reports and any corrective action required. The plan shall also identify the requirements of surface water monitoring upstream and downstream of landfill influence. Monitoring of basic indicator parameters (e.g., pH, electrical conductivity, BOD, COD, Chloride, Suspended Solids, Ammoniacal Nitrogen.) must be undertaken to identify any potential impact.

Furthermore, monitoring for additional parameters (e.g., major ions, metals and hazardous substances) should be undertaken based on the site-specific risks, characteristics of the leachate, groundwater and treated leachate effluent discharge (if applicable). The surface water monitoring shall include details on monitoring frequency, sampling location and justification for selected sampling site. Monitoring of landfill topography and settling behavior must be carried out by DBO contractor on an annual basis throughout the operational phase of the landfill, including the structure and composition of the landfill. The Monitoring Management Plan must detail the surface area occupied by waste; the volume and composition of waste; the methods of depositing waste; the time and duration of depositing waste; and a calculation of the remaining capacity still available at the landfill.

Appendix A.23 Groundwater Monitoring Programme

Aims of the Programme

The specific aims of the programme are as follows:

- To further establish baseline conditions for groundwater quality at the project sites;
- To provide early indications of any groundwater impacts resulting from conditions and activities at the project sites;
- To support the design and implementation of the project works;
- To support the implementation of interventions and mitigation measures in the event that project related impacts are identified or suspected.

Target Determinants and Tests

There may be a wide range of potentially harmful constituents in landfill leachate, including:

- Metals, such as iron (Fe,) nickel (Ni,) cadmium (Cd), chromium (Cr,) arsenic (As,) mercury (Hg) and lead (Pb).
- Volatile Organic Compounds, including the subset of benzene, toluene, ethylbenzene and xylenes collectively known by the acronym "BTEX."
- Total petroleum hydrocarbons (TPH)
- Semi-volatile organic compounds (SVOCs)
- Polychlorinated biphenyls (PCBs)
- Pesticides and herbicides
- Biological agents such as coliforms.
- pH, turbidity, dissolved oxygen, ammoniacal nitrogen, chloride, sulphate, nitrogen, phosphorous (*Note – these can be monitored via onsite equipment to reduce laboratory costs*).

Clearly it is not reasonable to sample and analyse groundwater for the entire range of potential determinants that might be present in leachate. In selecting the analytes set out in this monitoring program, the following considerations have been incorporated:

- The desire to provide a relatively simple programme which can give early indications of potential leachate impact on groundwater by focusing on leading indicators. In the event that impacts are suspected, additional site specific interventions and specialist expertise will be needed.
- The typical fate and transport characteristics of individual determinants in groundwater e.g. Selection of analytes that are typically more mobile in groundwater and thus strong early indicators of potential leachate impact.
- The analytes which are typically most commonly encountered, in the greatest volumes and most easily detected, again because they are likely to provide early indications of leachate impact.
- The limited availability of laboratory facilities in Pakistan and the complications associated with quality assurance of samples are relevant to the sampling programme. Use of field tests which can give direct and rapid indication of changes to groundwater conditions is an important element of the program. Such tests include organoleptic observations (colour, odour) along with field measurements of pH and electrical conductivity (EC).
- Alignment with standards in use in the region, specifically drinking water quality analyses for determinants such as biological oxygen demand (BoD), chemical oxygen demand (CoD), is intended to optimise the engagement of the local analytical capacity.

Methods and Standards

Where available, sampling protocols, analytical standards and reporting standards set by the statutory authorities, including the Government of Punjab Environmental Department and the Pakistan Environmental Protection Council, should be followed. In the absence of governing local standards, adoption of international good practice in relation to groundwater monitoring and leachate management should be adopted. Relevant guidance includes the following:

- UK Environment Agency Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water Technical Guidance Note 02 (https://www.gov.uk/government/publications/monitoring-of-landfill-leachate-groundwater-and-surface-water-lftgn-02)
- UK Environment Agency, 2003b, Development of a Methodology for Selection of determinant Suites and Sampling Frequency for Groundwater Quality Monitoring (https://www.gov.uk/government/publications/groundwater-quality-monitoring-selection-of-determinand-suites-and-sampling-frequency).

Sampling Procedures

The procedure for collecting groundwater samples should be carefully executed to ensure the samples are representative and uncontaminated. A general procedure to be used in collecting water samples from monitoring wells would be as follows:

- Safety Precautions:
  - Prior to sampling, ensure you have the necessary personal protective equipment (PPE), such as gloves and safety goggles.
  - Be aware of any potential hazards at the sampling site and take appropriate safety measures.
- Well Preparation:
  - Remove the well cap and, if necessary, clean the wellhead to prevent any contamination from surface debris.
  - If the well is not being sampled under pumped conditions. Purge the well of at least three well volumes and allow it to recover. Purging is the process where water is pumped or bailed from the well until the water is coming directly from the aquifer and not the stagnant water at the wellhead.
- Sample Containers:
  - Use clean, pre-rinsed sample containers made of appropriate materials (e.g., low-density polyethylene or glass) for collecting groundwater samples. Typically these will be provided by the analytical laboratory.
- Decontamination:
  - Wear single use nitrile or latex gloves to minimize the risk of contaminating the samples.
  - Rinse sample containers and equipment with the groundwater to be sampled prior to collection to ensure they are free from contaminants.
  - Fully decontaminate the sampling equipment between boreholes and/or use dedicated bailers in each well.
- Sampling Technique:
  - Use a bailer, pump, or other appropriate sampling device to collect the groundwater sample. Take care to avoid introducing air bubbles.
  - For purging or pumping, collect a minimum of three well volumes or until water parameters (e.g., pH, specific conductance, temperature) stabilize.
  - For volatile organic compounds (VOCs), including BTEX (benzene, toluene, ethylbenzene and xylenes) collect samples with a dedicated VOC kit if available (typically a bailer with Teflon check valve).
- Sample Volume:

  - Collect an appropriate volume of groundwater sample for your analysis needs. Typically, this is around 1-3 litres but may vary depending on the analysis required.
  - Guidance will usually be provided by the analytical laboratory.
- Sample Labelling:
  - Label the sample containers with essential information, including well ID, date, depth, and any specific analysis requirements.
- Transport and Storage:
  - Keep the samples cool and avoid exposure to direct sunlight.
  - Transport samples to the laboratory in a cooler with ice packs as soon as possible and in accordance with the laboratory preservation and holding requirements and the determinants being analysed. For example – VOCs will require degrade rapidly and will need to be analysed onsite, preserved or reach the laboratory quickly.
- Documentation:
  - Maintain detailed records of the sampling process, including well characteristics, well purging duration, sample time, sample date, sampler name and any deviations from the standard procedure.
- Quality Control:
  - Ideally Include field blanks and duplicate samples in your sampling regimen to monitor and control for potential contamination.
- Reporting:
  - Provide accurate and complete documentation of the sampling process and chain of custody when submitting samples to a laboratory for analysis.

It's important to note that specific protocols and requirements may vary depending on the type of analysis needed and the contaminants of concern. If in doubt, guidance should be sought from with a qualified environmental professional and/or the analytical laboratory.

Sampling Program for Component 1 – New Landfill

Pre- Construction and Construction Phase

Description	Location	Determinants/Tests	Frequency	Minimum Required Actions
Potential Receptor Baseline	Selected nearby water supply boreholes down hydraulic gradient from the site (estimate up to 4 locations)	Odour, appearance, Depth to Water, pH, EC	Quarterly 2024 to start of operations	Recording of data, recording condition of sampling point, identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Potential Receptor Baseline	Selected nearby water supply	PEQS drinking water analytes	Quarterly 2024 to start of operations	Identification of changes relative to previous

	boreholes down hydraulic gradient from the site (estimate up to 4 locations)			sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Potential Receptor Baseline	Selected nearby water supply boreholes down hydraulic gradient from the site (estimate up to 4 locations)	Total petroleum hydrocarbons, BTEX, CoD, BoD, Coliforms, metals (including Fe, Cd, Hg, Ni, Cr, As, Pb)	Annually or on at least three representative occasions (whichever is greater,) prior to start of operations.	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Component 1 Site Baseline	Permanent monitoring wells at Component 1 site	Odour, appearance, Depth to Water, pH, EC	Monthly following installation in 2024 to start of operations	Identification of changes relative to previous sampling events. Plotting of groundwater elevation and hydraulic gradient. Expert review of findings at least twice per year and in the event of anomalous results.
Component 1 Site Baseline	Permanent monitoring wells at Component 1 site	PEQS drinking water analytes	Quarterly following installation in 2024 to start of operations	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Component 1 Site Baseline	Permanent monitoring wells at Component 1 site	Total petroleum hydrocarbons, BTEX, CoD, BoD, Coliforms, metals (including Fe, Cd, Hg, Ni, Cr, As, Pb)	Quarterly following installation in 2024 to start of operations	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.

Operational Phase

Description	Location	Determinants/Tests	Frequency	Minimum Required Actions
Quality monitoring to identify potential leachate losses	Selected nearby water supply boreholes (estimate up to 4 locations)	Odour, appearance, Depth to Water, pH, EC	Quarterly following start of operations	Recording of data, recording condition of sampling point, identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Quality monitoring to identify potential leachate losses	Selected nearby water supply boreholes (estimate up to 4 locations)	PEQS drinking water analytes	Annually following start of operations	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Component 1 Site Operational Monitoring	Permanent monitoring wells at Component 1 site (8 locations)	Odour, appearance, Depth to Water, pH, EC	Monthly following start of operations	Identification of changes relative to previous sampling events. Plotting of groundwater elevation and hydraulic gradient. Expert review of findings at least twice per year and in the event of anomalous results.
Component 1 Site Baseline	Permanent monitoring wells at Component 1 site (8 locations)	Total petroleum hydrocarbons, BTEX, CoD, BoD, Coliforms, metals (including Fe, Cd, Hg, Ni, Cr, As, Pb)	Quarterly following start of operations	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.

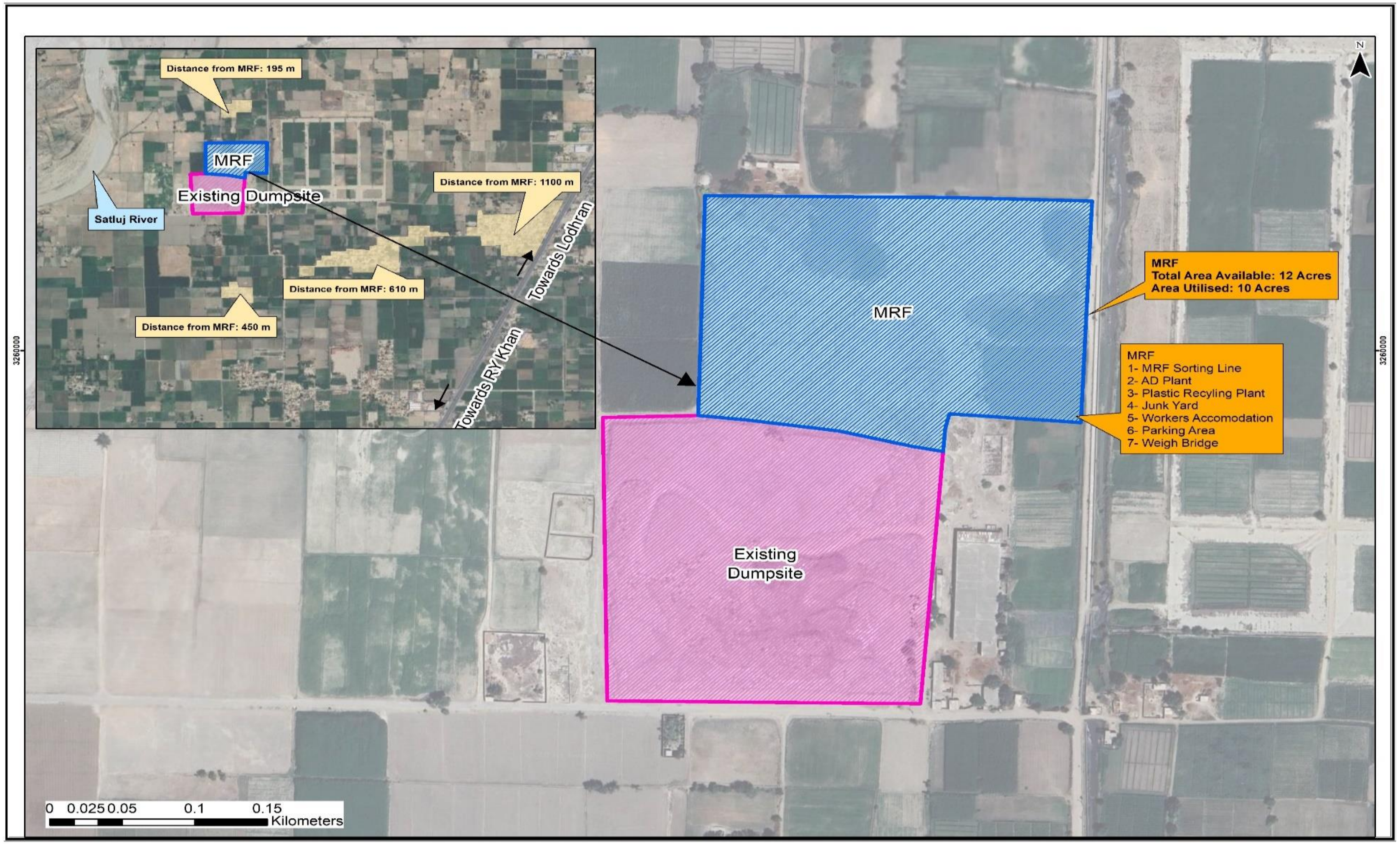
Sampling Program for Component 2 – MRF and Legacy Landfill

Pre-Construction, Construction and Operational Phase

Description	Location	Determinants/Tests	Frequency	Minimum Required Actions
Potential Receptor Baseline	Nearby water supply boreholes (estimate up to 4 locations)	Odour, appearance, Depth to Water, pH, EC	Quarterly from start of 2024	Recording of data, recording condition of sampling point, identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Potential Receptor Baseline	Nearby water supply boreholes (estimate up to 4 locations)	PEQS drinking water analytes	Quarterly from start of 2024	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Potential Receptor Baseline	Nearby water supply boreholes (estimate up to 4 locations)	Total petroleum hydrocarbons, BTEX, CoD, BoD, Coliforms, metals (including Fe, Cd, Hg, Ni, Cr, As, Pb)	Annually from start of 2024	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.
Component 2 Site Baseline	Permanent monitoring wells at Component 2 site (8 locations)	Odour, appearance, Depth to Water, pH, EC	Monthly following installation in 2024	Identification of changes relative to previous sampling events. Plotting of groundwater elevation and hydraulic gradient. Expert review of findings at least twice per year and in the event of anomalous results.

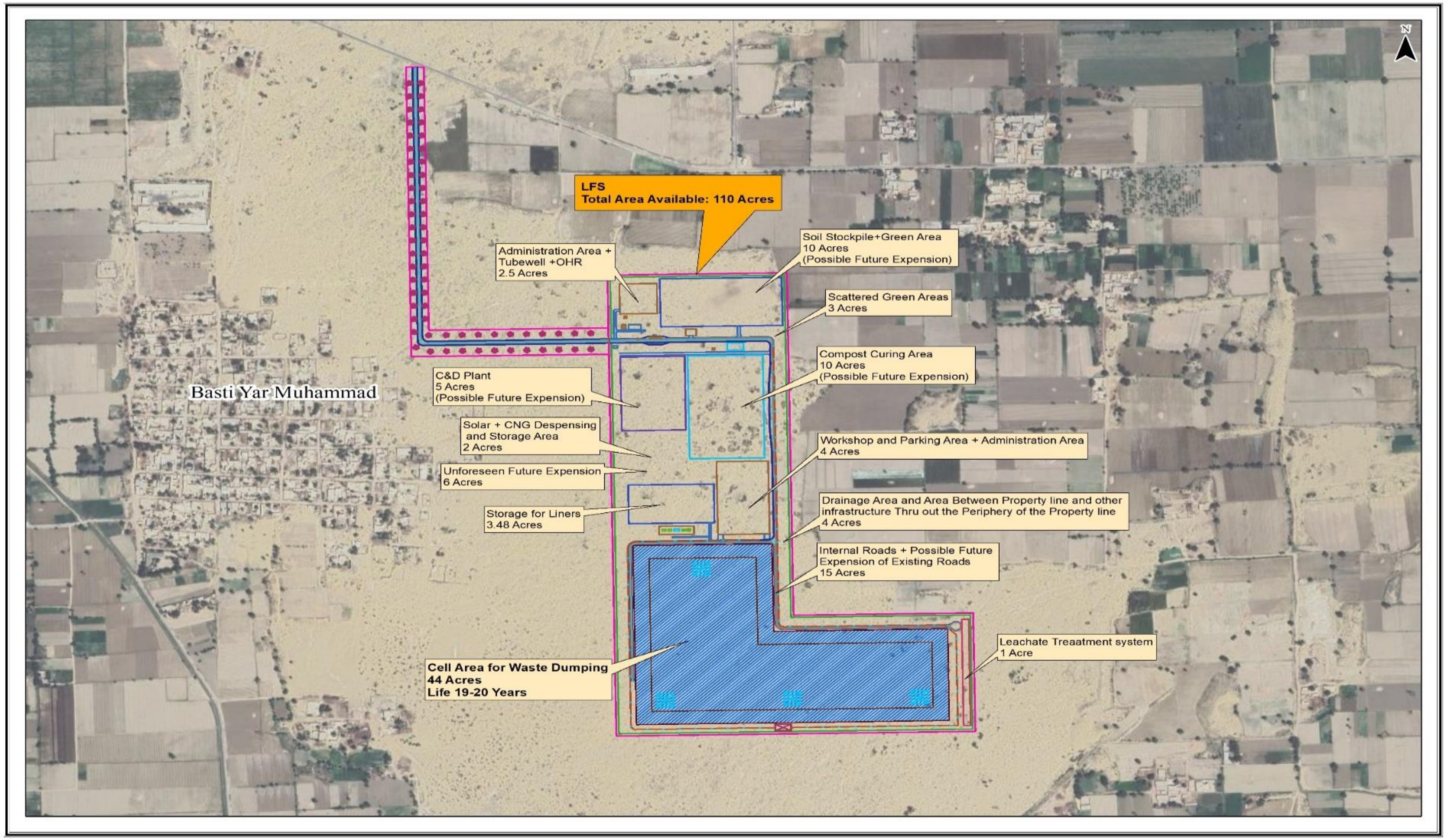
Component 2 Site Baseline	Permanent monitoring wells at Component 2 site (8 locations)	PEQS drinking water analytes	Quarterly following installation in 2024 until the final capping of the landfill. Ongoing frequency to be determined on the basis of observations but not less than annually.	Identification of changes relative to previous sampling events. Expert review of findings at least annually and in the event of anomalous results.
Component 2 Site Baseline	Permanent monitoring wells at Component 2 site	Total petroleum hydrocarbons, BTEX, CoD, BoD, Coliforms, metals (including Fe, Cd, Hg, Ni, Cr, As, Pb)	Quarterly following installation in 2024 until the final capping of the landfill. Ongoing frequency to be determined on observations but not less than annually.	Identification of changes relative to previous sampling events. Expert review of findings at least twice per year and in the event of anomalous results.

Appendix A.24 High Resolution Maps of the Project

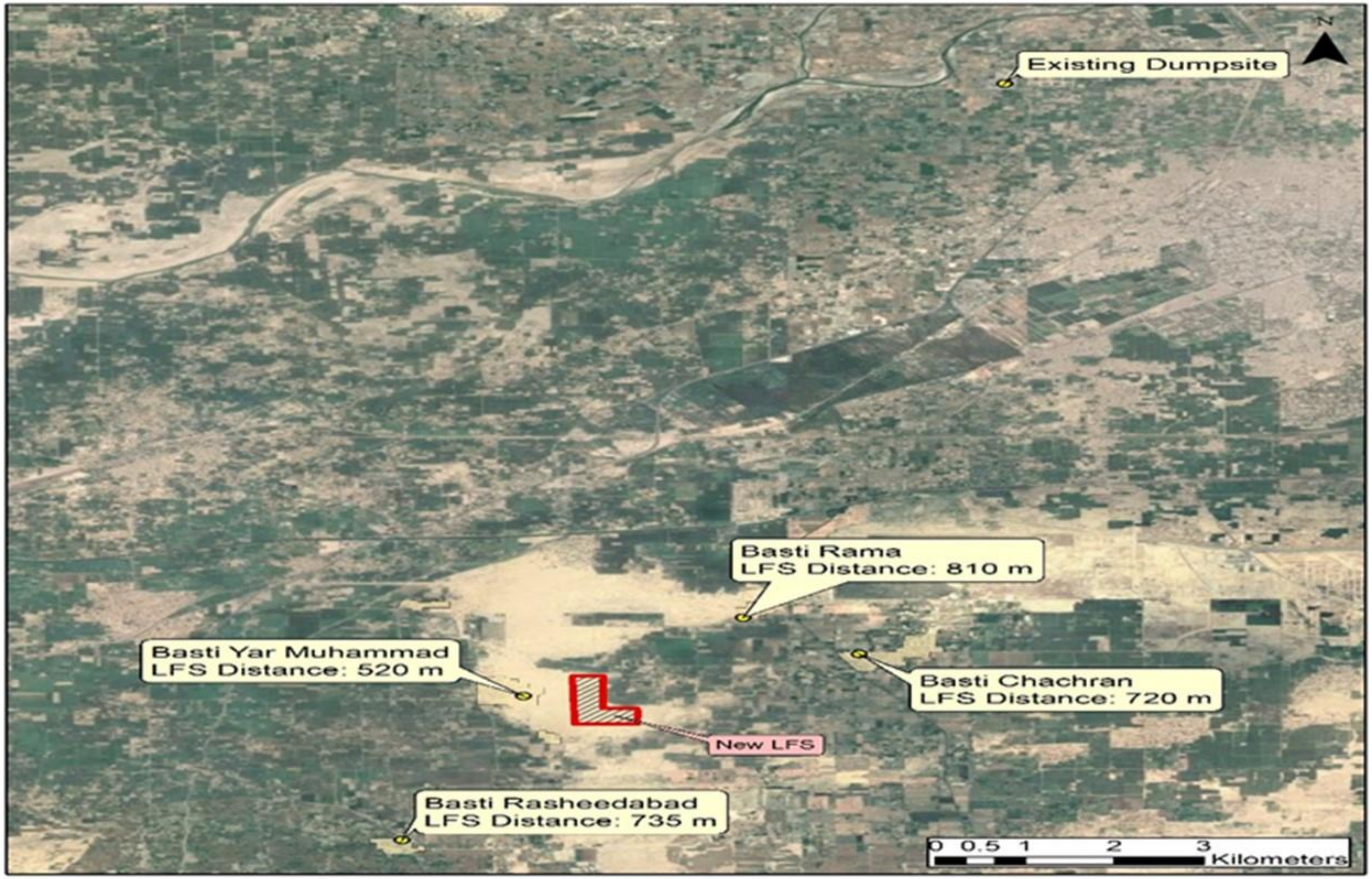


MRF Layout with Nearest Receptors

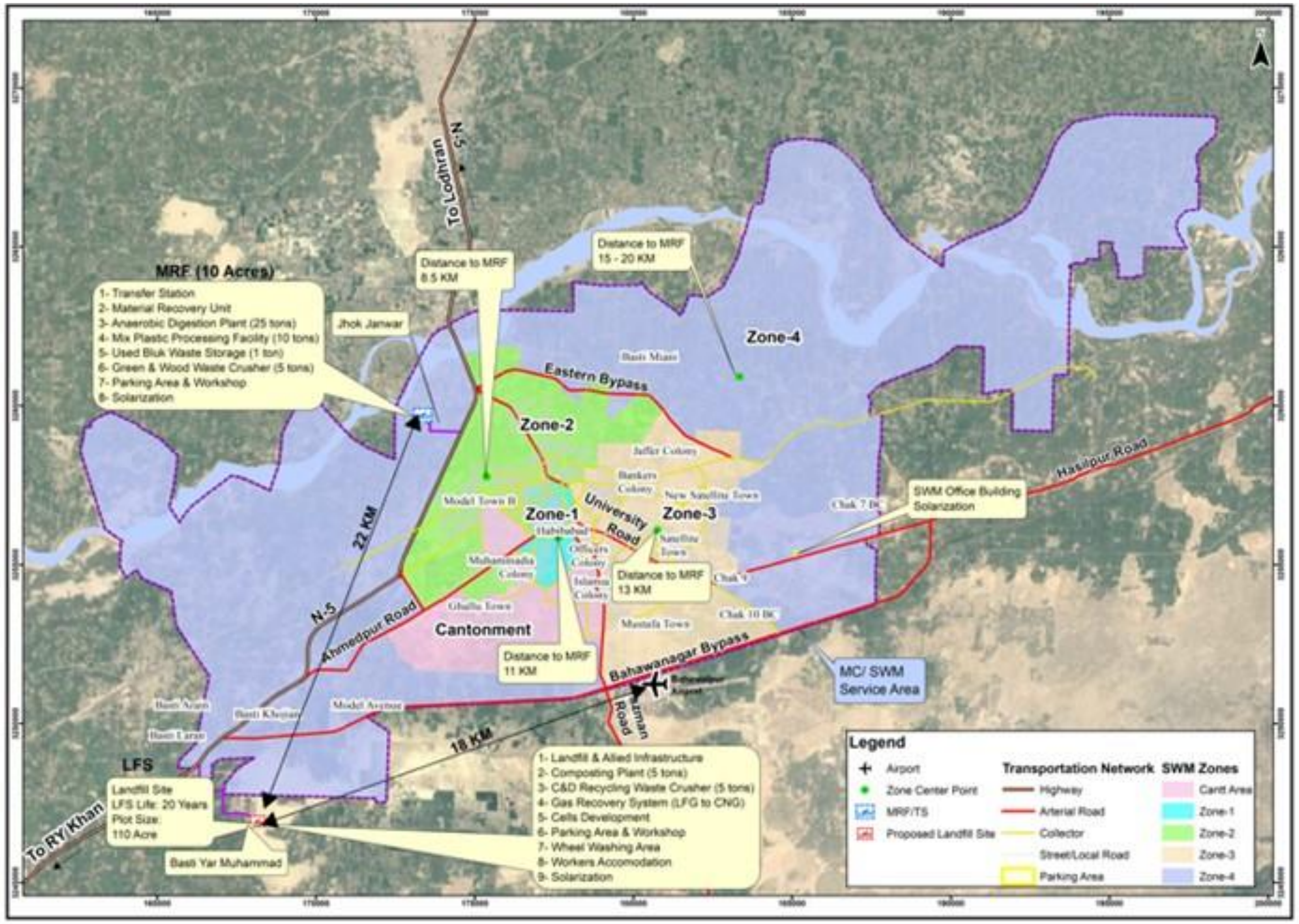
Annex-A-24-2



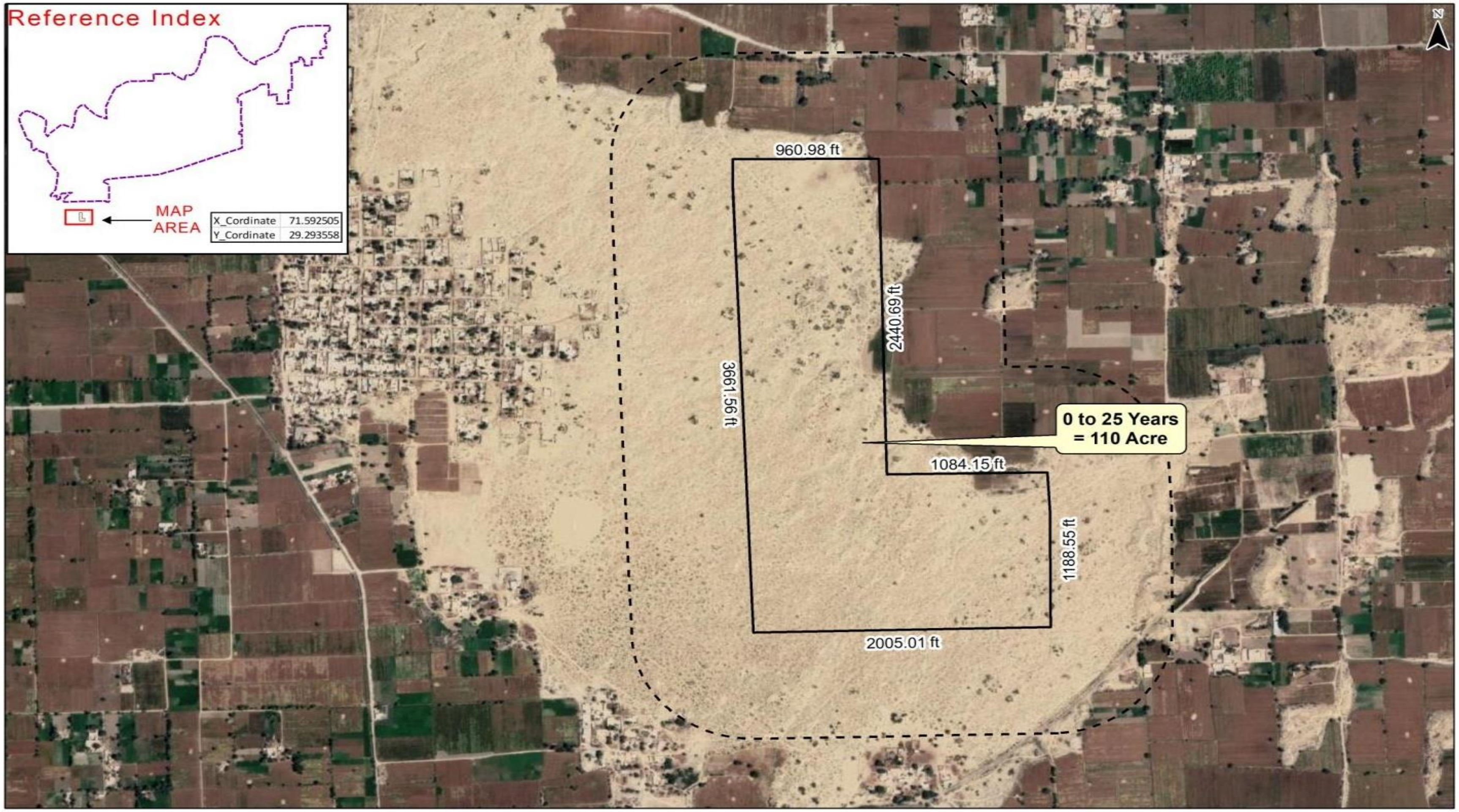
LFS Layout and Land Utilization Plan



Sensitive Receptors Near LFS



Project Facilities Location Map



	19-10-2022	ALI SARWAR		
1.0	05-07-2022	M. NASAR		
VER.	DATE	PREP.	CHECK./DATE	APPROV./DATE

Legend

LFS
LFS Buffer (250 m)

PROJECTION INFORMATION
Projection: UTM Zone 42 N
Datum: WGS84
Units / Dimensions: meters

PROJECT: PUNJAB URBAN DEVELOPMENT PROJECTS Engineering Design and Construction Management (PHASE 1)

CLIENT: LOCAL GOVERNMENT AND COMMUNITY DEVELOPMENT DEPARTMENT GOVERNMENT OF PUNJAB

CONSULTANT: TRACTEBEL ENGIE in joint venture with OSMANI Osmani & Company, ndc National Development Consultants, JERS Engineering Consultants

DOCUMENT TITLE: PROPOSED LANDFILL SITE BAHAWALPUR

SCALE: 1:8,000 (0.15 0.075 0 0.15 Kilometers)

ORIGINAL SIZE : A3

DATA SOURCE: Metropolitan Corporation (MC), EDCM Consultant.
DISCLAIMER: Although great care was taken in the preparation of this map, the authors is not liable for positioning inaccuracies, subsequent updates, errors, or omissions of data. However, suggestions for improvement or error notifications are welcome.

Annex-A-24-6

Machinery Type	Planned Quantity (EDCM)
Minitipper (1m3)	150

1.0	16-02-2022	Tasawar Iqbal		
VER.	DATE	PREP.	CHECK./DATE	APPROV./DATE

LEGEND

Parking Area = 1.125 Arce

PROJECTION INFORMATION

PROJECT: PUNJAB URBAN DEVELOPMENT PROJECTS Engineering Design and Construction Management (PHASE 1)

CLIENT: LOCAL GOVERNMENT AND COMMUNITY DEVELOPMENT DEPARTMENT GOVERNMENT OF PUNJAB

CONSULTANT: TRACTEBEL in joint venture with OSMANI Osmani & Company, National Development Consultants, JERS Engineering Consultants

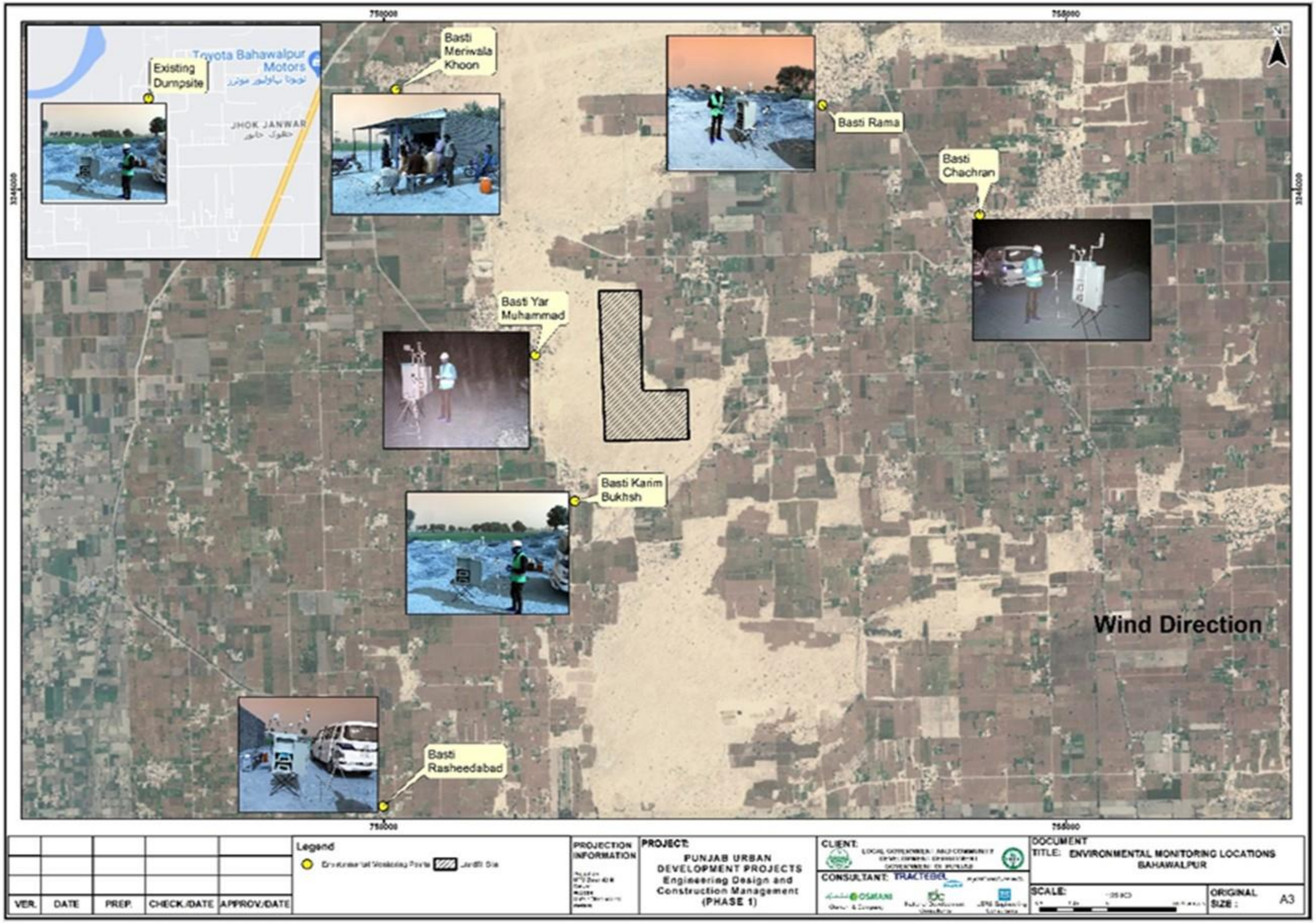
DOCUMENT TITLE: PROPOSED PARKING SITE BAHAWALPUR

SCALE: 1:800

ORIGINAL SIZE : A3

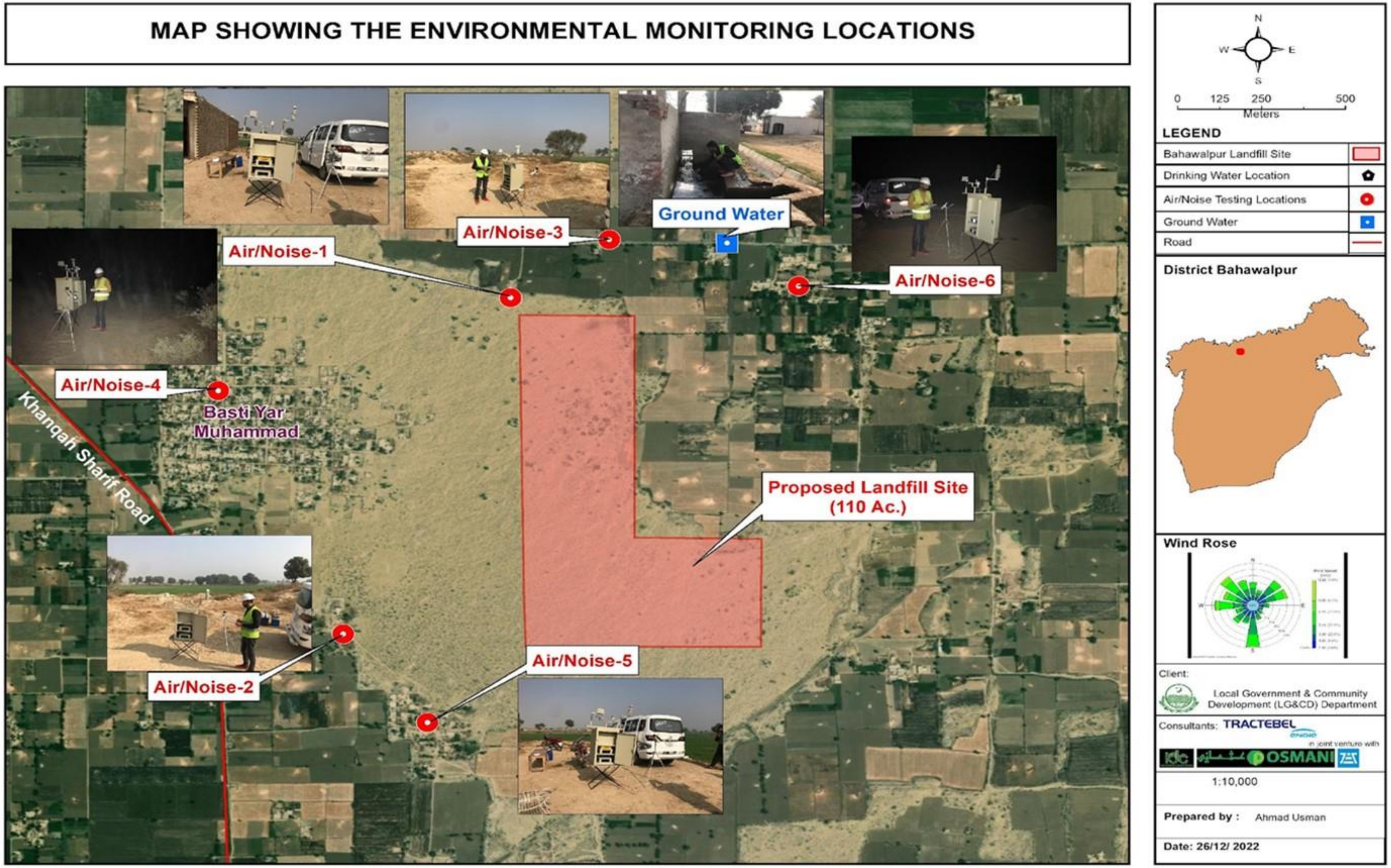
DATA SOURCE: Metropolitan Corporation (MC), EDCM Consultant

DISCLAIMER: Although great care was taken in the preparation of this map, the authors is not liable for positioning inaccuracies, subsequent updates, errors, or omissions of data. However, suggestions for improvement or error notifications are welcome.

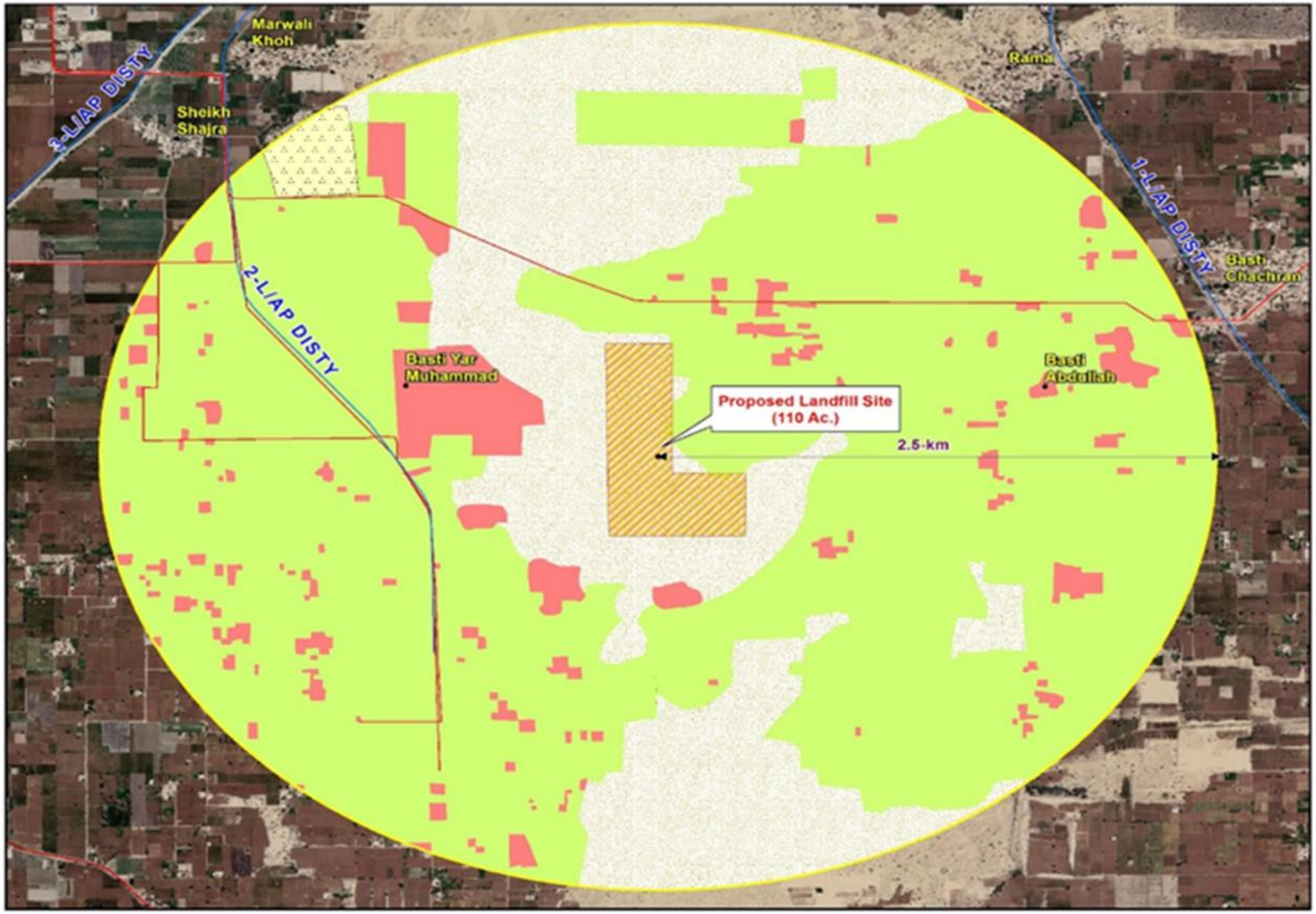

Existing Dumpsite
Toyota Bahawalpur Motors
JHOK JANWAR
Basti Meriwala Khoon
Basti Rama
Basti Chachran
Basti Yar Muhammad
Basti Karim Bukhsh
Wind Direction
Basti Rasheedabad
Legend
PROJECTION INFORMATION
PROJECT:
PUNJAB URBAN DEVELOPMENT PROJECTS
Engineering Design and Construction Management
(PHASE 1)
CLIENT:
CONSULTANT: TRACTEBEL
DOCUMENT TITLE: ENVIRONMENTAL MONITORING LOCATIONS BAHAWALPUR
SCALE:
ORIGINAL SIZE: A3
VER. DATE PREP. CHECK./DATE APPROV./DATE

Annex-A-24-8

MAP SHOWING THE ENVIRONMENTAL MONITORING LOCATIONS



MAP SHOWING LAND USE OF LANDFILL SITE
(WITHIN 2.5 KILOMETER RADIUS)



N
W E
S

0 250 500 1,000
Meters

LEGEND

- Bahawalpur Landfill Site
- Built Up Area
- Cultivated Land
- Graveyard
- Sand Dune

District Bahawalpur

LANDFILL SITE LAND USE STATISTICS

Sr. No	Land Use Type	Area (Acres)
1	Built Up Area	283
2	Cultivated Land	3284
3	Graveyard	41
4	Sand Dune	1243
	Grand Total	**4852**

Client:
Local Government & Community Development (LG&CD) Department

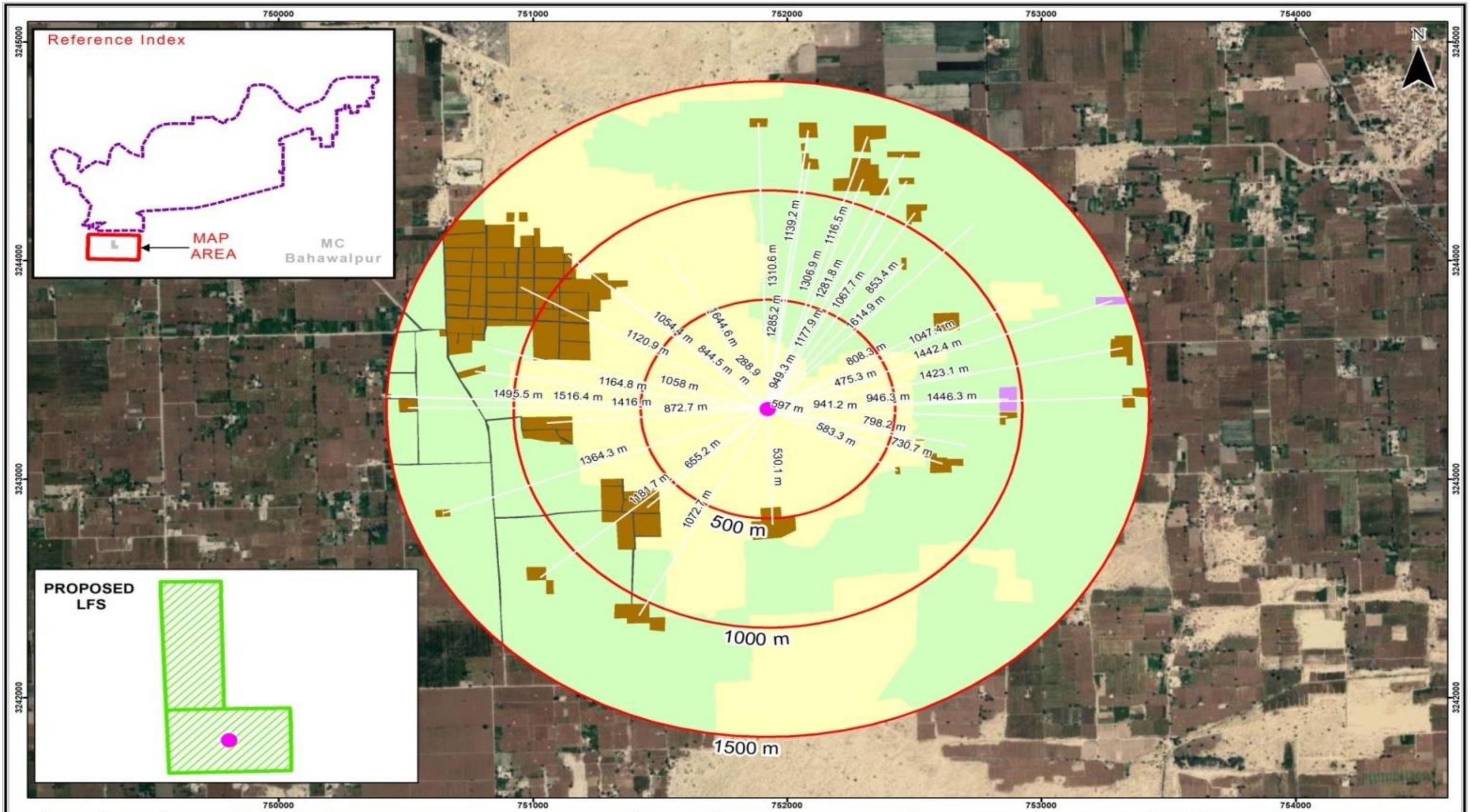
Consultants: TRACTEBEL
in joint venture with
OSMANI

1:20,000

Prepared by : Ahmad Usman

Date: 26/12/ 2022

Annex-A-24-10



1.0	27-10-2022	M AAMIR		
VER.	DATE	PREP.	CHECK./DATE	APPROV./DATE

Legend

- Proposed LFS Point
- Buffers
- Agriculture
- Built-up
- Industry
- Road
- Barren Land

PROJECTION INFORMATION

Projection: UTM Zone 42 N
Datum: WGS84
Units / Dimensions: meters

PROJECT: PUNJAB URBAN DEVELOPMENT PROJECTS Engineering Design and Construction Management (PHASE 1)

CLIENT: LOCAL GOVERNMENT AND COMMUNITY DEVELOPMENT DEPARTMENT GOVERNMENT OF PUNJAB

CONSULTANT: TRACTEBEL in joint venture with OSMANI Osmani & Company, National Development Consultants, JERS Engineering Consultants

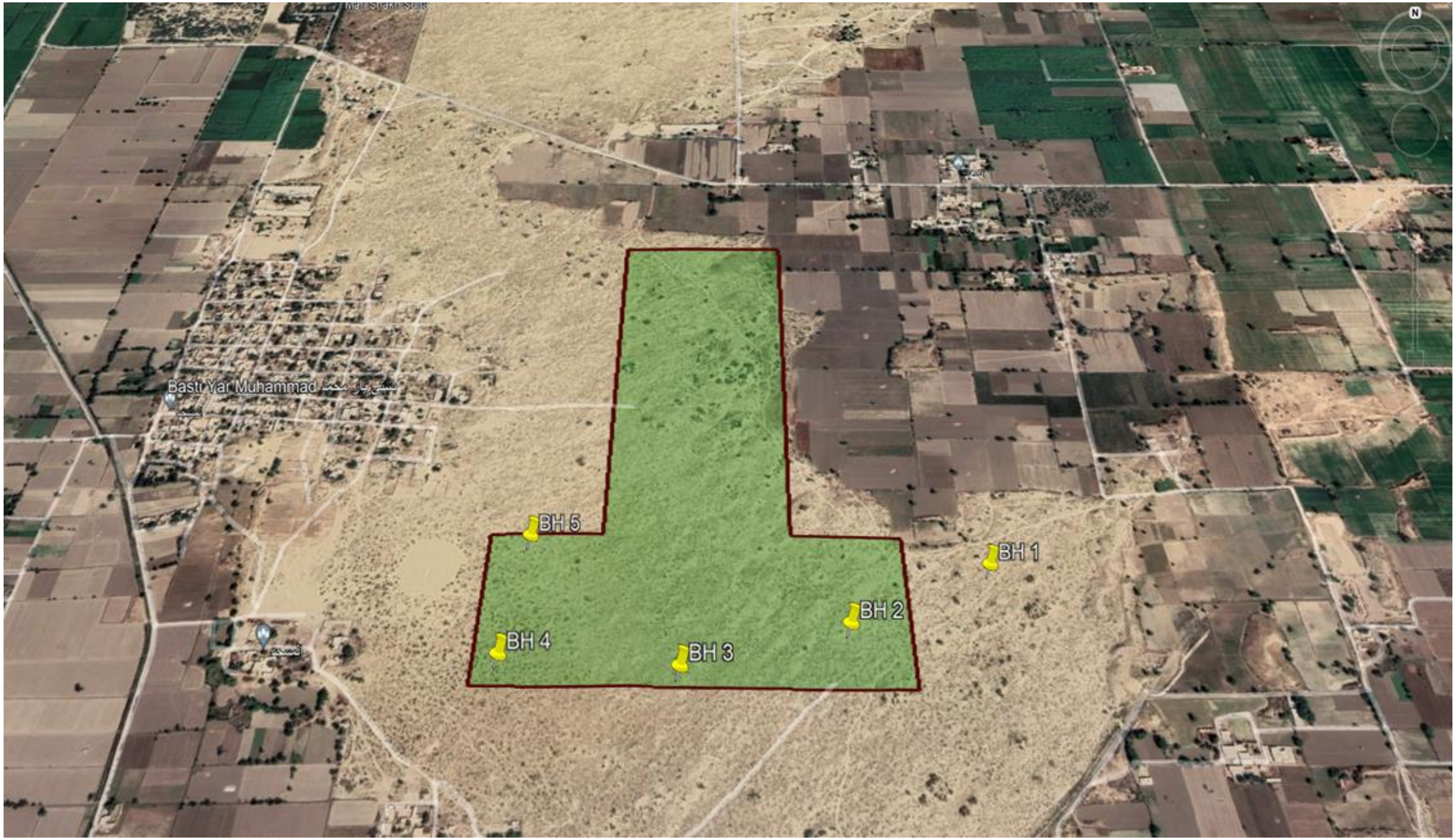
DOCUMENT TITLE: ENVIRONMENTAL FEATURES OF PROPOSED LFS BAHAWALPUR

SCALE: 1:15,000

ORIGINAL SIZE : A3

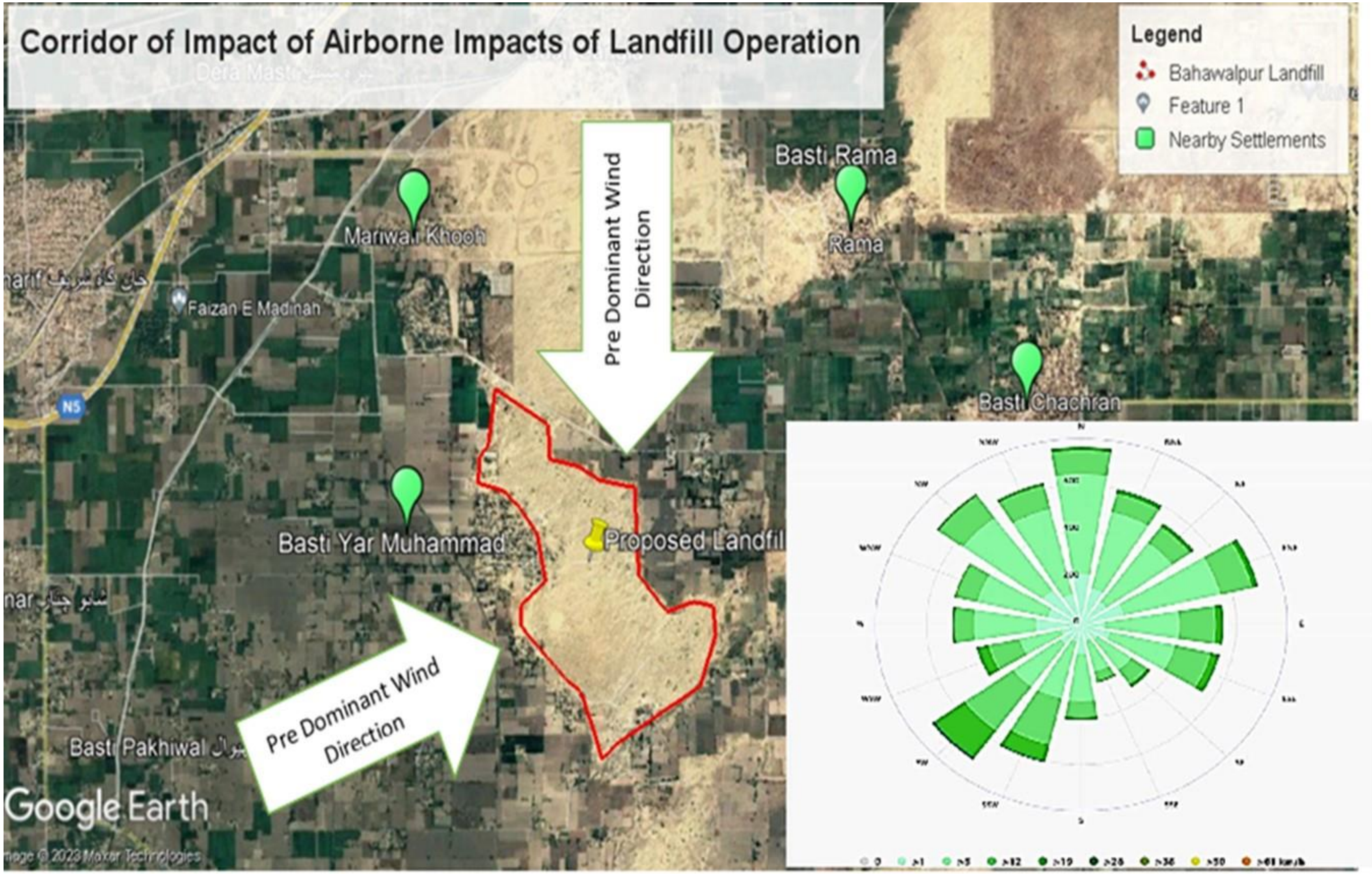
DATA SOURCE: Municipal Corporation (MC), Google Earth

DISCLAIMER: Although great care was taken in the preparation of this map, the authors is not liable for positioning inaccuracies, subsequent updates, errors, or omissions of data. However, suggestions for improvement or error notifications are welcome.



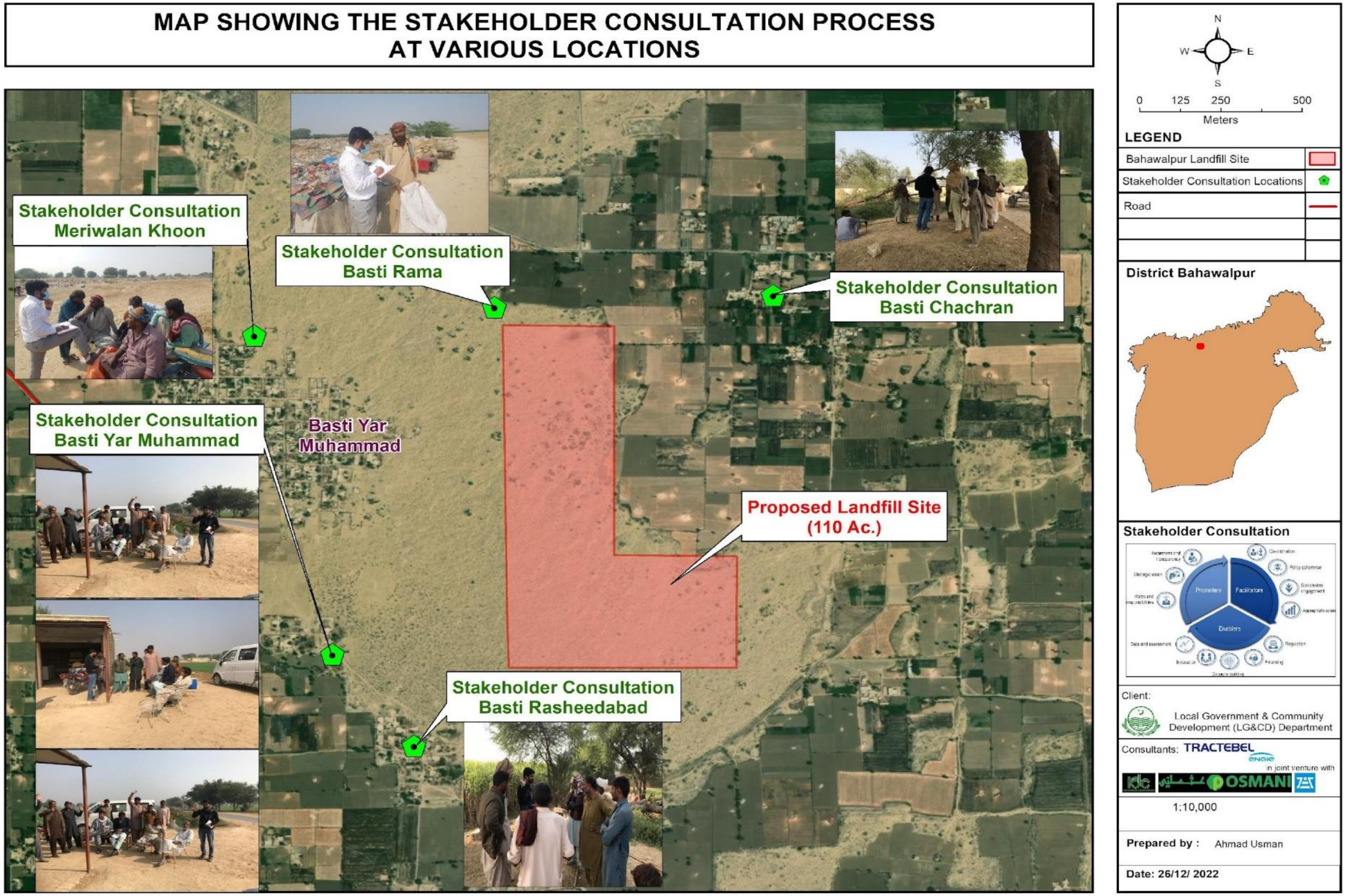
Borehole Location Map

Annex-A-24-12



Corridor of Impact of Airborne Impacts of Landfill Operation
Legend
Bahawalpur Landfill
Feature 1
Nearby Settlements
Basti Rama
Rama
Mariwali Khooh
Faizan E Madinah
Pre Dominant Wind Direction
Basti Chachran
Basti Yar Muhammad
Proposed Landfill
Pre Dominant Wind Direction
Basti Pakhiwal
Google Earth

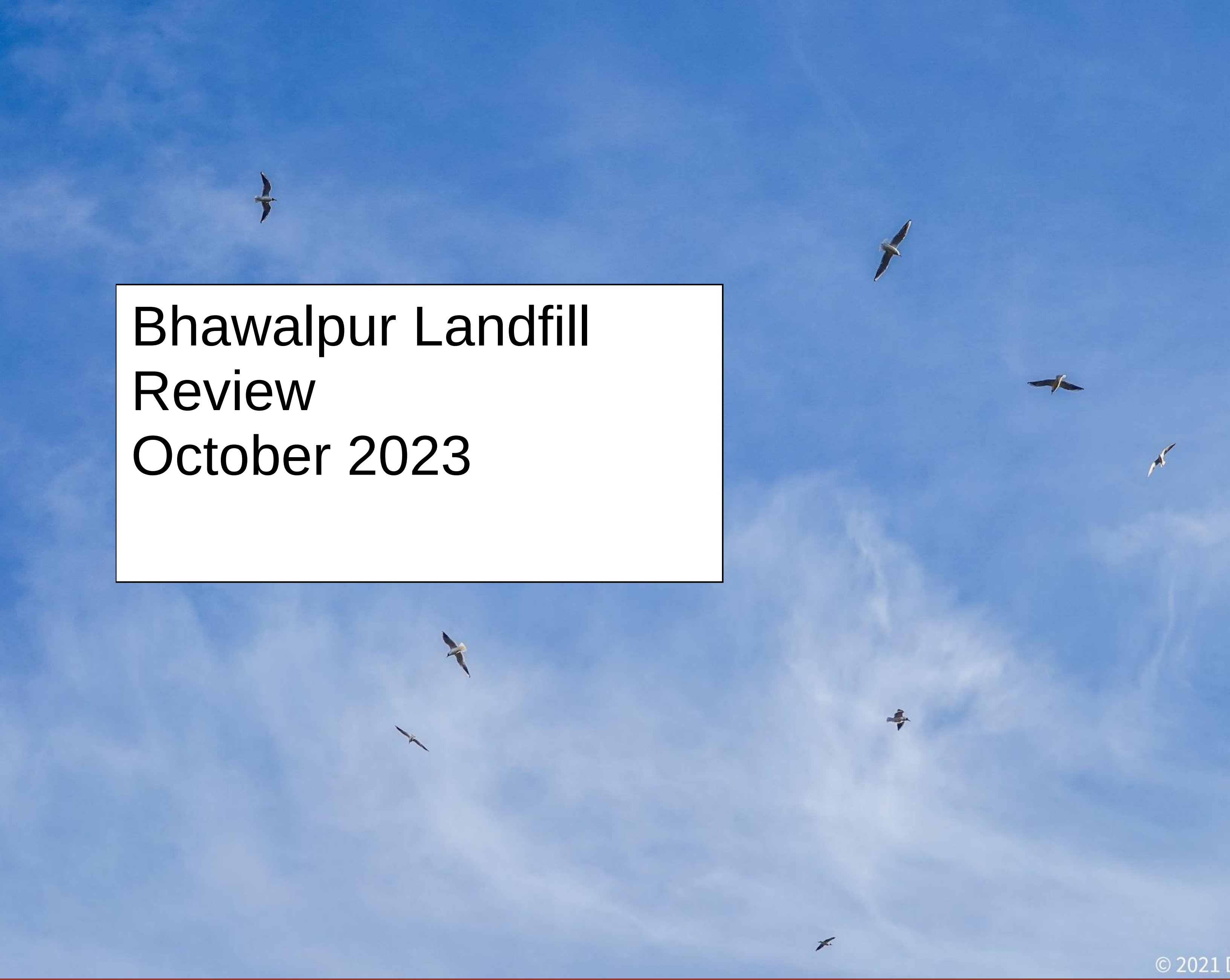
MAP SHOWING THE STAKEHOLDER CONSULTATION PROCESS AT VARIOUS LOCATIONS



Annex-A-24-14

ANNEX B

BIRD STRIKE ASSESSMENT



Bhawalpur Landfill Review
October 2023

	NAME	DATE
WRITTEN BY:	Andy Baxter	09/10/2023
CHECKED BY:	Lee Johnson	09/10/2023
FILE NAME	2023_Bahawalpur Landfill Review	
VERSION AND ISSUE DATE:	Draft	09/10/2023

Commercial and in Confidence

CONTENTS

14 Executive Summary

Landfill sites can result in a significant hazard to flight safety when large numbers of birds are present, and/or result in movements of hazardous birds through the same airspace as aircraft. All countries that are a signatory to the United Nations must therefore follow the International Civil Aviation Organisation (ICAO) Standards and Recommended Practices (SARPS). These state that "*Garbage disposal dumps or any such other source of attracting bird activity on, or in the vicinity of, an aerodrome should be eliminated or their establishment prevented, unless an appropriate wildlife assessment indicates that they are unlikely to create conditions conducive to a bird hazard problem*". The 'vicinity' is defined as within 13km of the A.R.P (Aerodrome Reference Point) and an appropriate assessment is one that reviews the hazards and risks that may impact air safety.

Many waste management sites exist within the vicinity of an aerodrome with some having bird management programs in place to mitigate possible risks. These can range from simple requirements to monitor the movements of hazardous birds to inform the aviation community of any changes in risk that may occur, through to conditions that require the active face of a landfill to be continuously patrolled by a bird control unit or to establish bird netting systems that will exclude hazardous species from the whole of the landfill.

Understanding the species that may be attracted to landfill sites within a given area will therefore enable an assessment of whether they may be hazardous to aviation, and how any risks may be controlled. Knowledge of the existing populations and the impact a new site may have on the presence of such species will determine whether a site is likely to increase the background population of hazardous birds for an area. Details around the day to day behaviours of birds in the local environment will then provide an indication of whether any of the species present could increase risks to aircraft operating on, or in the vicinity of, the aerodrome.

The development of a landfill site automatically assumes that such sites will attract hazardous species and are likely to increase risks to aircraft if located in the vicinity of an aerodrome. Nevertheless, sites are developed in these locations throughout the world and may or may not require controls to minimise risk. A likely worst case scenario for any proposed development can be indicated based on probable species presence and the location of the landfill site in relation to an aerodrome. This information can then be used to determine whether a proposed site should not be entertained (e.g. a site butted up to the boundary of an aerodrome right under the approach corridor would not be appropriate) or could be developed subject to appropriate controls when they are more distant from the aerodrome.

A process has therefore been suggested that reviews the existing presence of hazardous birds, any changes that may occur in relation to new developments and any options that could be implemented to minimise possible risks to be evaluated.

Given the current situation, it is apparent that the proposed site at Bahawalpur has the potential to influence risk, but, due to its distance from the aerodrome and the local surrounding environment, controls to minimise any risks could be achieved.

15 Background

Different interpretations of the elimination of waste management sites in the vicinity of aerodromes have been used across the globe. In some countries, such as the USA for example, landfill sites (that have the potential to attract thousands of birds that are hazardous to aircraft), are precluded from being built within 5km of an airfield but may be built elsewhere within the vicinity. In the UK, however, no developments are precluded but any that fall within 13km of an aerodrome are subject to local planning regulations that require consultation to preserve flight safety.

This report therefore provides an outline assessment of the potential concerns related to the development of the new landfill facility at Bhawalpur, Pakistan in relation to closure of the existing site and any potential changes to air safety risks from birdstrikes at Bhawalpur Airport. The new landfill development is located 13km WSW of the Bhawalpur Airport ARP and approximately 12km from the end of the 08 runway centerline. The site will replace the existing landfill site located approximately 11km NW of the runway.

Bhawalpur is a densely populated area in central Pakistan located along the relatively low lying lands along the Indus River corridor. Agricultural crops and animal farming are undertaken to the west along the irrigated landscape supported by canals from the tributary Sutlej River. Further east is open desert.

The wetland corridors in the area support a number of species that are hazardous to aviation but are unlikely to be attracted to foraging opportunities presented by a landfill. These are not, therefore, considered as part of this assessment. Species that are specifically attracted to forage on putrescible wastes represent those that are of interest to air safety in relation to landfills.

Species that have been recorded in the area and may be attracted to landfill sites therefore include, but are not limited to, members of the Pigeon (*Columbiformes*), Gull (*Laridae*), Stork (*Ciconiformes*), Egret and Ibis (*Pelecaniformes*), Birds of prey (*Accipitriformes*) Corvids and Myna (*Passeriformes*) families. Indeed, records from the site of the new landfill site confirm that several of the above are present although no records from the existing landfill site were available.

As the new landfill is located slightly further from the airport to the existing site, but is situated closer to the approach alignment of the 08 runway, caution will be required to ensure any potential risks are appropriately assessed. The presence of each hazardous species at the existing site and the numbers of birds currently attracted should be recorded along with their existing movements between feeding (the landfill site) and roosting / breeding sites. The likely attractions and potential impacts these may have when transmitted to the new landfill site on aircraft operating into and out from the airport can then be reviewed.

The airport itself serves the local community with small national flights and is not being used for international flights. Inter-city flights are operated twice a day hence the movement rate is very low. No strike information has been reported from the airport.

Birdstrike Management Ltd (BML), a company that specialises in delivering best practice management advice to reduce the risk of bird and other wildlife strikes on and around aerodromes, have therefore been requested to review the above concerns.

15.1 BML

Birdstrike Management Ltd (BML) were formed in 2013 by staff with decades of experience working in aviation wildlife hazard management and risk assessment for the UK government. BML now have 9 specialist staff devoted to aviation safety and have worked across every continent in the world at over 250 airports for airport, airline and development clients including some of the world's leading aviation insurance companies. Our staff support and work closely with ICAO, EASA and a number of National Aviation Authorities and continue to provide the standards and guidance that enables the international community to minimise risk. Our staff have vast experience dealing not only with aviation safety and the control of hazardous birds at aerodromes, but also in the control and understanding of the risks from, for example, hazardous wildlife at waste management facilities. We have undertaken major projects on developing netting exclosures to exclude hazardous birds from landfills, active wildlife control deterrence and monitoring programs to reduce the risks from hazardous birds at landfills and behavioural studies on and around landfill sites over the past three decades. Our understanding of birdstrike risks, species behaviours and site attractants around the globe therefore puts us in a unique position to be able to assess and advise on best practice requirements for developments in the vicinity of airports.

15.2 Hazardous bird populations

Although damage can occur from any wildlife, damage probability increases as the species struck become heavier or when many individuals (flocks of birds) are struck at the same time (multiple strikes). Civilian airliners and engines are designed to tolerate strikes with bird(s) up to a given weight and maintain sufficient thrust to return safely to an airport. For example, a modern 737 engine should (depending on air inlet size) be able to tolerate an impact on take-off with a single 1.8kg bird and maintain 50% thrust for at least 14 minutes after ingestion. Multiple strikes of smaller birds require similar tolerances for the same or greater overall weight ingested.

Many birds and other wildlife are, however, significantly heavier than these tolerances or flock in such a way that a strike involving multiple smaller birds (e.g. flock of Feral Pigeons) may result in sufficient mass being hit or ingested that the tolerances are not covered by engine or airframe certification standards. Catastrophic risk therefore remains a possibility whenever large and / or flocking birds are struck.

Local examples of hazardous birds that may transit the area or visit landfill sites would include (but not be limited to):

Species	**Approx mass**	**Approx severity**
White Stork (or similar), *Ciconia ciconia*;	3.4kg	26.7%
Small gulls, e.g. *Larus ridibundus*	345g	4.0%
Black Kite, *Milvus migrans*	765g	10.7%
Feral Pigeon (Rock Dove), *Columba livia*	345g	4.8%
Common Myna, *Acridotheres tristis*	120g	1.7%
Cattle Egret, *Bubulcus ibis*,	450g	6.3%

All of the above are capable of forming flocks and feeding *en-masse* at sites such as waste management facilities. Some landfills may attract over 10,000 birds at any one time and provide resources for several hundred thousand birds over the course of a year. Migratory birds can use such sites as stopovers to replenish lost resources whilst resident birds may target scavenging at such sites on a daily basis. Large flocks of birds that therefore have the potential to cause some form of damage to aircraft and are present in the vicinity of an aerodrome therefore require careful consideration.

16 Potential Risks

16.1 Severity

The likelihood of a bird causing damage to an aircraft when struck is related to many factors. The speed of the aircraft, the tolerance of the aircraft to ingestions or airframe strikes and the size of the species or number of each species struck in any one incident. All other things being equal, the chance of some form of damage occurring with civil aircraft operating out of civil aerodromes has been evaluated and equates to around 1.4% of strikes with every 100g of bird resulting in some form of damage. The level of damage can range from a paint scratch or dent on a wing's leading edge through to a (thankfully rare) catastrophic strike resulting in the loss of an aircraft or loss of life. The severity ratings listed in section 3.2, above, are therefore based on strikes with individual birds and can be used to indicate the likelihood of some form of damage occurring with each species. The greater the number of individuals struck, and the greater the size of any of those individuals struck, the higher the chances of one of those strikes resulting in damage.

16.2 Probability

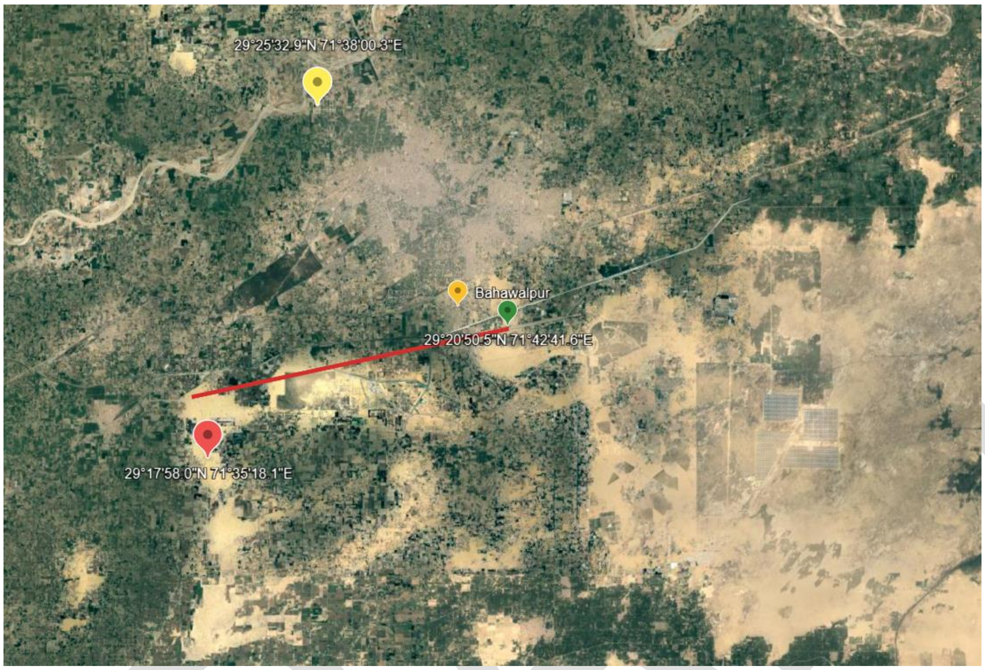
Clearly as the presence of birds in close proximity to aircraft (all other things being equal) rises, a higher probability of a strike occurring happens. As such, high severity species (generally those considered as large and / or flocking species), that occur in closer proximity to aerodromes results in the greatest probability of damaging strikes occurring. The behaviours of different species are important as some may be present in greater abundance than others but have a better ability to avoid aircraft and as such result in lower probabilities of being struck. Similarly, the movements of birds either towards or away from critical airspace (areas where aircraft are maneuvering or in flight on approach or departure corridors), will also affect the likelihood of strikes with such species occurring. Knowledge of the likely transits of hazardous species through a local area, or the movements that occur during the migration periods, in combination with their behaviours, will generally enable an assessment of risk to be developed.

Increasing the presence of large and / or flocking species in the vicinity of an aerodrome merits assessment, and such an assessment should consider whether any increase in hazard (the number of large and / or flocking birds present) could result in risk to aircraft.

16.3 Location and Risk Species

The relative locations of the airport, existing landfill site and proposed new landfill site are as follows:

Relative locations of the airport (green), existing landfill site (yellow) and proposed new landfill site (red) in relation to the western approach corridor to the airport (red line).



The likelihood of hazardous bird infringements from the landfill into critical airspace on and in the vicinity of Bahawalpur Airport will be dictated to by the behaviour of different species on and around the landfill.

Black Kite *Milvus migrans*

Black Kite is likely to be ubiquitous within the surrounding environment and is certainly a common species across the region despite not being reported from the data provided to date. Large numbers may aggregate at feeding sites hence landfill operations have the potential to increase their presence within the vicinity of any aerodrome. These, and other birds of prey or large soaring birds, may also thermal over a site to several thousand feet above ground level and therefore pose a direct threat to air safety when sites are located close to approach corridors. Aircraft on a direct approach to the Bahawalpur 08 runway will be at or around 2000' A.G.L at this distance from the aerodrome hence there is likely to be the potential for increased strike risks should thermalling over the new landfill occur. Similarly, any movements of birds to the north or north-east of the new landfill could result in crossings of the approach corridor.

It is considered likely that management controls at the landfill site would be needed if Black Kites and other large soaring bird species were present.

Gull species *Laridae*

Smaller gulls such as Black-headed Gull (*Chroicocephalus ridibundus*), frequent the coastlines and wetland areas of Pakistan during the winter. It is unknown whether they are present at this distance inland, although they are known to visit landfills in the general region and can be present in groups of several thousand individuals in other areas. Depending on the distance gulls fly to their nocturnal roost sites, gulls may also thermal upwards prior to departure each evening before moving off in the direction of their roost. If nearby roost sites (wetland areas) are available to the north, it is possible that movements could influence air safety. The nearest wetland area that is likely to be large enough to support a gull roost appears, however, to be the Punjnad Barrage at the Chenab River approximately 50km due west of the landfill. This is well within commuting distance of these species. Should birds arrive and depart from this direction, it is unlikely they would significantly impact air safety.

Gulls can be easily prevented from using landfill sites hence, whether they may or may not result in risk, if they are present, control could be implemented to ensure risks are minimised.

Egrets and Ibis' *Pelecaniformes*

Cattle Egret (*Bubulcus ibis*) appears to be a common resident species throughout the area and is likely to visit and forage at landfills should the opportunity arise. Their presence at this distance from the aerodrome is unlikely to influence their presence at the aerodrome as they are equally likely to forage in large numbers in agricultural areas and grasslands. A small number of birds foraging in grassland on an aerodrome is likely to result in far higher risk levels than a large number foraging on the distant landfill. Their movements between feeding and roosting sites could, however, impact air safety if they result in crossings of an approach corridor or the aerodrome itself at altitudes aircraft are operating at. Given the main agricultural areas are to the west of the city and aerodrome and the wetland areas are to the north and west of the landfill it is unlikely that these species' presence on the landfill will directly impact air safety.

If actions to deter gulls or Black Kites and other soaring bird species are being implemented at the landfill site it would be prudent to also minimise the presence of these species. It may not directly impact risks to aircraft but could reduce the likelihood of other species perceiving the landfill site as a feeding opportunity if Egrets and Ibis' are not present.

Passerines *Passeriformes*

Corvids including House Crow *Corvus splendens* and Large-billed Crow *Corvus macrorhynchos*, and Mynas such as Common Myna, *Acridotheres tristis* are members of the passerine (perching birds) order and are resident scavenging birds across the region. They will utilise a large number of natural and man-made habitats to feed, rest and breed and are likely to attempt to utilise any foraging opportunities provided by landfill sites. Such sites may result in large numbers of birds being present and can thus increase risks to air safety. Given the distance of the landfill from the aerodrome, and the relatively low altitude movements of these birds when moving through the environment however, it is unlikely that this group of species will directly influence air safety.

As with Egrets and Ibis species, if actions to deter gulls or Black Kites and other soaring bird species are being implemented at the landfill site it would be prudent to also minimise the presence of these species. It may not directly impact risks to aircraft but could reduce the likelihood of other species perceiving the landfill site as a feeding opportunity if Corvids and Mynas are not present.

Pigeon species *Columbiformes*

Feral Pigeons (*Columba livia domestica*) and various smaller ground dove species (e.g. Laughing Dove *Streptopelia senegalensis*), may be common residents in the region. There is no doubt that landfill facilities have the potential to increase their presence in the vicinity of an aerodrome although longer distance movements over 5km are unusual. Feral Pigeons in particular are more likely to remain within a given range of their resident area hence the landfill is sufficiently distant from the aerodrome that it is unlikely to influence the level of hazard at the aerodrome. Feral Pigeons are also highly unlikely to thermal over a landfill site and thus those birds that are present at a landfill this distant from an aerodrome will not directly affect air safety.

Other bird species

The above species and species groups represent an indicative list of the types of bird species that may utilise a landfill site in this area. It does not provide an exhaustive list of those species that will use the site but covers the main groupings and behaviours likely to affect risk. Species such as White Storks (*Ciconia ciconia*), for example, are resident in the region and may forage on landfill sites or soar overhead. Many species of scavenging passerines may be present as might other species of birds of prey including vultures. The above groupings, however, represent the likely species and behavioural traits that could influence flight safety and thus may require controls. Any other large and or flocking bird species that influence risk as per the above groups, should be managed accordingly.

In order to confirm these requirements, effectively assess the potential risks to air safety and therefore develop a more focused program of management actions (if applicable), the following monitoring and recording of hazardous bird presence in the area is recommended.

17 Monitoring and Recording program

The new landfill site may have little or no effect on air safety at Bahawalpur Airport. Equally, without understanding the likelihood of its attraction to species that may be hazardous to aircraft, it is difficult to confirm whether this will be the case, or whether risks may arise that could result in a reduction in the levels of air safety. It will be important, therefore, to confirm the existing levels of attraction the current landfill results in, whether this attraction changes by time of day or time of year and whether any other species are present in the local environment that could use the new landfill site and impact air safety.

It is recommended that the bird species, their abundance, timing and movements to and from the existing landfill site are recorded.

In an ideal world this would involve regular monitoring over several years to account for any natural variations that may arise, however, it may be possible to review daily and seasonal variations using significantly less observations whilst still gathering enough data to determine outline risks.

An outline program involving two randomly selected days each week between either dawn and midday or midday and dusk (or a single full day of observations) would be appropriate. All hazardous bird species, their arrival times and directions and hourly counts on, around or over the existing landfill site should be recorded.

The numbers and species of birds recorded in relation to their location and behaviour would be as follows:

1. Birds feeding on the active face
2. Birds feeding on any covered waste
3. Birds loafing on the site (resting anywhere on site but not feeding)
4. Birds loafing off site but clearly associating with the landfill (e.g. whilst awaiting feeding opportunities whilst sat in open space 1km distant)
5. Birds circling over the site
7. Birds flying in to / out from the site (including directions)

It would be recommended that this is done via a suitable vantage point or a standard walked route around the site for approximately 30 minutes every hour (depending on the numbers of birds present as to how long a count takes). Clearly if no birds are present this would need confirming for the day but would require far less time to record. Standard methods for counting should be followed and, where possible, altitudes of birds over the site should be recorded.

The directions of birds arriving or departing the site should be recorded in order to ascertain where they may be heading to/from at different times of year.

One morning and one afternoon of monitoring during the same week for one week each month would provide sufficient information to evaluate the use of the existing site over the course of a day and over the course of the year. If very few or no birds are recorded, it may be acceptable to reduce this further to seasonal checks provided the results are consistently showing no or very few birds seen.

18 Potential Mitigation Options

If large numbers of hazardous birds use the existing landfill and are roosting / breeding to the south and east of the landfill (in the city or beyond), it is highly likely that they may then start to move to the new landfill and result in flightlines of birds that either progress along or fly across the western approaches to the airport. Significant mitigation measures may then be needed to minimise the presence of hazardous birds using the landfill and to therefore minimise or eliminate the risks to air safety.

Consideration of the precise location of the new landfill would then be beneficial. It is possible that a movement of the proposed location just a few km’s north (e.g. to the north of the approach corridor) could result in virtually no risk arising. Without data and monitoring information to assess this hypothesis, however, the situation cannot be accurately described hence a potentially worst case scenario should be assumed whereby birds attracted are hazardous, thermal over the site and fly along the western approach corridor towards the aerodrome.

It is also possible that very few hazardous birds use the existing landfill in which case it will be likely that this will remain the case with the new development. In these circumstances it would be recommended that a monitoring brief be applied so that any changes in the presence of hazardous birds could be highlighted over time and management actions applied to minimise future risks if required. In these circumstances it is likely that the development of the new site could proceed without concern over increasing risks to air safety. As the data provided to date suggests the site has very few hazardous scavenging species present, it is not out of the question that such a finding may arise.

On the assumption that monitoring and recording identifies some hazardous species using the existing landfill and the potential for movements that could increase risks to air safety, however, and despite the distance of the proposed site from the aerodrome, a plan may need to be developed to deter or prevent species using the site. Such a plan could include;

18.1 Waste Treatment

Open discarding of food wastes is the key attractant to scavenging species hence any removal or prevention methods that stop such wastes being accessible to birds can minimise the attractiveness of a landfill site. Separation and management of waste either via sorting to remove putrescible wastes (edible waste), incineration of putrescible wastes or bio digestion of putrescible wastes can significantly reduce the attractiveness of a site to scavenging birds. Should no food wastes (inert landfill) be developed, little if any bird presence will occur. Management of putrescible wastes undercover or in a separated building will also prevent access to such species and remove the attraction of the site and thus risks to air safety.

18.2 Netting

The potential methods and techniques that may be needed could range from full netting exclosures to prevent any hazardous birds from accessing waste (exclusion of birds) or the site in general to netting that prevents access to the active tipping area only.

Example of a bird netting exclosure at an active tipping face on a landfill site

Active preventative methods may then include regular covering of the tipped and compacted waste with sufficient depths of inert material to prevent scavenging birds gaining access to food and ensuring the tipping face remains small and all other areas of the site are fully covered to prevent access.

18.3 Active Methods

There are many different tools available to disperse and control the presence of hazardous birds on landfill sites. Automated systems tend to only be viable at sites that have very low bird pressure on them (e.g. very few birds of species that are easily scared). This is because habituation (the process by which birds learn that a method does not result in any real threat and begin to ignore its use), occurs more easily with a randomly timed single system than a specifically targeted process that uses a variety of different methods.

Techniques such as the flying of falcons or hawks can be good for dispersing gulls, passerines, pigeons and egrets but may have little or no influence on birds of prey. They may also only work during the periods the birds are being flown and can therefore fail to disperse target species over the long term. Hawk and falcon use therefore always requires back-up methods for use when birds are not being flown or during periods of poor weather conditions when birds cannot be flown. As a method used within a suite of systems, the use of falcons or hawks at landfill sites can, however, be beneficial.

Distress calls can be used to disperse some passerines and potentially egrets but may also result in habituation and will need to be used as part of a suite of systems. They will not work against all species likely to frequent landfill sites in this region.

Pyrotechnics can have a very positive output but need to be carefully used to avoid potential fire risks in dry regions and, with their loud bangs, can result in nuisance to nearby neighbourhoods if overused. If available, pyrotechnics can provide a valuable tool for dispersing overhead birds and preventing birds accessing the tipping areas in the first place. Habituation may again occur hence their use should be within a multiple system approach.

Lasers are effective during poor light or low visibility conditions but may have little or no effect on some species during daylight hours. Given that most species will feed by day, lasers may not prove to be an effective system for deployment at a landfill site in this region.

Visual and other acoustic deterrents such as kites and wailers may have an initial impact via neophobia but are unlikely to provide a long-term solution to hazardous bird species at landfill sites. The can, however, be used to indicate actual threat such as shooting or lethal falconry.

Combinations of the above methods with, where feasible, the addition of lethal control via a shotgun to reinforce the threat from non-lethal methods being deployed can be highly advantageous. Such combinations are generally capable of reducing the presence of hazardous birds at landfill sites by over 90% and thus making even attractive landfill sites potentially compatible with aerodrome operations when located this distance from an airport.

19 Summary of options / recommendations

Data on hazardous birds associated with the existing landfill site in relation to the aerodrome are lacking. Information on the presence of hazardous bird species in the vicinity of the aerodrome may not have been previously collected and little information was available for species that may use the new landfill facility. Assumptions are therefore made about the possible presence of hazardous species at the new landfill site and the potential for them to increase risks to aircraft operating out of Bahawalpur Airport.

Landfill sites at this distance (c12-13km from an aerodrome) occur across the globe hence, due to the distance of the landfill site from the airport, development should be feasible without increasing risk to aircraft. Due to the proximity of the landfill to the western approach corridor to Runway 08, however, it is possible that if hazardous species were attracted, some may thermal overhead or cross critical airspace which could then result in risks to aircraft.

In order to determine whether this is likely to occur and how bird hazard management techniques could be implemented to reduce any potential risks, information on the species and numbers of birds that are likely to use the landfill site should be gathered. As the site does not currently exist, gathering information on the species, abundance and movements of birds that present a hazard to aircraft that use the existing landfill site would be recommended. Information could then be reviewed to develop a plan to minimise the presence of hazardous species using the new landfill and ensure the site does not increase the risks to aircraft operating out of Bahawalpur Airport.

20 References

ICAO Annex 14; Wildlife strike hazard reduction.

9.4.4 The appropriate authority shall take action to eliminate or to prevent the establishment of garbage disposal dumps or any other source which may attract wildlife to the aerodrome, or its vicinity, unless an appropriate wildlife assessment indicates that they are unlikely to create conditions conducive to a wildlife hazard problem.

ICAO Doc 9981 Procedures for Air Navigation Services (PANS) Aerodromes Ed.3.

6.3.5.2 Aerodrome operators should conduct an inventory of sites that attract wildlife within a defined radius around the aerodrome, paying particular attention to sites close to the airside and the approach and departure corridors.

ICAO Doc 9981 Attachment to Chapter 6

.. list of the types of land uses which have proven to attract hazardous wildlife and which should, in particular, be prevented, eliminated or mitigated on and in the vicinity of aerodromes:

d) garbage dumps and landfill sites;

ICAO Doc 9137 Airport Services Manual Part 3; Wildlife Hazard Management Ed. 5.

4.4.2 A 13-km circle centered on the aerodrome reference point is recognised where land use should be assessed with regard to wildlife hazard management.

Jackson, V.S., Brown, J., & Allan, J.R. (1999) A fixed netting system as a means of excluding birds from a domestic waste landfill. 1999 Birdstrike Committee – USA/Canada Joint meeting Vancouver.

Allan, J.R (2006). A Heuristic Risk Assessment Technique for Birdstrike Management at Airports. Risk Analysis. Volume 26, Issue3. June 2006. Pages 723-729.

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