SWM Strategy Outlines and Investment Proposal Report  
Final Version

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Tbilisi / Vienna, May 2017
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ANNEXES

ANNEX 1 Recommendations on Landfill Operation Improvement
1 INTRODUCTION

1.1 GENERAL INFORMATION

1.1.1 General Background

The City of Tbilisi has requested the European Bank for Reconstruction and Development (EBRD) to provide technical assistance for upgrading the standards of its solid waste management operations, including investing in the collection infrastructure.

The EBRD contracted GWCC – INTERIVAL ZT GmbH (GWCC) to assess the feasibility of investments in solid waste management operations and to prepare a bankable Project to finance these investments. In particular, GWCC prepared a detailed feasibility study including technical and financial aspects for investments in the waste management system in Tbilisi. This Project will be based on an effective least cost investment programme. The investment plan will be justified on the basis of thorough technical, financial and economic analysis. Furthermore, GWCC will develop a suitable Project Implementation Plan, including procurement schedule.

GWCC will complete a detailed feasibility report, confirming the feasibility, affordability and safety of the Project including the technical, financial and economic feasibility of the proposed Facilities.

The technical solutions to be applied will be based on the best available and reliable technology.

1.1.2 Objectives of this assignment

The overall objective of the investment will be to improve service, efficiency and environmental and social compliance of the municipal solid waste management system in City.

![Figure 1-1 Objectives of this Project](image)

**Work Phase I: Support on Procurement**

Performance period was June and July 2015 (see separate report “Evaluation support for ongoing procurement activities for a Municipal Solid Waste (MSW) processing plant”, July 2015.

**Work Phase II: Solid Waste Management Component**

Performance Period was rescheduled from August 2015 due to the results of Phase I and due to the wish of the City Administration of Tbilisi to first choose a possible contractor and the technology for their recycling purposes.

**Phase II will focus on the following components of the Tbilisi Solid Waste Management System:**

- Solid Waste Management Strategy of the City (including recycling component)
• Organisation of Waste Management System
• Waste Generation
• Waste Collection and Transportation
• Landfill – current status and development needs taking the recycling component into consideration (which is currently under preparation)

The main performance period was May 2015 – September 2016.

Specific objectives of the assignment shall include, inter alia:

• Provide tender evaluation support for ongoing procurement activities for the new waste processing plant (only Phase I);
• To review the needs in the City, definition and establishment of the area to be covered with the municipal solid waste management system (Phases II);
• To review and analyse the current situation of the waste treatment/separation/landfilling in Tbilisi in terms of condition of major equipment and facilities, recent past years performances, operation and maintenance (“O&M”) practices, capacity of the City to manage and address all relevant environmental and social risks and impacts, compliance with national laws and regulations and any liability issues; (Phase II);
• To prepare detailed investments on the basis of waste measurement and characterisation and recommendation of the most cost-effective waste management technology solutions; (Phase II);
• To advise regarding the most suitable commercially available technologies for efficient and environmentally and socially acceptable integrated waste management plant and to advise regarding the capabilities of the most prominent regional and other manufacturers of equipment that can be used for the facilities (Phase II);
• To prepare remediation/closure design and implementation plan for closing of the existing city landfill in Tbilisi, if required (Phase II);
• Estimate potential reductions in Greenhouse Gas (“GHG”) emissions arising from utilisation of biogas from existing and planned waste management sites (Phase II);
• To prepare financial projections for selected waste treatment facilities which are operated by the company; the projections shall be fully consistent with the proposed Project, strategic development plan and be based on prudent assumptions on the Company revenues and expenditures. Financial projections shall include annual balance sheets, income and cash flow statements. (Phase II);
• To prepare implementation arrangements including the need of technical supervision, to be envisaged for the successful implementation of the project. Determination of an efficient implementation strategy for the investments under the Project (Phase II);
• To explore the possibilities and challenges related to a decentralised ownership and control of the new facilities and all related activities including collection (ideally outsourced), tariff setting, and electricity generation (Phase II).
• The overall report should meet the requirements that will allow the Company to raise tariffs and include debt service under the proposed loan into the tariff structure.
1.2 **CONTENT OF THIS REPORT**

The following information is compiled in this report:

- Consultants recommendations / outlines for the Tbilisi Solid Waste Management (SWM) Strategy in a 15 years horizon until 2030 following the results of the Baseline Assessment and Analysis (separate report)
- Presentation of a justified Investment Proposal focusing on prioritized investments in the SWM system
- Consultant’s recommendations for complementary measures to be implemented in parallel to the investments

The Financial Analysis and Financial Modelling of a potential financing of the Investment Proposal by EBRD loan agreement is included in a separate report.

The whole Project Documentation consists of following separate reports:

- This report: “SWM Strategy Outlines and Investment Proposal Report, December 2016”
- Baseline Report, November 2016
- Evaluation Report for ongoing procurement activities for an MSW Processing Plant, July 2015

1.3 **METHODOLOGY**

To develop a feasible Investment Proposal it requires – as a basis – a clear view on the current situation, its development needs and technical knowledge on how to address these needs by investments. But it requires also intensive Consultations with the SWM Operator, the City Administration and the Financing Institution in order to discuss findings and provisional conclusions and to consider also the views of the project partners. Therefore, the following steps have been implemented together with the mentioned project partners:

- Analysis of Baseline Situation and resulting development needs
- Elaboration of a long term view (15 years horizon) on the SWM system in Tbilisi
- Elaboration of a draft long list of considerable Investment Packages which might address on the development needs
- Discussion of the long list with the project partners
- Elaboration of a short list of prioritized measures (the Investment Proposal)
- Discussion / clarification of the technical details of the Investment Proposal, the commercial implications and outlines of project financing with the Project partners
- Specification of complementary measures which are recommended to be implemented in order to achieve the project goals

All technical and institutional recommendations as included in this report are based on long term international operation knowledge of Urban SWM systems in cities similar to Tbilisi – with around 1 Million inhabitants, stable socio-economic conditions and more or less developed communal infrastructure.
2 SUMMARY PROJECT PROPOSAL

The Baseline assessment of the current situation in waste collection, transport and disposal in the City of Tbilisi has shown that the waste collection and transport is widely organized and capable to collect and dispose solid waste from town. Nevertheless it has to be mentioned that the current waste collection practice is organized rather inefficient which is reflected in low tonnage of collected waste versus kilometres driven. There are 2 major reasons for this situation:

- Central city areas can be operated only with small trucks due to narrow road conditions
- Limited volume of containers placed in public roads which results in rather short disposal intervals (in certain areas twice per day)
- Only one transfer station is available which is overloaded and is handling only 70 % of collected waste
- 30 % of waste is directly delivered to the landfill outside of town which is considered as a time consuming practice especially with small trucks

The current landfill has been subject of first upgrade investments but major improvements which would assure operation according to basic environmental and hygienic standards are still missing. Especially the collection, recirculation and treatment of leachate are not yet organized for lack of functioning technical facilities.

The City Administration is currently negotiating with an International Operator who is interested to be contracted for utilization of waste. The currently proposed technology and business plan concept is considered as doubtful in several aspects but nevertheless the analysis of different alternative development options has shown that the City will have anyhow to implement in midterm waste utilization measures in order to reduce the waste tipping at the landfill.

Based on the current status and identified development needs following conclusions have been made as basis for determination of an investment proposal for short term improvements:

- Investments in two transfer stations (one upgrade, one new construction) are considered as rather important for the efficiency of the waste collection system due to:
  - Daily disposal intervals
  - Operation of small truck types
  - Distance to Landfill
- Investments at the current landfill Didi Lilo are considered as required in order to assure future operations according to basic standards (EU Landfill Directive), gas collection, refurbishment of leachate collection and treatment should be given priority.
- The upgrade of the truck fleet is recommended based on a discerning truck fleet analysis and determination of the collection and transport needs.
- Investments in containers shall be made only after comprehensive reconsideration of the collection strategy – a transformation from public container points to lease container system for customers shall be considered in the mid-term. In the meantime the current container equipment shall be kept in function and place, certain extensions (additional container points) shall be considered in order to reduce collection in areas without containers.
Based on these priority development targets the following investment proposal has been determined in numerous consultation rounds between TSG, Consultant and City Administration.

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<th>№</th>
<th>Component</th>
<th>Description</th>
<th>PIP [USD]</th>
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<tr>
<td>TB-SW-02</td>
<td>Upgrade of truck fleet, replacement of old and repair intensive trucks</td>
<td>Replacement of old and repair intensive trucks, procurement of optimized truck types suitable for the specific waste collection conditions</td>
<td>6,400,000.00</td>
</tr>
<tr>
<td>TB-SW-03</td>
<td>Upgrade of existing transfer station</td>
<td>Refurbishment of site Bjelashvili – civil structures, roads and buildings, installation of modern automatic loading equipment and sufficient number of containers, capacity up to 250,000 tons per day</td>
<td>1,290,000.00</td>
</tr>
<tr>
<td>TB-SW-04</td>
<td>Construction of 2nd transfer station</td>
<td>Installation of second transfer station in order to optimize transport to landfill, capacity up to 250,000 tons per day</td>
<td>2,570,000.00</td>
</tr>
<tr>
<td>TB-SW-05</td>
<td>Rehabilitation of leachate system</td>
<td>Installation of recirculation equipment and necessary pipes, chambers, Rehabilitation of leachate treatment plant</td>
<td>4,340,000.00</td>
</tr>
<tr>
<td>TB-SW-07</td>
<td>Equipment for landfill operations</td>
<td>Provision of required equipment for environmental monitoring and landfill operations</td>
<td>400,000.00</td>
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<td>Total CAPEX</td>
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Table 2-1: Investment Proposal

With these priority investments the following development goals will be achieved:

- Improvement of efficiency in waste collection and transport by increase of tonnage collected waste / drive kilometres
- Reduction of repair efforts and costs for old and worn out waste collection trucks
- Support in upgrade of the landfill to basic environmental and hygienic standards and to assure that the landfill can be kept in operation also in mid term future

All measures can be considered as integrative component of the long term waste management strategy for Tbilisi City and will serve an improved situation in waste collection, transport and disposal.
3 SUMMARY BASELINE REPORT

The Baseline Situation can be summarized as follows. For further and detailed information please refer to separate Baseline Report.

3.1 SERVICE AREA

The service area covers the whole City within its current boundaries and is divided into five collection areas:

- Mtatsminda-Krtsanisi
- Isani Samgori
- Didube Chugureti
- Gldani-Nadzakadevi
- Vake-Saburtalo.

These collection areas are operated from three operation yards.

![Figure 3-1: Tbilisi – City Area](image)

3.2 ORGANIZATION AND LEGAL FRAME

Tbiliservice Group is a Multi Utility Company which is providing several municipal services:

- 4,155 employees (2015) of which 2,780 employees for street sweeping
- 890 employees working in waste collection services (drivers, cleaners, loaders)
- 60 mechanics are maintaining a car / truck pool of more than 300 units
- 329 employees in management and controlling of waste related services
- Total staff for waste services: 1379 persons (0.8 employees per 1,000 inhabitants, 3.8 employees / 1,000 ton collected waste)
The number of personnel can be considered as high in comparison with other enterprises due to specific challenges in waste collection which are strongly influenced by narrow conditions in the central city area as well as method of waste collection and disposal.

The Company is operating under the national legal waste frame and by laws and in compliance with applicable legislation for LLCs under ownership of municipal bodies.

3.3 **WASTE GENERATION**

The total served population in 2016 sums up to 1,113,000 (100% of population) 

The volume of waste collected can be assumed by following figures:

- Approx. 360,000 t/a (average July 2013 – June 2016) or approx. 990 t/d with
  - maximum in July with approx. 1,150 t/d,
  - minimum in January with approx. 820 t/d,
  - maximum on Mondays with approx. 1,090 t/d and
  - minimum on Weekends with approx. 900 t/d.

![Average Daily Amount of Waste Collected Per Month](image)

**Figure 3-2: Average daily waste collection during the year**

The assumptions per inhabitant are as follows:

- Approx. 320 kg/inh. per year or
- Approx. 0.9 kg/inh. per day

The waste flow matrix shows more or less 100% disposal of collected waste from households and waste similar to household waste (from commercial and institutional generators) at the landfill via one transfer station and around 30% direct delivery to the landfill.
**Assumed Wasteflow Matrix**

<table>
<thead>
<tr>
<th>Source</th>
<th>Product / Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 370,000 t/y (disposed at Didi Lilo)</td>
<td>~ 95,000 t/y</td>
</tr>
<tr>
<td>Household Waste</td>
<td>Deposit at Landfill Gldani</td>
</tr>
<tr>
<td>Household similar Waste from Institutions and Commerce</td>
<td>~ 255,000 t/y</td>
</tr>
<tr>
<td>Waste from Commerce / Industry</td>
<td>~ 10,000 t/y</td>
</tr>
<tr>
<td>Street Garbage</td>
<td>~ 15,000 t/y</td>
</tr>
<tr>
<td>Green Waste from Public Yards</td>
<td>~ 5,000 t/y</td>
</tr>
<tr>
<td>Construction Waste</td>
<td>40,000 – 60,000 t/y</td>
</tr>
</tbody>
</table>

**Figure 3-3: Tbilisi Waste Generation – assumptions for 2015**

The following can be concluded about current waste generation in Tbilisi:

- Seasonal fluctuation
- Well documented waste collection figures from Tbilservice
- Collected waste per capita: 320 kg/capita and year, 0.8 - 1 kg per day; value at the lower end of a developed city
- No visible signs for illegal waste tipping, dumping in city area (no detailed assessments in the suburbs have been made)
- Increase of waste generation to be expected for Tbilisi in midterm up to 500 - 600 kg / capita and year, determined by increase of living standard and intensified waste collection service

### 3.4 Collection and Transport

The current waste collection and transport system is being operated with a quite large truck pool, limited container volume at public roads and therefore rather short disposal intervals. The following special challenges have been identified in the Baseline Assessment:

- Very intensive disposal interval (up to twice per day) due to limited number of containers placed
- Actual container volume: 10 ltrs per capita (rather low value compared to other cities)
- Collection service provided in partly difficult areas (narrow roads, high frequent traffic roads) and therefore time consuming
- The collection routes partly contain long distances for fuelling
- Amount of collected waste per km: 0.1 tons/km
Fuel consumption per ton collected waste: 6 ltrs

Time for waste collecting 1 ton of waste: 1.2 hours

Only 70 % of waste operated via transfer station

Number of trucks rather high but could be partially justified by difficult collection conditions

20 % of trucks not in operating condition

The following improvement needs have been identified and the following measures have been recommended:

- Reconsideration of routing, reduction of drive kilometres without collection
- Analysis of technical condition truck fleet, replacement of old and repair intensive types – optimized O&M management and consideration in future procurements recommended
- Number and volume of containers currently rather low but increase can be done only mid-term and based on adjusted customer interface – transfer from public container points to lease container provided to customers
- Relevant volumes currently collected without containers – additional containers could be placed in certain areas
- Due to long distance to landfill – additional transfer station to be considered – optimization of drive kilometres for waste collection enabled – cost benefit analysis currently under elaboration

### 3.5 Landfill Operations

There are currently two landfill sites in operation:

1) Landfill Site for solid waste: Didi Lilo
   - Location: 9 km east of Tbilisi
   - Type of Waste: Municipal solid waste, not separated
   - Capacity: 350 000 t/year
   - Daily take over tonnage: 900 t - 1,400 t

2) Landfill Site only for construction waste: Gldani
   - Location: 7 km northeast of Tbilisi
   - Type of Waste: Construction waste, excavation material
   - Capacity: n.a.
   - Average daily take over tonnage: n.a.
The following issues have been identified during the baseline assessment:

**Landfill** is to a large extent state of the art with the following problem areas:

- Landfill as built does not sufficiently provide for a controlled degradation of the deposited, non-separated municipal solid waste
- Clear concept for maintaining the reaction processes does not seem to have been developed; this would include
  - No intermediate cover
  - Controlled recirculation of leachate
  - Landfill gas extraction
- Design deficits
  - Leachate drainage with no flushing capability
  - No provision for controlled recirculation (see above)
- Operational deficits (this may also be result of design deficits)
  - Blockages of collection pipes
  - Leachate treatment not functioning properly
  - Improvised recirculation
  - Ponding in tipping area
  - No recirculation in covered areas
- Landfill gas and odour problem due to missing gas collection system and large open tipping fields
- Flying trash despite intermediate cover
- Birds, especially in winter during migration period

The following measures and activities are recommended to improve the situation and to upgrade the landfill to basic environmental and safety standards:

- Major revision of the landfill design with optimization of the landfill configuration
- Revise sealing system in new sections to conform with advanced international practice
- Reorganization of tipping procedure – reduction of open tipping area
- Optimize the leachate management
- Provide more options for leachate handling depending on quantity and quality (recirculation, storage, treatment)
- Optimize leachate recirculation capacity
- Rehabilitate the leachate treatment plant
- Improve leachate collection system, provide flushing capability
- Optimize landfill gas management
- Optimize landfill operation
- Reconsider the methods and procedures for preventing or intercepting flying trash
- If intermediate cover is necessary, then replace native soil contenting high clay amounts with construction waste or excavation material with low clay content to prevent blockages

For the Site Gldani the following measures are recommended:
- Quick completion of measures required by environmental authority
- Closure of the site as soon as possible
- If not possible in the short term, then only deposit of non-contaminated excavation material
- Redirection of construction waste to new sites

Furthermore **new sites for construction waste** have to be selected. For the development of these sites the following has to be considered:
- Important: Construction waste is an environmental hazard!
- Adaption of the sites according to international standards
- Installation of base sealing and run-off collection
- Installation of weighing bridge and electronic registration
- Fencing to prevent illegal dumping and waste picking
- Consider installation of construction waste recycling
- Collection of run-off from tipping area – recirculation or treatment
- Monitoring program – surface water run-off, groundwater, aerosols, quality of deposited excavation material

### 3.6 COMMERCIAL SITUATION

**Tariff Policy**
- Tariff set by administrative procedures
- Tariff base is the number of household members
- Maximum number of members is 4; other members do not pay
- Current tariff @ GEL 2.50/cap/month, GEL 2.00/cap/month for vulnerable households
- Tariffs already close to affordability levels
- Legal constraints to adjust tariffs (max. GEL 3.00/cap/month defined in law)
- Tariff for legal entities @ GEL 15.00/m³, 29 categories for tariff calculation

### Revenues and Collection rate

<table>
<thead>
<tr>
<th>Category</th>
<th>2015</th>
<th>2014</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Billed</td>
<td>Collected</td>
<td>Billed</td>
</tr>
<tr>
<td>Households</td>
<td>25,430,918</td>
<td>21,492,333</td>
<td>25,519,849</td>
</tr>
<tr>
<td>Legal Entities</td>
<td>17,110,235</td>
<td>17,043,274</td>
<td>14,187,812</td>
</tr>
<tr>
<td>Total</td>
<td>42,541,153</td>
<td>38,535,606</td>
<td>39,707,762</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collection Rate</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>84.51%</td>
</tr>
<tr>
<td>Legal Entities</td>
<td>99.61%</td>
</tr>
<tr>
<td>Total</td>
<td>90.58%</td>
</tr>
</tbody>
</table>

**Draft conclusions and resulting development needs**

- Establishment of profit and cost centres for the different services, incl. newly merged companies
- Application of suitable accounting policies (revenues from the City should be calculated as revenues and not as contributions in share capital)
- User fees could be transferred directly to the company, this could increase accountability
- Review of tariff regulation
4 **OUTLINES FOR LONG-TERM INVESTMENT STRATEGY – 15 YEARS HORIZON UNTIL 2030**

4.1 **GENERAL PRINCIPLES**

In general it has to be stated that the City of Tbilisi is currently operating SWM collection and disposal based on the priorities of provision of clean roads, avoiding fly tipping in the city and disposal of all waste at a regulated landfill site, which has been recently upgraded to the major standards of a controlled landfill. Therefore it can be summarized that Tbilisi has a controlled situation in provision of service quality for the citizens and widely in compliance with basic hygienic, environmental and safety standards.

The City does not have a detailed and approved solid waste management strategy planning instrument but there are conceptual ideas about future SWM organization in Tbilisi. The current discussion with the KDV-Consortium (the Recycling Operator) reflects on these concept ideas, which can be summarized as follows:

**General Principles:**

- **Hygienic safe collection and disposal** of all generated solid waste in the city area
- **Legal compliance** of waste operations with the relevant legislation
- **Cost efficiency** – organization of the SWM services at lowest possible effort and expense
- **Commercial sustainability** – operation based on business plans and commercial concepts considering cost covering tariffs, optimised expenditures and other revenues, such as sales of recyclables
- **Environmental compliance** – operations will be implemented in compliance with national environmental standards and international knowledge in environmentally sound SW operations
- **Minimized risks** – operation of risk management and provision of up to date operational emergency concepts and facility reserves
- **Future orientation** – timely identification of urban developments and consideration in the SWM strategy
- **Technological innovation** – consideration and application of latest know how and operational experience

**Specific Principles for SWM Tbilisi**

- The City will keep strategic responsibility about scope and performance of the SWM services in Tbilisi
- For the day-to-day operation of waste collection and landfill operations the City has contracted a company (Tbilservice Group, TSG) under its ownership
- The City confirms to extend the waste collection services to the whole city area
- The waste collection shall be organized in the best possible way at lowest possible costs and with lowest impact on public hygiene and environment
Implementation of separate collection of recyclables shall be implemented in the mid-long-term based on legal requirements and dependent on the selected technological solution for waste treatment.

The City does not intend in the short and medium term to establish own measures concerning waste treatment. These services shall be outsourced to private operators based on concession contracts or other financing models.

The City intends also in future to operate via TSG a waste landfill for communal solid waste from households (or residual waste after recovery and treatment) and operation of a landfill for construction waste.

### 4.2 Long-term Projections

#### 4.2.1 Population Development

The table below shows the expected population development of the city from 2015 – 2020 (source: Tbilisi City Hall 2014). It was expected the population is growing 0.7% per year. Compared to the actual development, the population in 2016 with 1,113,000 is already 78,000 less than it was expected.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1,183,300</td>
<td>0.7%</td>
</tr>
<tr>
<td>2016</td>
<td>1,191,300</td>
<td>0.7%</td>
</tr>
<tr>
<td>2017</td>
<td>1,199,400</td>
<td>0.7%</td>
</tr>
<tr>
<td>2018</td>
<td>1,207,400</td>
<td>0.7%</td>
</tr>
<tr>
<td>2019</td>
<td>1,215,500</td>
<td>0.7%</td>
</tr>
<tr>
<td>2020</td>
<td>1,223,500</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

Table 4-1 Estimated population growth by Tbilisi City Hall (2014)

It is assumed this is mostly due to the census held in 2014 which cleared up the population register. Within the Consultant’s updated projections, the average growth rate of 0.7% will be maintained. The table below shows the updated population growth estimation until 2030.
<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1,113,000</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>1,120,791</td>
<td>7,791</td>
</tr>
<tr>
<td>2018</td>
<td>1,128,637</td>
<td>7,846</td>
</tr>
<tr>
<td>2019</td>
<td>1,136,537</td>
<td>7,900</td>
</tr>
<tr>
<td>2020</td>
<td>1,144,493</td>
<td>7,956</td>
</tr>
<tr>
<td>2021</td>
<td>1,152,504</td>
<td>8,011</td>
</tr>
<tr>
<td>2022</td>
<td>1,160,572</td>
<td>8,068</td>
</tr>
<tr>
<td>2023</td>
<td>1,168,696</td>
<td>8,124</td>
</tr>
<tr>
<td>2024</td>
<td>1,176,877</td>
<td>8,181</td>
</tr>
<tr>
<td>2025</td>
<td>1,185,115</td>
<td>8,238</td>
</tr>
<tr>
<td>2026</td>
<td>1,193,411</td>
<td>8,296</td>
</tr>
<tr>
<td>2027</td>
<td>1,201,764</td>
<td>8,354</td>
</tr>
<tr>
<td>2028</td>
<td>1,210,177</td>
<td>8,412</td>
</tr>
<tr>
<td>2029</td>
<td>1,218,648</td>
<td>8,471</td>
</tr>
<tr>
<td>2030</td>
<td>1,227,179</td>
<td>8,531</td>
</tr>
<tr>
<td>Total</td>
<td>114,179</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-2 Updated population estimation by Consultant

It is expected that the population will reach 1.2 Mio in 2030, given the current political and economic development in Georgia remains stable.

4.2.2 Waste collection projections

4.2.2.1 Waste generation in the European Union

The figure below shows average waste amounts generated in the member states of the European Union.

Average amount of municipal waste generated is approximately 500 kg per Inhabitant and year.

In high developed countries, these values are significantly higher than in lower developed countries.

It has to be noted that these values represent averages per country. Values in larger cities tend to be higher.
4.2.2.2 General

Below, a waste collection projection will be presented. The projection is taking into account the population development, the growing waste amounts collected as well as experience from other countries.

An exact collection projection is very difficult as habits of population and economic development play a major role for future waste amounts. Further information campaigns on household and school level can change habits.

Basis is the total amount of waste collected by TSG via system collection.

Note: Collected waste amounts differ from waste amount generated. Both will not match up 100%. The projection below already is taking into account an increase of the collected waste generated up to 95% until 2030.

Note: Amounts of waste include household waste and similar waste from e.g. public institutions and commerce (as currently collected by TSG).

Within the projections potential recyclables (paper, plastics, metal and glass) currently disposed at the landfill are included. The displayed amounts show total amount of waste generated and do not take into account separation and recovery actions.

The projections will be utilized for the different variants and their combinations explained below and will also show the volumes of waste to be expected to assess future container and transport volume necessary.

Three main variants were developed:

- **Low collection scenario**
  - Slow increase of waste collection
    - 2% growth per year until 2025
    - 3% growth per year from 2026

- **Medium collection scenario**
4.2.2.3 Collection scenario “Low”

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Total waste collected</th>
<th>increase per year</th>
<th>Waste collected</th>
<th>Accumulated waste collected</th>
<th>Increase to 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons/year</td>
<td>%</td>
<td>kg/Inh/year</td>
<td>tons</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>1,113,000</td>
<td>370,000</td>
<td>2</td>
<td>332</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>1,120,791</td>
<td>377,400</td>
<td>2</td>
<td>337</td>
<td>747,400</td>
<td>102%</td>
</tr>
<tr>
<td>2018</td>
<td>1,128,637</td>
<td>384,948</td>
<td>2</td>
<td>341</td>
<td>1,132,348</td>
<td>104%</td>
</tr>
<tr>
<td>2019</td>
<td>1,136,537</td>
<td>392,647</td>
<td>2</td>
<td>345</td>
<td>1,524,995</td>
<td>106%</td>
</tr>
<tr>
<td>2020</td>
<td>1,144,493</td>
<td>400,500</td>
<td>2</td>
<td>350</td>
<td>1,925,495</td>
<td>108%</td>
</tr>
<tr>
<td>2021</td>
<td>1,152,504</td>
<td>408,510</td>
<td>2</td>
<td>354</td>
<td>2,334,005</td>
<td>110%</td>
</tr>
<tr>
<td>2022</td>
<td>1,160,572</td>
<td>416,680</td>
<td>2</td>
<td>359</td>
<td>2,750,685</td>
<td>113%</td>
</tr>
<tr>
<td>2023</td>
<td>1,168,696</td>
<td>425,014</td>
<td>2</td>
<td>364</td>
<td>3,175,699</td>
<td>115%</td>
</tr>
<tr>
<td>2024</td>
<td>1,176,877</td>
<td>433,514</td>
<td>2</td>
<td>368</td>
<td>3,609,213</td>
<td>117%</td>
</tr>
<tr>
<td>2025</td>
<td>1,185,115</td>
<td>442,184</td>
<td>2</td>
<td>373</td>
<td>4,051,397</td>
<td>120%</td>
</tr>
<tr>
<td>2026</td>
<td>1,193,411</td>
<td>451,028</td>
<td>3</td>
<td>378</td>
<td>4,502,425</td>
<td>122%</td>
</tr>
<tr>
<td>2027</td>
<td>1,201,764</td>
<td>464,559</td>
<td>3</td>
<td>387</td>
<td>4,966,983</td>
<td>126%</td>
</tr>
<tr>
<td>2028</td>
<td>1,210,177</td>
<td>478,496</td>
<td>3</td>
<td>395</td>
<td>5,445,479</td>
<td>129%</td>
</tr>
<tr>
<td>2029</td>
<td>1,218,648</td>
<td>492,850</td>
<td>3</td>
<td>404</td>
<td>5,938,329</td>
<td>133%</td>
</tr>
<tr>
<td>2030</td>
<td>1,227,179</td>
<td>507,636</td>
<td>414</td>
<td>6,445,965</td>
<td>137%</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-3 Waste collection “Low” scenario Tbilisi 2016 - 2030

4.2.2.4 Collection scenario “Medium”

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Total waste collected</th>
<th>increase per year</th>
<th>Waste collected</th>
<th>Accumulated waste collected</th>
<th>Increase to 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons/year</td>
<td>%</td>
<td>kg/Inh/year</td>
<td>tons</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>1,113,000</td>
<td>370,000</td>
<td>3</td>
<td>332</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>1,120,791</td>
<td>381,100</td>
<td>3</td>
<td>340</td>
<td>751,100</td>
<td>103%</td>
</tr>
<tr>
<td>2018</td>
<td>1,128,637</td>
<td>392,533</td>
<td>3</td>
<td>348</td>
<td>1,143,633</td>
<td>106%</td>
</tr>
</tbody>
</table>
Table 4-4 Waste collection scenario "Medium" Tbilisi 2016 - 2030

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Total waste collected</th>
<th>Increase per year</th>
<th>Waste collected</th>
<th>Accumulated waste collected</th>
<th>Increase to 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1,113,000</td>
<td>370,000</td>
<td>3</td>
<td>332</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>1,120,791</td>
<td>381,100</td>
<td>3</td>
<td>340</td>
<td>751,100</td>
<td>103%</td>
</tr>
<tr>
<td>2018</td>
<td>1,128,637</td>
<td>392,533</td>
<td>3</td>
<td>348</td>
<td>1,143,633</td>
<td>106%</td>
</tr>
<tr>
<td>2019</td>
<td>1,136,537</td>
<td>404,309</td>
<td>3</td>
<td>356</td>
<td>1,547,942</td>
<td>109%</td>
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<tr>
<td>2020</td>
<td>1,144,493</td>
<td>416,438</td>
<td>4</td>
<td>364</td>
<td>1,964,380</td>
<td>113%</td>
</tr>
<tr>
<td>2021</td>
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<td>428,931</td>
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<td>372</td>
<td>2,393,312</td>
<td>116%</td>
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<td>2022</td>
<td>1,160,572</td>
<td>441,799</td>
<td>4</td>
<td>381</td>
<td>2,835,111</td>
<td>119%</td>
</tr>
<tr>
<td>2023</td>
<td>1,168,696</td>
<td>459,471</td>
<td>4</td>
<td>393</td>
<td>3,294,582</td>
<td>124%</td>
</tr>
<tr>
<td>2024</td>
<td>1,176,877</td>
<td>477,850</td>
<td>4</td>
<td>406</td>
<td>3,772,433</td>
<td>129%</td>
</tr>
<tr>
<td>2025</td>
<td>1,185,115</td>
<td>496,964</td>
<td>4</td>
<td>419</td>
<td>4,269,397</td>
<td>134%</td>
</tr>
<tr>
<td>2026</td>
<td>1,193,411</td>
<td>516,843</td>
<td>4</td>
<td>433</td>
<td>4,786,239</td>
<td>140%</td>
</tr>
<tr>
<td>2027</td>
<td>1,201,764</td>
<td>537,516</td>
<td>4</td>
<td>447</td>
<td>5,323,756</td>
<td>145%</td>
</tr>
<tr>
<td>2028</td>
<td>1,210,177</td>
<td>559,017</td>
<td>5</td>
<td>462</td>
<td>5,882,773</td>
<td>151%</td>
</tr>
<tr>
<td>2029</td>
<td>1,218,648</td>
<td>586,968</td>
<td>5</td>
<td>482</td>
<td>6,469,741</td>
<td>159%</td>
</tr>
<tr>
<td>2030</td>
<td>1,227,179</td>
<td>616,316</td>
<td>5</td>
<td>502</td>
<td>7,086,057</td>
<td>167%</td>
</tr>
</tbody>
</table>

4.2.2.5 Collection scenario “High”

Table 4-5 Waste collection scenario “High” Tbilisi 2016 - 2030

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Total waste collected</th>
<th>Increase per year</th>
<th>Waste collected</th>
<th>Accumulated waste collected</th>
<th>Increase to 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1,113,000</td>
<td>370,000</td>
<td>3</td>
<td>332</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>1,120,791</td>
<td>381,100</td>
<td>3</td>
<td>340</td>
<td>751,100</td>
<td>103%</td>
</tr>
<tr>
<td>2018</td>
<td>1,128,637</td>
<td>392,533</td>
<td>3</td>
<td>348</td>
<td>1,143,633</td>
<td>106%</td>
</tr>
<tr>
<td>2019</td>
<td>1,136,537</td>
<td>404,309</td>
<td>3</td>
<td>356</td>
<td>1,547,942</td>
<td>109%</td>
</tr>
<tr>
<td>2020</td>
<td>1,144,493</td>
<td>416,438</td>
<td>4</td>
<td>364</td>
<td>1,964,380</td>
<td>113%</td>
</tr>
<tr>
<td>2021</td>
<td>1,152,504</td>
<td>428,931</td>
<td>3</td>
<td>372</td>
<td>2,393,312</td>
<td>116%</td>
</tr>
<tr>
<td>2022</td>
<td>1,160,572</td>
<td>441,799</td>
<td>4</td>
<td>381</td>
<td>2,835,111</td>
<td>119%</td>
</tr>
<tr>
<td>2023</td>
<td>1,168,696</td>
<td>459,471</td>
<td>4</td>
<td>393</td>
<td>3,294,582</td>
<td>124%</td>
</tr>
<tr>
<td>2024</td>
<td>1,176,877</td>
<td>477,850</td>
<td>4</td>
<td>406</td>
<td>3,772,433</td>
<td>129%</td>
</tr>
<tr>
<td>2025</td>
<td>1,185,115</td>
<td>496,964</td>
<td>4</td>
<td>419</td>
<td>4,269,397</td>
<td>134%</td>
</tr>
<tr>
<td>2026</td>
<td>1,193,411</td>
<td>516,843</td>
<td>4</td>
<td>433</td>
<td>4,786,239</td>
<td>140%</td>
</tr>
<tr>
<td>2027</td>
<td>1,201,764</td>
<td>537,516</td>
<td>4</td>
<td>447</td>
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<td>5</td>
<td>502</td>
<td>7,086,057</td>
<td>167%</td>
</tr>
</tbody>
</table>

4.2.2.6 Summary Waste Generation Scenario

In all scenarios a steady growth of the waste amounts is assumed.

The increase of annual waste collected until 2030 varies between plus 37% up to plus 98%.

Annual waste collected per inhabitant per scenario:

- **Low growth scenario**: ~ 400 kg/Inh./year in 2030
- **Medium growth scenario**: ~ 500 kg/Inh./year in 2030
- **High growth scenario**: ~ 600 kg/Inh./year in 2030
Note: This annual averages include household and similar waste alike. This value should not be confused with the annual amount collected per producer on household level.
The figures below show the development of waste amounts of the scenarios for
- total waste generation and
- waste generation per inhabitant.

**Figure 4-2 Waste generation scenarios for Tbilisi 2016 - 2030: Total amount of waste collected per year**

**Figure 4-3 Waste collection scenarios for Tbilisi 2016 - 2030: Amount of waste collected per Inhabitant and year**

The Low Scenario does not fully meet the current tendencies of Tbilisi’s economic and general development. In general, with the economic growth, the amount of waste will also increase. Furthermore an amount per inhabitant similar to EU member states with rural characterization seems unfitting.
The **High Scenario** is also not considered as realistic as the amount per inhabitant would be similar with the higher developed EU Members.

For further calculations, the **Medium Scenario is considered the most realistic scenario**. The amount of waste generated per inhabitant is similar to the current EU average, a useful guiding value balancing the tendency of higher urban waste generation potential of Tbilisi and the lower development stage of Tbilisi compared to the EU as a unit.

### 4.2.2.7 Waste Composition Scenario

Type and composition of the total waste collected on household level strongly depends on the economic situation and past and future development of a city or country.

In low and medium developed countries the share of organic material (kitchen waste and green waste) makes the largest share. With economic growth and increased welfare waste share of packaging material (paper, glass, metal and plastics) increases.

The graph below gives a rough estimation of the development of the waste composition of the total waste stream on basis of TSG’s waste analysis from 2014 (refer to Baseline Report).

![Waste composition graph](image)

**Figure 4-4: Estimated future MSW composition of Tbilisi collected waste**

In general it can be assumed that the total share of organic waste will be reduced and the share of packaging material will increase with increased wealth and with this shift to increased consumption of refined and packed foods. The table below shows rough estimations of the future shares of the main waste fractions of the assessment performed by TSG in 2014.

<table>
<thead>
<tr>
<th>Year</th>
<th>Organic</th>
<th>Paper, Carton</th>
<th>Foil, PVC</th>
<th>PET</th>
<th>Glas</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>70.0 %</td>
<td>9.5 %</td>
<td>9.7 %</td>
<td>3.3 %</td>
<td>2.4 %</td>
<td>5.1 %</td>
<td>100 %</td>
</tr>
<tr>
<td>2030</td>
<td>59.0 %</td>
<td>12.0 %</td>
<td>14.0 %</td>
<td>5.0 %</td>
<td>3.0 %</td>
<td>7.0 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>

In total, the amount of all waste types within the residual waste stream is expected to increase (refer to waste generation scenario above):
4.3 Analysis of Development Options

4.3.1 General

There is a high variety of technical solutions available for solid waste management from generation to final disposal. These vary from basic to high end solutions, from very well tested and often successfully implemented solutions to new and untested approaches with high or low realisation probability. Also the level of disposal service provided by the operator might vary extremely.

The following sections serve to gain a short insight into different options along the whole waste management chain from collection and transportation to treatment and disposal.

For all variants an outlook will be given for the year 2030, assuming a prolongation of the stable development situation in terms of political, economic and social surrounding conditions in Georgia and Tbilisi during the last 10 years. All assumptions are based on the population and waste generation scenarios as described above for Tbilisi.

Variants for Waste Collection and Transportation

The following major variants for the system collection for solid waste from private, institutional and commercial customers have been taken under consideration:

Variant 0 - Public collection points: The current system with collection points at public places will be kept in general with small updates like underground containers in special areas.

Variant 1 - Lease container system: Switch from public container points to lease container system, where containers at different sizes will be provided to customers, and stored by them at their private premises. No separate collection of recyclables foreseen.

Variant 2 – Lease containers for residual waste, public collection points for recyclables: Switch from public container points to lease container provided to customers...
only for residual waste. Public collection points will be used as recycling collection points (with separate bins for paper, glass, metal, plastic, green waste).

Variant 2 will be explained in detail by means of a best practice model.

**Variants for waste treatment and disposal**

The following major variants for solid waste disposal and treatment have been taken under consideration:

**Variant A – the “Zero Option”:** The current situation will be kept and waste disposal 100% at current landfill without treatment

**Variant B – the “currently discussed Recycling Option”:** Hand over of 100% collected waste to a private operator for waste utilization via KDV technology (utilization of waste for production of diesel) as intended by the City; residual waste taken back from operator and disposed at current landfill

**Variant C:** Contracting of a private operator for waste utilization with energy re-use by application of common used technologies, such as waste combustion.

The following combinations of variants are possible, whereas some combinations are either uncommon or not recommendable to be implemented in Tbilisi. The marked variants are being discussed more in details in the following sections:

<table>
<thead>
<tr>
<th>Variant</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variant 0A</td>
<td>Status Quo</td>
</tr>
<tr>
<td>Variant 0B</td>
<td>current intention of City and TSG</td>
</tr>
<tr>
<td>Variant 0C</td>
<td>not very common solution due to necessity of pre-treatment before combustion</td>
</tr>
<tr>
<td>Variant 1A</td>
<td>Old European Standard Solution (not applied anymore)</td>
</tr>
<tr>
<td>Variant 1B</td>
<td>not applied, unproven waste utilization technology for cities</td>
</tr>
<tr>
<td>Variant 1C</td>
<td>not very common solution due to necessity of pre-treatment before major utilization stage</td>
</tr>
<tr>
<td>Variant 2A</td>
<td>combination is pointless</td>
</tr>
<tr>
<td>Variant 2B</td>
<td>not in the range of discussion</td>
</tr>
<tr>
<td><strong>Variant 2C</strong></td>
<td>Common European City Solution in compliance with EU</td>
</tr>
</tbody>
</table>

**4.3.2 Waste Collection and Transportation**

**Variant 0: Maintain the current system**

**4.3.2.1 Variant 0: Future container volume and location**

Current collection and transportation practice foresees that waste is collected from public containers on a daily basis. This has to be done promptly after waste is brought by clients to the containers along the street. Reason is the little storage capacity of approx.12.5 litre/Inhabitant at an average waste generation of 6 litres per Inhabitant and day in 2016.

As the amount of waste generated is expected to increase, the current storage capacity available per inhabitant will not be sufficient.

The **average daily amount of waste generated** is expected to increase from

- ~1,000 t/d in 2016 to ~1,700 t/d in 2030, respectively from
- **~1,200 t/d in 2016 to ~2,000 t/d in 2030 during peak generation** in June

To maintain the current ratio of ~11.5 m³ container volume available per ton on a peak day in July (14,000 m³ container volume for 1,200 tons), additional 9,000 m³ or 9,000 of the currently utilized 1.1 m³ containers have to be made available (23,000 m³ container volume for 2,000 tons) until 2030. This makes it necessary to place ~700 containers adequately per year.

**Total number of 1.1 m³ container volume on the street in 2030: ~23,000 pcs.**

These additional 9,000 containers have to be placed along the street in accordance with current practice. It has to be considered that this additional space needed is in direct competition with public space like parking lots and sidewalks. Further, TSG already struggles with complaints of neighbours of collection points.

4.3.2.2 **Variant 0: Future routing and collection fleet**

Waste generation takes mostly place in the morning and in the evening. The flexibility to buffer the steadily growing amounts of waste within the current routing practice ("empty the containers just after they got filled") can only be maintained with a also steadily growing vehicle fleet.

As Tbilisi already struggles with traffic issues, it is very likely these issues will be not solved in the coming years. It can be expected with growing well-being that number of vehicles will further increase, with direct negative influence on this waste collection practice.

Assuming routing can be optimized and amount of waste collected per trip will increase from 3.3 tons per trip to 4 tons per trip (+20% efficiency), with the increased waste amounts the **number of daily trips would increase to 400 trips** (currently 300). Without optimization 500 trips per day seems very likely.

4.3.2.3 **Variant 0: Future hygiene and service quality**

Change in current hygiene and service quality could be achieved by usage of containers with automatic closing lids.

The increase of service quality with this variant is rather limited. The increase of number of containers in central city areas is being restricted by space and customer resistance against containers nearby their houses.

4.3.3 **Waste Collection and Transportation Variant 1: Lease container system without source separation**

4.3.3.1 **Lease container system for residual waste**

4.3.3.1.1 **Overview: Lease container system**

The lease container system can be seen as the most common used waste collection method within the European Union. It is very often combined with separate collection.

**Key assumption behind the system is that waste is actually the property of the generator of the waste.** Within system collection these are households, public institutions and commerce. They store their waste in bins and containers which are made available by the company or entity assigned for waste collection by the respective authority (in Tbilisi: TSG, authorised by the City).

The provided container sizes, collection intervals and billing for waste collection services in the EU vary from municipality to municipality and strongly depend on the size and structure of the municipality. Residual waste is not collected within public contain-
ers but on household level or – in dense urban areas – on multi storey building level.

In the following, two examples of lease container systems are briefly shown:

- **Rural areas with mostly private houses**
  
  o One bin (120 - 240 ltrs) per household
  
  o Waste is collected in a pre-defined interval, e.g. every second week on the same day
  
  o The household has the option and responsibility to make his bin accessible for the collection enterprise (e.g. by putting his bin at the disposal day on the sidewalk in front of his property)
  
  o The household tariff is being composed in different ways, such as:
    
    - fee per person registered within his household
    - fee based on number of disposals per year
    - fee based on size of provided container

- **Urban areas with multi storey building structure (as in Tbilisi)**
  
  o For every household within a building, sufficient container volume has to be made available by the waste management company to the building management entity
  
  o Waste is collected in a pre-defined and published interval, e.g. every week on the same day
  
  o Containers are emptied without pre-consulting the household
  
  o Containers are typically stored in locked areas, only clients and collection entity can access them (see examples for multi-storey buildings below)
Roofless waste collection for multi storey building in Vienna

Indoor waste collection for multi storey building in Vienna, with access from inside the building

Indoor waste collection for multi storey building in Vienna, with access from outside the building

Tariffs are composed under the same principles as for private houses according to the number and type of containers and the pre-defined collection interval.

Billing is done by the house management company (which is the customer towards the waste management enterprise); the fees are then being split internally between the households (based on space of flat, per persons registered or other methods approved by the house community).

In the following the necessary system changes are listed necessary to switch to such a waste collection system.

4.3.3.1.2 Required accompanying measures to transform current system into lease container system

The change from public collection points into a lease container system is mainly not a technological issue but can be a sophisticated organizational task especially in large cities.

- The system change of a waste collection practice will take several years and is a task to be performed during a well prepared legal and organizational transformation process:
  - Change could start in areas were the collection practice needs adjustment anyway, e.g. in areas with "bell system" in place
  - Area by area could be updated, e.g. first areas with multi storey buildings, where external collection points for each build will be necessary anyway.
• The system change can not be handled by the waste collection entity itself. The City and especially the legal department and other sub-departments responsible for housing have to be included in the process:
  o The system change has to be embedded into the current waste management legislation of the City
  o The service contract between the City and the waste collection entity has to be updated and renewed as the type of service delivery will change.
  o Several existing regulations and codes have to be reviewed and customized, e.g.
    ▪ The building code should foresee inter alia “waste collection rooms” or “waste collection locations” for newly constructed buildings
    ▪ Regulation on design and implementation of waste collection rooms” or “waste collection locations” defining inter alia
      • Number and type of bins and/or containers necessary
      • Size of waste collection rooms and locations
      • Access to the locations
  • The system change should to be accompanied by a multi stage information campaign to inform the population on the upcoming changes and to assure basic acceptance in the population.

4.3.3.2 Variant 1: Future container volume and location

4.3.3.2.1 Assumed future container volume and location

The estimated total storage volume for a weekly served lease container system can be assumed with 115,000 m³ with a
  • peak daily waste generation of 2,000 tons/day,
  • weekly disposal service
    o 14,000 tons/week or
    o 93,000 m³/week ² and
  • additional buffer storage of 25 %

4.3.3.2.2 Households

The necessary future container volume per private person in 2030 can be assumed with 80 l/inh/week for private persons¹:
  • Daily peak waste generation per person in 2030
    o 1.6 kg/pers/day or
    o 11 litres per person and day².

Assumed total storage for private persons: ~ 100,000 m³

On household level the necessary future container volume in 2030 can be assumed with 300 l/household/week
  • with average household size 3.3 persons per household³

¹ Calculation basis includes waste from commerce, institutions etc.; used here as buffer
² Peak day: 2,000 tons/day; 1.227 Mio Inhabitants; Waste density 0.15 kg/m³
This means in a multi storey building with 30 apartments, it would be necessary to supply 10 containers with volume 1.1 m³.

4.3.3.2.3 Schools and Kindergardens
Per students at least 10 l/week with weekly disposal interval can be assumed.
With approx. 300,000 children between the age of 2 and 16 in 2030 (own estimation):
Total storage for Schools and Kindergardens necessary: 3,000 m³

4.3.3.2.4 Office Buildings
Per 1000 m² at least 1000 l/week storage volume with a weekly disposal interval can be assumed.
With approx. 2 Mio m² of office space available
Total storage for office buildings necessary: 2,000 m³

4.3.3.2.5 Hotels
Per bed at least 30 l/week storage volume necessary with a weekly disposal interval can be assumed.
With approx. 15,000 beds in 2030
Total storage for Hotels necessary: 500 m³

4.3.3.2.6 Supermarkets, Bazaars and Shops
Per 500m² retail floor space at least 2,000 l/week storage volume with a weekly disposal interval can be assumed.
With approx. 1,400,000 m² of retail in 2030
Total storage for Supermarkets, Bazaars and Shops necessary: 5,500 m³

4.3.3.2.7 Other generators of household waste
These are inter alia, universities, public administration, museums etc.
Total storage for other generators of household waste necessary: 4,000 m³

4.3.3.3 Variant 1: Future routing and collection fleet
The change to a lease system makes a completely re-organization of the current collection routing necessary.
Instead of collect waste on a daily basis from containers along the street during relatively long trips, it will be necessary to collect waste directly from households on significant shorter trips.
With the increased storage capacity on household level, the collection is not depending on the “just in time” collection of waste in the morning and evening hours (when households generate their waste). Collection could be performed during early morning hours (from e.g. 4 AM onwards) to avoid the rush hour in Tbilisi (~ 9 AM – 12 AM).

---

4 Colliers International: Tbilisi Real Estate Market Report 2014:
Office space 2014: 912,367 m²
Hotel beds available 2016: 8,784 pcs
Retail space 2014: 887,280 m².
The figure below shows the change of collection method on household level:

- Variant 0: long path for client to collection point; short path for collection vehicle
- Variant 1: short path for client; long path for collection vehicle to the households

![Diagram showing Variant 0 and Variant 1 collection paths](image)

**Figure 4-6: Change of path for collection in Variant 1: Change on household level**

The figure below shows the changes with Variant 1 on routing level:

- Interval of route is reduced to once per week per container
- Routes get shorter as the amount of waste along the route is increased with the new storage capacity within the households

![Diagram showing Variant 0 and Variant 1 collection routes](image)

**Figure 4-7: Change of path in Variant 1: Change on route level**
Variant 0 practice example:
- Daily collection route with 3 trips per day
- Some containers get emptied twice a day
- Total ~ 21 trips/week
- Most of the containers are filled only 50% or less
- Especially during last trip vehicle filling level is low

Variant 1 practice example:
- Weekly route with six trips per week
- Every container emptied once
- Total ~ 6 trips/week
- Most of the containers are almost 100% full

The new routes within Variant 1 in the example above could be performed, e.g. by 6 trucks on 1 single day or the same truck on 3 or 6 days.

**Example calculation route capacity:**

<table>
<thead>
<tr>
<th>Collection vehicle capacity</th>
<th>Served inhabitants per route</th>
<th>Served households per route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variant 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 tons capacity</td>
<td>230</td>
<td>70</td>
</tr>
<tr>
<td>5.5 tons capacity</td>
<td>460</td>
<td>140</td>
</tr>
<tr>
<td>10 tons capacity</td>
<td>900</td>
<td>270</td>
</tr>
</tbody>
</table>

The table above shows an overview on the served population per weekly trip depending on the available collection truck.

The change to Variant 1 would make it necessary to invest in routing software capable to handle the number of households served.

Service area should be analyzed according to which truck type is suitable to serve the area (e.g. “Old Town” should be served by smaller trucks, while main roads should and areas with multi storey building with large trucks). With this analysis routes can be defined in accordance with the truck fleet available.

**4.3.3.4 Variant 1: Future hygiene and service quality**

In together with the rising living standards in the cities it has to be expected that higher service quality and hygienic standards for communal services will be requested by the population and commerce. This variant will provide following benefits for the customers:

- Reduction of delivery path of residual waste for clients is a huge service quality improvement.
- Removal of residual waste containers along the street is an increase of hygiene and service quality.
- The optimized operation of waste collection trucks and especially the reduction of operations during rush hours is also a considerable increase of the service quality.

---

5 Vehicle with 5.7 m³ storage and compaction capacity up to 0.45 t/m³; 11.2 kg/week person
6 Vehicle with 12 m³ storage and compaction capacity up to 0.45 t/m³; 11.2 kg/week person
7 Vehicle with 17 m³ storage and compaction capacity up to 0.60 t/m³; 11.2 kg/week person
4.3.4 Waste Collection and Transportation Variant Analysis 2: Lease container system with source separation

4.3.4.1 Lease container system
The lease container system is explained above (section 4.3.3.1).

4.3.4.2 Source separation
4.3.4.2.1 Introduction source separation
Source separation means that household waste is not collected in one single bin or container as residual waste as a whole but will be separated by the waste generator on household level.

Common fractions on household level which can be collected separately are:

<table>
<thead>
<tr>
<th>Main Category</th>
<th>Sub Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Waste</td>
<td>Residual Waste</td>
</tr>
<tr>
<td></td>
<td>Bulky Waste</td>
</tr>
<tr>
<td>Recyclables</td>
<td>Paper and Cardboard</td>
</tr>
<tr>
<td></td>
<td>Glass</td>
</tr>
<tr>
<td></td>
<td>Metal</td>
</tr>
<tr>
<td></td>
<td>Wood</td>
</tr>
<tr>
<td></td>
<td>Plastic (PET, PP, PE, PS)</td>
</tr>
<tr>
<td></td>
<td>Electronic Waste</td>
</tr>
<tr>
<td>Organic Waste</td>
<td>Kitchen Waste</td>
</tr>
<tr>
<td></td>
<td>Green Waste</td>
</tr>
<tr>
<td>Inert Waste</td>
<td></td>
</tr>
<tr>
<td>Hazardous waste</td>
<td>Oils</td>
</tr>
<tr>
<td></td>
<td>Medicaments</td>
</tr>
<tr>
<td></td>
<td>Paint and Coating</td>
</tr>
<tr>
<td></td>
<td>Gas discharge lamps</td>
</tr>
<tr>
<td></td>
<td>Batteries and accumulators</td>
</tr>
</tbody>
</table>

The decree of source separation can be adjusted dependent on the needs and capacities of the client and the operator of the waste collection system as well as on the final treatment and disposal technology in place.

4.3.4.2.2 Best Practice example of source separation: Vienna
There are numerous nuances concerning source separation. The below mentioned is a well established model. But also the described approach needs continuous monitoring and improvement actions.

In the following, separated collection in the City of Vienna is briefly pictured as an example on the current source separation practice performed in Europe in many other cities. Of course a variety of practices exists and every city has its own unique approach developed over the past decades.

The current approach of source separation in Vienna was established over 30 years ago, with it special strengths and weaknesses and taking into account the special needs and demands of the city’s population.

The described approach should not be seen as the latest state of the art but as an impulse and basis for further consideration of an improved waste collection system (and especially source separation) in Tbilisi.
Note: The recently upcoming approach in source separation – Single Stream Recovery, which is a further development of the source separation approach – is being described after this section.

Depending on the type of city development different source separation and collection strategies are being applied:

- Old Town, high density of old buildings
- New development areas mixed with industrial areas; multi-storey buildings with open space in between
- Private Housing Area (2 storey buildings) with private gardens

The table below shows the main three area types and the practice of waste handling in these areas.

<table>
<thead>
<tr>
<th></th>
<th>Old Town, high density of old buildings:</th>
<th>New development areas mixed with industrial areas; multi-storey buildings with open space in between</th>
<th>Private Housing Area (2 storey buildings) with private gardens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage capacity</td>
<td>Little storage capacity within buildings for waste bins and containers available</td>
<td>Sufficient storage capacity within or in front of buildings for waste bins and containers available</td>
<td>Little storage capacity and necessity on household level for several bins or containers</td>
</tr>
<tr>
<td>Separate collection on public collection points</td>
<td>Glass, Metal and PET</td>
<td>Glass, Metal and PET</td>
<td>Glass, Metal and PET, Paper/cardboard, Organic Waste (Green and Kitchen)</td>
</tr>
<tr>
<td>Comment</td>
<td>Often no separate collection of organic waste (kitchen waste is treated as residual waste)</td>
<td></td>
<td>Often private composting in own yards of green and kitchen waste</td>
</tr>
<tr>
<td>Plastics aside PET</td>
<td>Aside of PET and packaging of washing and cleaning agents plastic is not collected separately and is disposed in residual bins and containers. Reason: Waste is incinerated in facilities with a high degree of energy utilization and the plastic is used to substitute fossil fuels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

More specific waste types such as hazardous waste, bulky waste and inert waste (e.g. construction waste from private construction measures) can be brought to special waste collection centres operated by the Vienna Waste Collection Company. Apart from these waste collection centres, there are small mobile units placed at markets and public yards where customers can dispose off their hazardous waste. By leaflets and advertisements in local newspapers the population is kept informed about location and date where the mobile units are open for taking over of hazardous waste.

The figures below show the distribution of public collection points for each of the three described development areas.
Figure 4-8: Recyclables collection points in Vienna: Old Town, high building density and old buildings source: https://www.wien.gv.at/umweltgut/public/

Figure 4-9: Recyclables collection points in Vienna: New development areas mixed with industrial areas; multi-storey buildings with open space in between source: https://www.wien.gv.at/umweltgut/public/
Figure 4-10: Recyclables collection points in Vienna: Private Housing Area (2 storey buildings) with private gardens source: https://www.wien.gv.at/umweltgut/public/

Below two examples of source separation collection points

Collection point in mixed area of multi storey buildings and private houses with gardens. From left to right:
Glass (white/green lid), Organic Waste (brown lid), Metals (blue lid), PET (yellow lid) and paper (red lid)

Collection Point in multi-storey area
From left to right:
Metals (blue lid) and PET (yellow lid)
[on the far left container of private textile collection company]

The efficiency of the separate collection in Vienna is listed below (source: Wiener Abfallvermeidungsprogramm und Wiener Abfallwirtschaftsplan, 2012)

<table>
<thead>
<tr>
<th>Fraction</th>
<th>2005</th>
<th>2009</th>
<th>Relative Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>66%</td>
<td>67%</td>
<td>+ 1,5%</td>
</tr>
<tr>
<td>Glass</td>
<td>47%</td>
<td>55%</td>
<td>+ 17%</td>
</tr>
<tr>
<td>Metal</td>
<td>19%</td>
<td>26%</td>
<td>+ 37%</td>
</tr>
<tr>
<td>Organic</td>
<td>38%</td>
<td>43%</td>
<td>+ 13%</td>
</tr>
<tr>
<td>PET</td>
<td>n/a</td>
<td>22%</td>
<td>n/a</td>
</tr>
</tbody>
</table>

4.3.4.3 Variant 2: Future container volume and location

With a source separation model the necessary container volume on household level for residual waste can be reduced by approx. 9 % from volume of 100.000 m³ (estimation see section 4.3.3.2.2) to approx. 91.000 m³.

Taking 75 % of the efficiency of separation achieved in Vienna (see above) for Tbilisi in 2030, the following amounts of resources potentially can be collected separately (on basis of waste analysis of TSG from 2014 and own projections):
- Paper / Carton 50%: ~ 41,000 tons in 2030 (of estimated 82,000 tons)
- Glass 41%: ~ 8,500 tons in 2030 (of estimated 21,000 tons)
- Metal 20%: ~ 2,000 tons in 2030 (of estimated 8,000 tons)
- PET 17%: ~ 5,000 tons in 2030 (of estimated 29,000 tons)

In this variant no separate collection of organic waste is foreseen.

In total about 56,500 tons (375,000 m³ at 0.15 kg/to) or 9% of the household waste stream could be separately collected and utilized for further recycling processes.

- Placement of separate collection containers could be done similar as done in the best practice example above by using current residual waste collection points spread all over the city
- For collection of glass, special containers and vehicles should be purchased, according to international practice.

4.3.4.4 Variant 2: Future routing and collection fleet

Routing for residual waste collection has to be performed similar to the above mentioned strategy (see section 4.3.3.3) but considering the lower waste volume.

For the public recyclables collection points separate routing for each recyclables type needs to be foreseen. Also different truck types are being typically used.

Outsourcing of collection of recyclables directly to the company with interest in the material is a feasible and proven practice (e.g. glass recycling company is responsible for emptying glass waste containers).

4.3.4.5 Variant 2: Future hygiene and service quality

Similar to variant 1 (see section 4.3.3.4 above), the hygiene and service standards would be improved.

The customers need to be trained (convinced) to accept and actively participate in separation of recyclables. This requires normally intensive information and awareness campaigns and a certain time period until visible success can be noticed.

4.3.4.5.1 Alternative Source Collection: Single Stream Recycling

Single Stream Recycling is currently widely implemented in Australia, the United States and Canada (e.g. in San Francisco, Toronto, Denver, Tucson, San Jose, Philadelphia, Dallas or Ontario).

Within a single-stream recycling system all recyclables, including newspaper, cardboard, plastic, aluminium, etc., are placed in a single bin. The recyclables are collected by a single truck and taken to a Materials Recovery Facility (MRF).
The original idea was the assumption that this system would encourage clients to participate in the recycling programmes of cities and municipalities as it is not necessary by the client to sort recyclables. A further incentive was potential reduced collection cost.

A recently performed study (A Comparison of Single and Multi-Stream Recycling Systems in Ontario, Canada by Calvin Lakhan, 2015) highlighted the differences in cost and recycling performance between single and multi-stream recycling systems in Ontario, Canada by using data from 223 provincial municipalities over a 10 year period.

Results show that a careful analysis before implementation has to be done to ensure economic, social and environmental viability is proven. Also given infrastructural and operational characteristics have to be taken into account.

The study came to the following main results:

- Municipalities implementing single stream recycling face higher material management costs than those with multi-stream recycling (policy decisions have been predicated single stream being cheaper than multi-stream recycling).
- Inclusion of too many different materials in the recycling program should be carefully analysed concerning effort for sorting process and achievable market price.
- Single stream recycling is most appropriate in densely populated urban areas where there are large quantities of recyclable material generated. The mechanization of single stream MRFs allow for significant material processing capacity.
- In areas where single stream recycling is offered, significant efforts should be made in educating households about what constitutes acceptable materials to minimize levels of contamination at the MRF level and increase processing efficiency.
- Municipalities with single stream recyclable collection should provide households with bins/carts that have sufficient space to accommodate for the generation of recyclables. Given that all recyclable materials are being placed in one bin/cart, there is a risk that there may be inadequate capacity for household recyclables.
4.3.5 Strengths and Weaknesses of Waste Collection and Transportation Variants

Below the major strengths and weaknesses of each Variant are listed.

<table>
<thead>
<tr>
<th>Variant</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variant 0: Maintain current system</td>
<td>Containers easily accessible for TSG along the street (apart from rush hours) No complex change of system required</td>
<td>Little container storage volume “on the street” due to restrictions in space and customer resistance Containers have to be emptied on a daily basis Waste collection strongly linked to waste generation: “Just-in-time collection” Low service quality for clients Smell on the street through open lids Waste reduction strategy not sufficiently supported (customer awareness)</td>
</tr>
<tr>
<td>Variant 1: Lease container system without separate selection</td>
<td>Sufficient waste storage volume at household level for several days provided. Comfortable service level for customers Waste issue is widely removed from the street scene High potential for increased efficiency of waste collection</td>
<td>Change of current collection system required Customers might lack of sufficient space in their premises for storage of containers Change of current clients mind set concerning waste collection needs to be initiated by awareness actions (time and budget intensive) No source separation: Recyclables have to be sorted out (with often lower resource quality) after collection</td>
</tr>
<tr>
<td>Variant 2: Lease container system with separate selection</td>
<td>Sufficient waste storage volume at household level for several days provided. Waste issue is widely removed from the street scene. The handling with recyclables is facilitated and more efficient. Reduction of waste to be tipped at the landfill</td>
<td>Change of current collection system required Customers might lack of sufficient space in their premises for storage of containers Change of current clients mind set concerning waste collection needs to be initiated by awareness actions (time and budget intensive) Higher logistical effort and planning capacity necessary</td>
</tr>
</tbody>
</table>

Table 4-6: Collection and Transportation Variants: Strength and Weakness Analysis
4.3.6 Waste treatment and disposal: Current practice in Europe

4.3.6.1 Household waste treatment and disposal: General development in the European Development

The figure below shows the current distribution of waste disposal types for the total of 27 EU countries (the present member states minus Croatia). It is obvious that the trend in the last 20 years went from landfilling to recycling, incineration and composting. Furthermore the effects of awareness campaigns and commercial sector actions towards waste reductions are showing promising results after a decade of peak waste generation 2000 - 2008.

![Municipal waste treatment, EU-27, (kg/capita)](source http://www.eea.europa.eu/)

The composition of methods for waste treatment and disposal in the different member states is different, as mentioned in the sections below.

4.3.6.2 Household waste treatment and disposal: Example Austria

Austria is considered as a very high developed country and solid waste management is not fully comparable with the current situation in Georgia. The following is more to show a possible target scenario for 2030 and beyond for the City of Tbilisi. It is extracted from the National Waste Management Plan 2011 of Austria.

Of the total household waste was collected in 2009 in Austria were

- Collected separately: 57% of which were
  - Recyclables: 35,6 %
  - Organic Waste: 19,3 %
  - Hazardous Waste: 2,5 %

- Collected as residual or bulky waste: 43%

Household waste then was treated in following shares:

- Incineration: 36,4 %
- Mechanical-Biological Treated: 28,7 %
- Recycled: 32,0 %
- Hazardous 2,5%
- Directly disposed 0,4

See figure below.

Figure 4-13: Development of waste treatment practice in Austria 1989 - 2009

In total, about 15% of the household waste had to be finally disposed at landfill sites in 2009 (see figure below). This includes residuals of thermal treatment, mechanical-biological treatment and small amount of residuals extracted from recyclables and organic waste. 20 years before over 70% of household waste was landfilled.

Figure 4-14: Development of landfilling practice in Austria 1989 - 2009

4.3.6.3 Household waste treatment and disposal: Example Slovakia

In Slovakia waste treatment and disposal rates differ from the practice in Austria. About 9% of household waste is currently reused (recycling and composting).
Table 4-7: Treatment rates of municipal waste in Slovakia in 2010, as percentage of MSW generated

The EU Landfill Directive requests from its Member States to reduce the amount of biodegradable municipal waste which is tipped at landfills. As a country that tipped more than 80% of its MSW at landfills in 1995, Slovakia has been granted to meet the target of 75% in by 2010, of 50% in 2013 and of 35% in 2020 (see below).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material recycling</td>
<td>3.6</td>
</tr>
<tr>
<td>Composting</td>
<td>5.0</td>
</tr>
<tr>
<td>Incineration with energy recovery</td>
<td>9.5</td>
</tr>
<tr>
<td>Incineration without energy recovery</td>
<td>0.7</td>
</tr>
<tr>
<td>Landfilling</td>
<td>78.0</td>
</tr>
<tr>
<td>No information</td>
<td>3.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Eurostat 2012

4.3.7 Waste Treatment and Disposal Variant Analysis A: Waste disposal 100 % at current landfill without treatment

4.3.7.1 Variant A: General description

Within this variant, the current status quo of waste disposal is being continued without substantial changes.

100 % of waste collected is disposed at the current landfill without treatment.

The landfill site has to be extended according to the tipping needs.

4.3.7.2 Variant A: Future capacity needs for landfill (by volume and area)

With the above waste generation prognosis (medium generation scenario) the capacity needs until 2030 can be estimated with

- approx. 9 Mio m³ disposal volume will be required or
- approx. 30 – 44 ha as disposal area, depending on the average height of the landfill body.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total waste collected</th>
<th>Accumulated waste collected</th>
<th>Waste Volume per year collected 1)</th>
<th>Required volume at landfill 2)</th>
<th>Required area landfill Variant A-I 3)</th>
<th>Required area landfill Variant A-II 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons/year</td>
<td>tons</td>
<td>m³</td>
<td>m³</td>
<td>hctrs</td>
<td>hctrs</td>
</tr>
<tr>
<td>2016</td>
<td>370,000</td>
<td>2,466,667</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>381,100</td>
<td>2,540,667</td>
<td>938,875</td>
<td>4.7</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>392,533</td>
<td>2,616,887</td>
<td>1,429,541</td>
<td>7.1</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>404,309</td>
<td>2,695,393</td>
<td>1,934,927</td>
<td>9.7</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>416,438</td>
<td>2,776,255</td>
<td>2,455,475</td>
<td>12.3</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>428,931</td>
<td>2,859,543</td>
<td>2,991,640</td>
<td>15.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>441,799</td>
<td>2,945,329</td>
<td>3,543,889</td>
<td>17.7</td>
<td>11.8</td>
<td></td>
</tr>
<tr>
<td>2023</td>
<td>459,471</td>
<td>3,063,142</td>
<td>4,118,228</td>
<td>20.6</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>2024</td>
<td>477,850</td>
<td>3,185,668</td>
<td>4,715,541</td>
<td>23.6</td>
<td>15.7</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>496,964</td>
<td>3,313,095</td>
<td>5,336,746</td>
<td>26.7</td>
<td>17.8</td>
<td></td>
</tr>
<tr>
<td>2026</td>
<td>516,843</td>
<td>3,445,618</td>
<td>5,982,799</td>
<td>29.9</td>
<td>19.9</td>
<td></td>
</tr>
<tr>
<td>2027</td>
<td>537,516</td>
<td>3,583,443</td>
<td>6,654,695</td>
<td>33.3</td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>559,017</td>
<td>3,726,781</td>
<td>7,353,466</td>
<td>36.8</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>2029</td>
<td>586,968</td>
<td>3,913,120</td>
<td>8,087,176</td>
<td>40.4</td>
<td>27.0</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>616,316</td>
<td>4,108,776</td>
<td>8,857,572</td>
<td>44.3</td>
<td>29.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-8: Variant A - Waste collected and required volume and area

1) Waste volume during collection uncompressed: 0.15 to/m³
2) Waste volume during land filling compressed: 0.80 to/m³
3) Estimated required area landfill A-I: Average height of landfill body 20 m
4) Estimated required area landfill A-II: Average height of landfill body 30 m

This variant is not favourable due to, inter alia, its

- immense requirements concerning space and volume
- high costs for disposal of waste
- loss of recyclables and re-usable material
- very likely non-compliance with Georgian law concerning separation collection
- non-compliance with the EU-Landfill Directive

### 4.3.7.3 Required other activities

Besides the investment into tipping area further actions are necessary to operate and maintain the landfill, inter alia

- adapt leachate treatment plant in accordance with the increased leachate volumes expected
- gas collection and treatment system needs to be extended in several operation phases
- investigations for additional landfill extensions required
- closure of landfill sections and after care measures extensive due to size of landfill and composition of tipped waste
4.3.8 Waste Treatment and Disposal Variant Analysis B: Contracting private operator for waste utilization via KDV (as currently intended by the City)

4.3.8.1 Variant B: General description
According to the current waste utilization intentions of TSG and the City this option foresees a waste utilization plant on site of the landfill with an uncommon and unproven approach:

- Treatment based on the technology of KDV - Katalytische Drucklose Verölung (catalytic low pressure depolymerization).
- Residuals of utilization technology will be disposed at the current landfill operated by TSG

Note: This technology is not recommended by the Consultant as it is not a commonly used technology (for details refer to Baseline Report section 2.13.17), Two well established alternatives are briefly described below in section 4.3.9:

- Mechanical Biological Treatment (MBT)
- Waste Incineration as the State of the Art Waste-to-Energy technology

4.3.8.2 Future capacity needs for landfill
With the above waste collection prognosis (medium generation scenario) and at least 30% of residual waste to be disposed at the landfill\(^8\), the capacity needs until 2030 can be estimated with

- approx. 2.7 Mio m\(^3\) disposal volume will be required or
- approx. 9 – 13 ha as disposal area, depending on the average height of the landfill body.

\(^8\) Deloitte 2015, KDV waste processing plant development for KDV Georgia: “KDV Georgia plant will be ready to process up to 70% of the total generated waste in Tbilisi”
Table 4-9 Variant B - Waste collected and required tipping area if 30% of residual waste has to be disposed of at the landfill

1) Waste volume during collection uncompressed: 0.15 t/m³
2) Waste volume during land filling compressed: 0.80 t/m³
3) Estimated required area landfill A-I: Average height of landfill body 20 m
4) Estimated required area landfill A-II: Average height of landfill body 30 m

With a more realistic approach of approx. 50% of waste to be disposed of at the landfill, the capacity needs until 2030 can be estimated with

- approx. 4.4 Mio m³ disposal volume will be required or
- approx. 15 – 22 ha as disposal area, depending on the average height of the landfill body.

Table 4-10 Variant B - Waste collected and required tipping area if 50% of waste has to be disposed of at the landfill

1) Waste volume during collection uncompressed: 0.15 t/m³
2) Waste volume during land filling compressed: 0.80 t/m³
3) Estimated required area landfill A-I: Average height of landfill body 20 m
4) Estimated required area landfill A-II: Average height of landfill body 30 m
4.3.8.3 Further actions besides development of landfill capacity

Besides the investment into landfill capacity further actions are necessary to operate and maintain the landfill, inter alia:

- refer to all comments / recommendations as included in the Baseline report, make land and site infrastructure available for KDV plant (Baseline Report section 2.13.17)
- landfill infrastructure (leachate, gas collection and treatment) needs to be extended according to the extension of the tipping area

4.3.9 Waste Treatment and Disposal Variant Analysis C: Contracting private operator for waste utilization by application of proven technologies

4.3.9.1 General

Waste Utilization at urban scale is being applied in numerous examples worldwide. Major technological approaches are including always waste to energy components by combustion technologies but there are many combinations with other utilization methods being applied and in operation. In the following two major common waste utilization methods (both including a set of several applicable technologies) are briefly presented:

- Mechanical Biological Treatment
- Waste Incineration (Thermal treatment or Waste-to-Energy)

For both utilization methods, also disposal of residuals as output from utilization at the landfill has to be considered.

4.3.9.2 Mechanical Biological Treatment (MBT)

4.3.9.2.1 General

The following brief description of Mechanical Biological Treatment (MBT) can also be found in “Mechanical Biological Treatment of Municipal Solid Waste” (Department for Environment, Food & Rural Affairs, UK, 2013).

MBT is a generic term for an integration of several mechanical processes commonly found in other waste management facilities such as Materials Recovery Facilities (MRFs), composting or Anaerobic Digestion plant.

MBT is a residual waste treatment process that involves both mechanical and biological treatment and compliments, but does not replace other waste management technologies (e.g. waste incineration).
4.3.9.2.2 Mechanical separation
A common aspect of many MBT plant used for MSW management is the sorting of mixed waste into different fractions using mechanical means.

Sorting the waste allows an MBT process to separate different materials which are suitable for different end uses as material recycling, biological treatment and energy recovery

4.3.9.2.3 Biological treatment
There are a variety of different biological treatment techniques which are used in MBT plant. Key categories of biological treatment are

- „Aerobic treatment (Composting)“ may be used to either bio-stabilise the waste or process a segregated organic rich fraction.
- Anaerobic Digestion: used to process a segregated organic rich fraction

4.3.9.2.4 Key issues
When considering key issues are therefore:

- Plant/Facility Siting;
- Traffic;
- Air emissions / health effects;
- Dust / odour;
- Bio-aerosols;
- Flies, vermin and birds;
- Noise;
- Litter;
- Water resources;
- Design principles and visual intrusion;

Source: "sreichenhauer.com 2006"
4.3.9.3 Waste Incineration

4.3.9.3.1 General
The following information is a summary of the Waste-to-Energy in Austria (C. Holzer and F. Neubacher, 2015)

4.3.9.3.2 Basic functions of incineration
During incineration, organic substances (hydro-carbon compounds) are oxidized under high temperature, converting them into carbon dioxide and water vapor.

The process consists of four stages:

- **Drying**: Water is evaporated to turn the humid fuel into a "dry substance".
- **Degasification**: Organic substances (low-temperature carbonization gas) escape. The solid residue is then referred to as “pyrolytic coke” or “coke”.
- **Gasification**: Solid carbon is converted into combustible carbon monoxide (CO) utilizing a gasification agent (e.g. H₂O, CO₂ or O₂). The solid residue left over once gasification is complete is referred to as ash, slag, bed material or fly ash.
- **Oxidation**: The combustion of the (combustible) gases CO and hydrogen (H₂) to convert them into CO₂ and H₂O. This is accompanied by high release of heat. Oxidation requires oxygen (e.g. from air). For complete incineration, excess air is required, which presents itself as residual oxygen in the off gas from incineration.

4.3.9.3.3 Type of Incineration Plants

**Production of Electricity and Heat**
New plants should be connected to industrial production facilities which require year-round heat supply, or at sites which are connected to a sufficiently powerful regional district heating network.

Waste incineration plants with cogeneration of thermal power (heating, cooling) and electricity can achieve an optimum energy efficiency of some 80% in total, depending on the plant design.

Plants that solely generate electricity (no heat usage) only achieve an efficiency of approximately 20%. However, using suitable heat pumps, thermal (or cooling) output can exceed the input electricity threefold, making thermal waste treatment plants that only generate electricity useful for power generation.

The electricity consumed by the thermal waste treatment plant itself amounts to approx. 3% to 6% of the thermal energy input.

The simplified figure below shows the energy flows of a waste incineration plant equipped with a condensing turbine comparing them with those of a cogeneration plant for electricity and thermal energy (e.g. heating steam for industrial production).
The following waste incineration technologies are well tested and differ in the way the air and fuel are fed into the incinerator:

- **Grate firing systems** (air flows from underneath through the solid particulate fuel placed on top of the grate),
- **Fluidized-bed incineration** (intense gas turbulence keep the suspended, small-piece fuel in hot sand and incineration gas in a “fluidized”, dynamic state of movement),
- **Dust firing systems** (the finely ground fuel is transported pneumatically in the gas flow with simultaneous incineration),
- **Rotary kiln with afterburner** (various types of solid, pasty and liquid wastes can be treated in the slowly rotating kiln. The flue gas is subsequently burned with auxiliary fuel in the connected afterburning zone).

Experience has shown that the simplest way to incinerate mixed residual waste is in a grate firing system. Alternatively, residual waste can be used in fluidized-bed incineration. Compared to grate firing systems this option shows slightly higher energy efficiency and better properties of the slag for recovery, however mechanical processing of the input material is required. Rejects from waste paper recycling, mechanically de-watered sewage sludge, and mechanically processed waste fractions (e.g. shredder light fractions, etc.) with a low or exceptionally high calorific value can be used efficiently in the fluidized bed system which is another advantageous difference to grate firing systems.

### 4.3.9.3.4 Basic requirements

Waste incineration plants can generally be constructed at any industrial site. The site and operating conditions, however, should be chosen in such a way as to ensure utilization of energy recovery throughout the year is utilized.
Site requirements are not only determined by ecological considerations, but also considerably depend on economic aspects, to ensure that treatment costs remain at an acceptable level. The following site requirements should be considered:

- Year-round heat requirement at a high efficiency (cogeneration to provide electricity, process heat or district heating)
- Reduction potential for environmental stress (e.g. replacement of old boilers, utilization of polluted air from existing production facilities for the operation of the incineration plant, improvement of transport infrastructure, etc.)
- Spatial planning requirements, including planning restrictions for protected and recreational areas
- Suitable meteorological (and topographical) conditions on the site
- Discharge possibilities of treated waste water (with its content of chlorides) from off-gas cleaning into a large river or sea – or an effluent-free process
- Good transport links and favourable site in the main disposal area (including railway connection)
- Existing infrastructure (e.g. transport facilities, laboratory) and technical installations (e.g. turbine and generator, water supply, off-gas chimney)
- An experienced technical team for plant operation and maintenance.

In many cases – particularly with larger plants to be newly built – an essential site requirement is the existence of a suitable system of transport logistics and intermediate storage facilities for waste and residues which must meet ecological and economic criteria. In such cases transport by train should be an option to be considered.

![Figure 4-18: Unloading possibilities for waste shipped by train to EVN Abfallverwertung (automatic unloading of containers by crane or unloading by truck)](image)

### 4.3.9.4 Energy content of waste necessary for incineration

Despite the separate collection of different waste fractions, the typical calorific value of residual waste ranges between 10 - 11 MJ (Mega Joules) per kilogram. This means that 1 ton of residual waste is roughly equal to 1 ton of brown coal or 250 litres of heating oil.
The range of calorific value for auto-thermal combustion (combustion without auxiliary fuel) depends on the technology used and control of the incineration process. While a typical grate firing facility requires a minimum calorific value of approximately 7 MJ per kg for auto-thermal combustion, a suitably configured fluidized-bed incineration plant can achieve this starting from approximately 3 MJ per kg.

### 4.3.9.4.1 Waste types usable for incineration

Residual and other mixed wastes with high calorific value (e.g. residual municipal waste) can and should be thermally treated in suitably equipped plants at appropriate sites for recovery of energy.

The question of whether a certain type of waste should be materially recycled or incinerated for energy recovery can only be answered on a case-by-case basis, as the specific waste composition and available treatment technologies must be considered with special attention on mass and energy balances, resource conservation, and environmental impacts.

Specific waste materials such as paper, cardboard, glass, PET containers, and scrap metal, as well as green waste (which can be used to make high-quality compost), should be separately collected and recycled.

### 4.3.9.4.2 Co-Incineration of Waste in Industry

Quality of waste used as fuel must be suitable for the industrial furnace (calorific value, chemical composition, storage stability, dosability, etc.). The incineration requirements must be met (control technology, minimum temperature and minimum residence time,

---

**Figure 4-19: Calorific values if different fuel types**

The range of calorific value for auto-thermal combustion (combustion without auxiliary fuel) depends on the technology used and control of the incineration process. While a typical grate firing facility requires a minimum calorific value of approximately 7 MJ per kg for auto-thermal combustion, a suitably configured fluidized-bed incineration plant can achieve this starting from approximately 3 MJ per kg.

### 4.3.9.4.1 Waste types usable for incineration

Residual and other mixed wastes with high calorific value (e.g. residual municipal waste) can and should be thermally treated in suitably equipped plants at appropriate sites for recovery of energy.

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Specific waste materials such as paper, cardboard, glass, PET containers, and scrap metal, as well as green waste (which can be used to make high-quality compost), should be separately collected and recycled.

### 4.3.9.4.2 Co-Incineration of Waste in Industry

Quality of waste used as fuel must be suitable for the industrial furnace (calorific value, chemical composition, storage stability, dosability, etc.). The incineration requirements must be met (control technology, minimum temperature and minimum residence time,
minimum oxygen content, etc.), and the required atmospheric emission and residue treatment must be ensured, including monitoring by measurement.

Certain wastes can be converted into quality-assured waste fuels through appropriate sorting, separating and processing steps.

Co-incineration of certain waste fuels in suitable industrial production plants can be an economically and ecologically expedient way to complement dedicated waste incineration plants.

<table>
<thead>
<tr>
<th>Waste</th>
<th>Production process</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processed plastics</td>
<td>Cement kiln</td>
<td>Main firing, precalciner</td>
</tr>
<tr>
<td>Used oil, halogen-free solvents</td>
<td>Cement kiln</td>
<td>Only in main firing</td>
</tr>
<tr>
<td>Shredded tires</td>
<td>Cement kiln</td>
<td>Only in secondary firing</td>
</tr>
<tr>
<td>Light fraction from packaging waste collection</td>
<td>Blast furnace</td>
<td>Pelletization and feeding via tuyere</td>
</tr>
<tr>
<td>Sawdust and wood shavings contaminated with organic chemicals</td>
<td>Cement kiln</td>
<td>Only in main firing</td>
</tr>
</tbody>
</table>

Source: SNORM 521004-1, 2005

Figure 4-20 Examples for co-incineration of waste types

4.3.9.5 Intermediate storage of waste before incineration process

Moving from land filling to waste incineration also requires fundamental changes in waste logistics. A thermal plant definitely requires a consistent supply (thermal performance in MW for every second is calculated by multiplying the calorific value of the waste in MJ/kg by the amount of waste fed to the system in kg/s). Thermal waste recovery, therefore, requires the development and application of systems to store treated waste in an environmentally sound manner. In particular, this is an effort to bridge seasonal fluctuations and plant downtime and also to bridge the time period during which additional facilities are under construction.

4.3.9.6 Residuals from waste incineration

Composition of waste and fuels used, as well as that of the incineration gas and the required additives, engenders flows of inorganic substances, which are recoverable to a greater or lesser degree depending on the processes and type of technology used.

A significant share of solid residues from incineration can be recovered for recycling (e.g. metals or gypsum), and some are of sufficient quality to be used as construction material (e.g. stones and sand from the fluidized-bed, sintered slag, sintered ashes as a glasslike granulate).

By concentrating inorganic substances in certain residue streams (e.g. particulate matter or filter cake with an increased heavy metal content), they can be prepared for mechanical treatment for of recovery, or at least for proper landfill disposal.
The solid residues from residual waste incineration make up 25% - 30% of the weight of the untreated residual waste. Owing to the relatively high density of these residues, the landfill volume required is only 10% of the original volume.

4.3.9.6.1 Constraints concerning construction and operation of waste incineration plants

Basically it has to be reminded that the tolerance of waste landfills which are operated at low costs and not in compliance with basic technical, environmental and hygienic standards are considered as the major economic constraint for waste incineration plants, but also for implementation of waste reduction strategies and any other environmentally sound waste treatment.

Waste landfills of the old generation without sufficient leachate and gas treatment infrastructure (e.g. like those operated in Austria until end of the nineties and those currently encountered in Tbilisi) are usually operating at much lower OPEX than those of state of the art thermal waste treatment plants by a factor of 4 (up to a factor of 10!).

Prevention of waste is being undermined not by targeted and cost-intensive treatment, but by cheap waste disposal which is currently common in many regions of the world, also in Georgia – unfortunately not taking into account the long-term effects in the form of soil, air and water pollution, as well as losses of usable land by generation of contaminated sites.

Other potential constraints are being identified in:

- general strategy of public bodies to keep waste disposal tariffs as low as possible
- subsequently low interest by the Government to support waste treatment at technological modern level
- lack of managerial know how of city administrations and waste utilities in initiation, tendering, financing and management of waste utilization projects
- long procedures for site permits due to the industrial character of the plant
4.3.9.6.2 Remediation of old landfill sites

Thermal treatment is also required in case of remedying a contaminated landfill site. If proper splitting is ensured, the costs for contaminated site remediation can be reduced – compared to complete clearing and incineration of the contaminated material – by reintegrating the separated and treated fine fractions in a sealed section of the landfill at the given contaminated site.

4.3.9.7 Future capacity needs for landfill in case of utilization by incineration technologies for waste treatment

With the above waste generation prognosis (medium generation scenario) an average of **25% of residuals to be disposed at the landfill after incineration** and with a roundabout density of ash, slag, bed material or fly ash of approx. 1 t/m³, the capacity needs until 2030 can be estimated with

- **approx. 1.8 Mio m³ disposal volume or**
- **approx. 6 - 9 ha as disposal area**, depending on the average height of the landfill body.

*Note: Of course these development values 2016 - 2030 have more a symbolic nature, as development, construction and taking in operation of an incineration plant takes up to 10 years. The identical time frame used for Variant A and B used serve the better comparison of the three Variants.*

<table>
<thead>
<tr>
<th>Year</th>
<th>Total waste collected</th>
<th>Accumulated waste collected</th>
<th>Waste Volume per year collected 1)</th>
<th>Required volume at landfill 2)</th>
<th>Required area landfill Variant A-I 3)</th>
<th>Required area landfill Variant A-II 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons/year</td>
<td>tons</td>
<td>m³</td>
<td>m³</td>
<td>hctrs</td>
<td>hctrs</td>
</tr>
<tr>
<td>2016</td>
<td>370,000</td>
<td>2,466,667</td>
<td>92,500</td>
<td>0.5</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>381,100</td>
<td>2,540,667</td>
<td>187,775</td>
<td>0.9</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>392,533</td>
<td>2,616,887</td>
<td>285,908</td>
<td>1.4</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>404,309</td>
<td>2,695,393</td>
<td>386,985</td>
<td>1.9</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>416,438</td>
<td>2,776,255</td>
<td>491,095</td>
<td>2.5</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>428,931</td>
<td>2,859,543</td>
<td>598,328</td>
<td>3.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>441,799</td>
<td>2,945,329</td>
<td>708,778</td>
<td>3.5</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>2023</td>
<td>459,471</td>
<td>3,063,142</td>
<td>823,646</td>
<td>4.1</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>2024</td>
<td>477,850</td>
<td>3,185,668</td>
<td>943,108</td>
<td>4.7</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>496,964</td>
<td>3,313,095</td>
<td>1,067,349</td>
<td>5.3</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>2026</td>
<td>516,843</td>
<td>3,445,618</td>
<td>1,196,560</td>
<td>6.0</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>2027</td>
<td>537,516</td>
<td>3,583,443</td>
<td>1,330,939</td>
<td>6.7</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>559,017</td>
<td>3,726,781</td>
<td>1,470,693</td>
<td>7.4</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>2029</td>
<td>586,968</td>
<td>3,913,120</td>
<td>1,617,435</td>
<td>8.1</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td><strong>616,316</strong></td>
<td><strong>4,108,057</strong></td>
<td><strong>1,771,514</strong></td>
<td><strong>8.9</strong></td>
<td><strong>5.9</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4-11 Variant C - Waste collected and required volume and area**

1) Waste volume during collection uncompressed: 0.15 to/m³
2) Waste volume during land filling compressed: 1.00 to/m³
3) Estimated required area landfill A-I: Average height of landfill body 20 m
4) Estimated required area landfill A-II: Average height of landfill body 30 m
4.3.9.8 Future investment needs beside volume and area development

Waste Utilization Projects at such scale typically require a huge set of measures and certain budget and time for implementation of all preparatory actions. The costs of such waste incineration projects vary between 700 - 2.300 MEUR (see graph below) depend essentially on the following specific site-related features:

Technical features: Waste volume and composition, availability of suitable locations, available technical infrastructure, thermal output capacity of the incineration plant

Organization features: Selection of appropriate organization model capability of City / Waste Enterprise in project preparation and management selection of professional Consultancy support in process and plant engineering as well as supervision of construction

Legal Features: General waste management frame law and specific legislation applicable for such plants (especially environmental legal frame) terms, conditions and time period to run all required permits and approvals including EIA and community participation

Financing features: Selection of financing model (in together with organization model) financing costs OPEX (which are strongly dependent on market prices and operation terms and conditions as determined by law and in the operation permits) including costs for disposal of residuals potentials for revenues by energy sales

![Diagram of investment needs]

Source: UV&P, 2013

Figure 4-22: Overall costs of a thermal waste treatment plant over a time period of 40 years
4.3.9.9 Hygienic and environmental risks

Treatment of emissions is necessary because of the unavoidable formation of dust and gaseous air pollutants in the emission from waste incineration; even if incineration is complete (i.e. when the residual concentrations of organic carbon compounds and carbon monoxide in the flue gas are at an absolute minimum).

Gaseous pollutants can be divided into organic substances (i.e. unburned or organic carbon) and inorganic substances (e.g. carbon monoxide, sulfur oxide, hydrochloric acid, nitrogen oxide, and gaseous mercury).

Key parameters are: particulates, total organic carbon (TOC), carbon monoxide (CO), sulfur dioxide (SO₂), hydrogen chloride (HCl), hydrogen fluoride (HF), nitrogen oxide (NOₓ or NO + NO₂) and mercury (Hg).

Limits are necessary for noise pollution caused by plant operation and shipment, against odour formation during handling and intermediate storage of wastes, and particularly against atmospheric emissions from thermal treatment and further downstream for waste water from atmospheric emissions cleaning and emissions from the treatment of solid residues.

Storage of waste foreseen for incineration is liable to entail considerable risks in terms of environmental pollution (carrying by the wind, smell, pollution of bodies of water and soil) and the danger of self-ignition and arson.

4.3.10 Strengths and Weaknesses of Waste Treatment and Disposal Variants

The following table shows a comparison of the total waste volumes and area needs for each variant.

<table>
<thead>
<tr>
<th>Variant</th>
<th>Total amount of waste disposed in 2030 [m³]</th>
<th>Total amount of disposal area required [hctr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variant A: Waste disposal 100 % at current landfill without treatment</td>
<td>9 Mio</td>
<td>30 - 44</td>
</tr>
<tr>
<td>Variant B: Contracting private operator for waste utilization via KDV as intended by TSG</td>
<td>2.7 – 4.4 Mio</td>
<td>9 - 22</td>
</tr>
<tr>
<td>Variant C: Contracting private operator for waste utilization by incineration</td>
<td>1.8 Mio</td>
<td>6 - 9</td>
</tr>
</tbody>
</table>

Table 4-12 Comparison of the total waste volumes and area needs for each variant

Below the main strengths and weaknesses of each Variant are being briefly presented.

<table>
<thead>
<tr>
<th>Variant</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variant A: Waste disposal 100 % at current landfill without treatment</td>
<td>No fundamental changes to current waste disposal approach required</td>
<td>Huge demand in landfill extension up to 44 hctrs required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High operation expenses for site infrastructure due to large size of area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High expenses for a long term period for protection measures after closure of landfill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential affection of surrounding environment – huge expenses for environmental protection due to large size of area</td>
</tr>
</tbody>
</table>
### Table 4-13 Strengths and weaknesses of each Variant

<table>
<thead>
<tr>
<th>Variant</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variant B: Contracting private operator for waste utilization via KDV as intended by TSG</strong></td>
<td>City / TSG can delegate full responsibility for utilization of all collected waste to private operator</td>
<td>Risk of Technical failure (Note: such plants do not exist at this scale)</td>
</tr>
<tr>
<td></td>
<td>Reduction of waste tipped at landfill, cost reduction against Variant A</td>
<td>Risk of Commercial failure of project due to miscalculations in commercial concept</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full responsibility of City / TSG to take back all residual waste from operator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No possibility for City / TSG to create revenues from sales of recyclables</td>
</tr>
<tr>
<td><strong>Variant C: Contracting private operator for waste utilization by incineration</strong></td>
<td>City / TSG can delegate full responsibility for utilization of all collected waste to private operator</td>
<td>Long and comprehensive project preparations to be considered</td>
</tr>
<tr>
<td></td>
<td>Application of common used technology (numerous examples in Cities worldwide)</td>
<td>Huge investment project for the City, not financeable within current tariff frame</td>
</tr>
<tr>
<td></td>
<td>Application of environmental standards also in the long run assured</td>
<td>High expenses for operation</td>
</tr>
<tr>
<td></td>
<td>Energy re-use enabled (electricity, district heating)</td>
<td>Relevant tariff increases required</td>
</tr>
<tr>
<td></td>
<td>Reduction of waste tipped at landfill, cost reduction against Variant A</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3.11 Comparison of Variants - Recommendations

The table below shows a comparison of collection and disposal variants with brief justification comments. Please note that these comments shall not be considered as result of an in depth evaluation of variants but shall be seen as a first orientation and for stakeholders for the decision finding process about the future of the Solid Waste Management System in Tbilisi. The different colours shall give a picture, which variants are being considered as applicable for Tbilisi and which variants should not be applied.

Red Colour……not recommended option, extra ordinary high risks and uncertainties for the City

Orange Colour…recommended but sub-optimal solution

Yellow Colour….feasible as temporary solution for a short - mid-term horizon

Green Colour….proven technology, applied in many other cities worldwide, recommended for the mid-term horizon
<table>
<thead>
<tr>
<th>Variant Combination</th>
<th>Recommendation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variant 0A</strong>&lt;br&gt;(Status Quo):&lt;br&gt;Unsorted street collection and 100% disposal at landfill</td>
<td>Recommendable only as an intermediate step until advanced system will take place</td>
<td>Future waste amounts unlikely to be handled with current collection and transport system&lt;br&gt;Large number of collection trucks required due to short disposal intervals&lt;br&gt;In mid-term future most probably also not compliant with legal frame in Georgia&lt;br&gt;Recyclables are not being separated / reused&lt;br&gt;High costs for landfill extension, operation, closure and after care measures&lt;br&gt;High GHG Emissions at landfill</td>
</tr>
<tr>
<td><strong>Variant 0B</strong>&lt;br&gt;(Current intentions of City and TSG)&lt;br&gt;Unsorted street collection, utilization of waste by KDV and disposal of residuals</td>
<td>Not recommended due to high technological, contractual and commercial uncertainties</td>
<td>Future waste amounts unlikely to be handled with current collection and transport system&lt;br&gt;Large number of collection trucks required due to short disposal intervals&lt;br&gt;Uncommon Solution: Utilization Variant not applied so far at such scale – technical and commercial feasibility doubtful – high risks for the City&lt;br&gt;Transformation of organic carbons contained in waste into diesel requires high amount of energy&lt;br&gt;GHG Emissions extra ordinary high when including in the balance also the output (diesel product)</td>
</tr>
<tr>
<td><strong>Variant 0C</strong>&lt;br&gt;Unsorted street collection and waste incineration plant</td>
<td>Recommendable only as an intermediate step until advanced collection will take place</td>
<td>Future waste amounts unlikely to be handled with current collection and transport system&lt;br&gt;Large number of collection trucks required due to short disposal intervals&lt;br&gt;High costs for investment and operation due to 100% of waste collected has to be utilized in combustion plant – extensive pre-treatment required.</td>
</tr>
<tr>
<td><strong>Variant 1A</strong>&lt;br&gt;(Old European Solution)&lt;br&gt;Unsorted lease bin collection and 100% disposal at landfill</td>
<td>Recommendable only as an intermediate step until advanced system will take place</td>
<td>Large container volumes required at customer side&lt;br&gt;Recyclables are not being separated / reused&lt;br&gt;High costs for landfill extension, operation, closure and after care measures&lt;br&gt;High GHG Emissions at landfill</td>
</tr>
<tr>
<td><strong>Variant 1B</strong>&lt;br&gt;(Old European collection solution with unproven waste utilization technology)&lt;br&gt;Unsorted lease bin collection, utilization of KDV technology and disposal of residuals</td>
<td>Not recommended due to high technological, contractual and commercial uncertainties</td>
<td>Large container volumes required at customer side&lt;br&gt;Uncommon Solution: Utilization Variant not applied so far at such scale – technical and commercial feasibility doubtful – high risks for the City&lt;br&gt;Transformation of organic carbons contained in waste into diesel requires high amount of energy&lt;br&gt;GHG Emissions extra ordinary high when including in the balance also the output (diesel product)</td>
</tr>
<tr>
<td>Variant Combination</td>
<td>Recommendation</td>
<td>Notes</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------</td>
<td>-------</td>
</tr>
</tbody>
</table>
| Variant 1C          | Recommendable only as an intermediate step until advanced system will take place | Uncommon solution  
Large container volumes required at customer side  
Recyclables not sorted and only Waste to Energy measures take place  
High costs for investment and operation due to 100% of waste collected has to be utilized in combustion plant – extensive pre-treatment required. Likely not in line with Georgian law |
| Variant 2A          | Not recommended | Separation and subsequent disposal of separated resources is pointless |
| Variant 2B          | Not recommended | Separation is pointless as operator of KDV is expected to take over mixed residual waste  
Refer to other comments about utilization technology |
| Variant 2C-1        | Considerable solution but only in mid-term approach due to time required for preparatory measures | Alternative modern solution implemented in certain regions of Mid Europe (Austria, Germany, Northern Italy).  
Mixed container system of lease containers and public collection points for recyclables requires high efforts in organization of collection and transport  
MBT Technologies need to be carefully designed in order to meet commercial and environmental performance goals  
Step by step implementation of operation stages possible:  
- start phase with semi-manual sorting of recyclables  
- second phase: extraction of “high caloric fraction” (sold e.g. to cement industry)  
- third phase: treatment of residuals after 1) and 2)  
Combustion required for the sorted out “high caloric fraction” – this fraction could be used in certain industries (e.g. pulp and paper, cement)  
Careful evaluation of feasibility and comparison with Variant 2C-2 recommended  
Selection of site, EIA and public participation processes take certain time and budget |
| Variant 2C-2        | Considerable solution but only in mid-term approach due to time required for preparatory measures | Modern solution implemented worldwide in developed large urban agglomerations  
Mixed container system of lease containers and public collection points for recyclables requires high efforts in organization |
Table 4-14 Comparison of collection and disposal variants with brief justification comments

<table>
<thead>
<tr>
<th>Variant Combination</th>
<th>Recommendation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tory measures and currently applied low tariff system</td>
<td>of collection and transport Combustion technologies need to be carefully designed in order to meet commercial and environmental performance goals especially energy efficiency and exhaust treatment Careful evaluation of feasibility recommended Selection of site, EIA and public participation processes take certain time and budget Cost intensive solution: essential tariff increase required</td>
</tr>
</tbody>
</table>

4.4 **Optimization of current Waste Transfer Station**

### 4.4.1 General

This chapter will outline the optimization of current waste transfer techniques in order to meet the increasing amount of waste to be handled in the near future.

Currently waste transfer is done via the Transfer Station Beliashvili. The transfer station consists of two discharge bays. Transfer vehicles are loaded directly by the collection vehicles (for further details please see Baseline Study).

Two transfer station scenarios were developed, outlined in detail below:

- **Transfer Variant 0: Retain with current practice:**
  - One transfer station
  - No upgrade of transfer station
  - No source separation

- **Transfer Variant 2: Updating transfer station operations:**
  - Two transfer stations
  - Construction of second transfer station
  - With and without source separation in 2030

Both variants show the development of transfer station capacity needs with the medium waste collection scenario described above until 2030.

### 4.4.2 Operation Zones Variant 1

The table below shows the estimated amount of waste to be transferred according to current and future population estimations as well as the spatial conditions of Tbilisi.

While in Variant 0 waste delivered directly to landfill remains with 30%, for Variant 1 this amount is reduced to approx. 18% with approx 49% transferred via Beliashvili and 33% via new transfer stations.

*Note: The shares of Variant 1 are tentative and also strongly depend on the future location of the new transfer station (refer to map below)*
### Variant 0: Retain with current practice: 1 Transfer Station, No upgrade of Transfer Station

<table>
<thead>
<tr>
<th>Current Status</th>
<th>Short Term Scenario: Medium</th>
<th>Long Term Scenario: Medium; no separation</th>
<th>Long Term Scenario: Medium; seperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>360,000</td>
<td>405,000</td>
<td>610,000</td>
</tr>
<tr>
<td>2020</td>
<td>405,000</td>
<td>405,000</td>
<td>610,000</td>
</tr>
<tr>
<td>2030</td>
<td>610,000</td>
<td>610,000</td>
<td>610,000</td>
</tr>
</tbody>
</table>

### Variant 1: 2 updated Transfer Stations

<table>
<thead>
<tr>
<th>Current Status</th>
<th>Short Term Scenario: Medium</th>
<th>Long Term Scenario: Medium; no separation</th>
<th>Long Term Scenario: Medium; seperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>360,000</td>
<td>405,000</td>
<td>610,000</td>
</tr>
<tr>
<td>2020</td>
<td>405,000</td>
<td>405,000</td>
<td>610,000</td>
</tr>
<tr>
<td>2030</td>
<td>549,000</td>
<td>610,000</td>
<td>610,000</td>
</tr>
</tbody>
</table>

### Waste Basic Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Current Status</th>
<th>Short Term Scenario: Medium</th>
<th>Long Term Scenario: Medium; no separation</th>
<th>Long Term Scenario: Medium; seperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Inh.</td>
<td>1,108,717</td>
<td>1,144,493</td>
<td>1,227,179</td>
</tr>
<tr>
<td>Waste Basic Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Amount of waste produced</td>
<td>tons</td>
<td>360,000</td>
<td>405,000</td>
<td>610,000</td>
</tr>
<tr>
<td>Waste to landfill per year</td>
<td>tons</td>
<td>360,000</td>
<td>405,000</td>
<td>610,000</td>
</tr>
<tr>
<td>Waste Separated</td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Waste Separated</td>
<td>tons</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Waste per inh and year to landfill</td>
<td>kg/Inh/a</td>
<td>320</td>
<td>350</td>
<td>500</td>
</tr>
<tr>
<td>Waste seperated per Inh and year</td>
<td>kg/Inh/a</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Amount of waste collected annual average</td>
<td>tons/day</td>
<td>1,000</td>
<td>1,110</td>
<td>1,670</td>
</tr>
<tr>
<td>Peak in July (+20%)</td>
<td>tons/day</td>
<td>1,200</td>
<td>1,330</td>
<td>2,000</td>
</tr>
<tr>
<td>Directly to landfill</td>
<td>%</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Transfer via Beliashvili</td>
<td>%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>Transfer via new transfer station</td>
<td>%</td>
<td>34%</td>
<td>34%</td>
<td>34%</td>
</tr>
</tbody>
</table>

### Daily waste average

<table>
<thead>
<tr>
<th>Description</th>
<th>Current Status</th>
<th>Short Term Scenario: Medium</th>
<th>Long Term Scenario: Medium; no separation</th>
<th>Long Term Scenario: Medium; seperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directly to landfill</td>
<td>tons/day</td>
<td>300</td>
<td>330</td>
<td>500</td>
</tr>
<tr>
<td>Transfer via Beliashvili</td>
<td>tons/day</td>
<td>700</td>
<td>780</td>
<td>1170</td>
</tr>
<tr>
<td>Transfer via new transfer station</td>
<td>tons/day</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Peak in July</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directly to landfill</td>
<td>tons/day</td>
<td>360</td>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>Transfer via Beliashvili</td>
<td>tons/day</td>
<td>840</td>
<td>930</td>
<td>1400</td>
</tr>
<tr>
<td>Transfer via new transfer station</td>
<td>tons/day</td>
<td>0</td>
<td>0</td>
<td>450</td>
</tr>
</tbody>
</table>

### Table 4-15: Estimated amount of waste to be transferred according to current and future population estimations
Figure 4-23 Potential operation zones with two transfer stations
4.4.3 Variants Transfer Station: Vehicle capacity and operation hours

With the above estimated total waste amounts expected to be transferred, number and type of vehicles (loading capacity) necessary can be estimated.

For this, the following base assumptions were made:

<table>
<thead>
<tr>
<th>Transfer Station</th>
<th>Variant 0 (values as in 2016)</th>
<th>Variant 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beliashvili</td>
<td>Beliashvili</td>
</tr>
<tr>
<td>Amount of waste per trip</td>
<td>8.8 tons</td>
<td>10; 12 and 13.5 tons (Sub-variants for different vehicle capacities)</td>
</tr>
<tr>
<td>Length of round trip</td>
<td>65 km</td>
<td>65 km</td>
</tr>
<tr>
<td>Duration per trip</td>
<td>2.8 h</td>
<td>2.5 h (increased operation efficiency)</td>
</tr>
<tr>
<td>Operation hours per vehicle and day</td>
<td>13.5 h/d</td>
<td>15 h/d (2 shifts á 7.5h transfer-transport)</td>
</tr>
</tbody>
</table>

Table 4-16: Basis assumptions for transfer vehicle assessment

Note: As waste amount collected in summer period is higher than in winter period (for details refer to Baseline Study) shift duration during these two seasons could also vary, e.g. 8.5 h shifts in summer and compensatory 7.5 shifts in winter.

As a result of the above initial data described, the table below shows the estimated
- amount of collection vehicles needed for waste transfer for each variant
- number of trips per day in summer (peak waste collection)
- total operation hours per day depending on duration of shift

Note: Variant 1 takes into account to utilize current vehicles for transfer (up to 10 tons capacity) in operation in Beliashvili also in 2020. Therefore it is estimated that in 2020 in Beliashvili only vehicles with a capacity 10 tons/trip capacity are in operation.
### Operation District II New Transferstation: Number of Transfer vehicles for operation on peak days

<table>
<thead>
<tr>
<th></th>
<th>Variant 0</th>
<th>Variant 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of round-trip</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Waste amount transported per trip tons</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Duration of trip h</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Trips per day in summer</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Operation hours for transfer-transport h/day</td>
<td>100</td>
<td>140</td>
</tr>
<tr>
<td>Required vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 shifts á 7.5h transfer-transport Nº of vehicles</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>2 shifts á 8.5h transfer-transport Nº of vehicles</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Waste amount transported per trip tons</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Duration of trip h</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Trips per day in summer</td>
<td>38</td>
<td>57</td>
</tr>
<tr>
<td>Operation hours for transfer-transport h/day</td>
<td>76</td>
<td>114</td>
</tr>
<tr>
<td>Required vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 shifts á 7.5h transfer-transport Nº of vehicles</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>2 shifts á 8.5h transfer-transport Nº of vehicles</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Waste amount transported per trip tons</td>
<td>13.5</td>
<td>13.5</td>
</tr>
<tr>
<td>Duration of trip h</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Trips per day in summer</td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>Operation hours for transfer-transport h/day</td>
<td>66</td>
<td>100</td>
</tr>
<tr>
<td>Required vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 shifts á 7.5h transfer-transport Nº of vehicles</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>2 shifts á 8.5h transfer-transport Nº of vehicles</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4-17: Estimation of transfer vehicles necessary, depending of capacity of vehicle and daily operation hours per vehicle
The table below gives an summary overview of the vehicles estimated to be necessary for future waste transfer.

- Variant 0 shows the need of 34 transfer vehicles with maintaining current operations.
- Within Variant 1, with longer summer shifts (8.5 h/d) and transition to vehicles with higher capacity (13.5 tons/trip) approx. 18 vehicles would be necessary in total.

In general, Variant 1 shows a need of 18 – 27 transfer vehicles, depending on loading capacity of transfer vehicle and duration of operation hours per day.

<table>
<thead>
<tr>
<th></th>
<th>Variant 0</th>
<th>Variant 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total amount of required transfer vehicles with retaining current operation practice</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currently ~ 13.5/h d operation per vehicle</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total amount of required transfer vehicles with 7.5h operation shift in summer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both transfer stations with 10 tons/trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both transfer stations with 12 tons/trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both transfer stations with 13.5 tons/trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total amount of required transfer vehicles with 8.5h operation shift in summer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both transfer stations with 10 tons/trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both transfer stations with 12 tons/trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both transfer stations with 13.5 tons/trip</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: For every transfer station and every sub variant one (1) stand-by vehicle was included per transfer station

Table 4-18: Summary of estimation of transfer vehicles necessary

Several further indicators were estimated, showing the most crucial benefits in change of operation practice (refer to table below).

With change from current practice of Variant 0 to Variant 1 with vehicles with 13.5 tons capacity and source separation, in 2030

- daily mileage for waste transfer could potentially be reduced by approx. 3,300 km/day (approx. -38%),
- mileage per ton transported would be reduced by 3.2 km/ton (approx. -43%) and
- total operation hours of vehicles by approx. 160 h/d (approx. -43%).
### 4.4.4 Variants Transfer Station: Waste Discharge bays

With the findings of the Baseline Study as well as with the results of the estimated increasing waste amounts to be collected it will be necessary to not only invest in an additional transfer station but also in increasing the capacity of both transfer stations until 2030, refer to table below.

Within Variant 0, the total amount of waste per discharge bay will increase up to 700 tons/day.

To reduce stress of waste discharge it is recommended within Variant 1 to increase the number of discharge bays in two stages:

- **Beliashvili Transfer Station:**
  - 2020: 3 Discharge Bays (+1 compared to 2016)
  - 2030: 4 Discharge Bays (+2 compared to 2016)

- **New Transfer Station**
  - 2020: 2 Discharge Bays (+2 compared to 2016)
  - 2030: 3 Discharge Bays (+3 compared to 2016)

### Table 4-20: Estimation of number of waste discharge bays necessary

<table>
<thead>
<tr>
<th></th>
<th>Variant 0</th>
<th>Variant 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
<td>2020</td>
</tr>
<tr>
<td><strong>Operation District II Beliashvili on peak days in July</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of waste discharge bays</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Waste in tons per discharge bay and day</td>
<td>420</td>
<td>470</td>
</tr>
<tr>
<td><strong>Operation District III New Transfer Station on peak day in July</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of waste discharge bays</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Waste in tons per discharge bay and day</td>
<td>230</td>
<td>230</td>
</tr>
</tbody>
</table>

$^{11}$: Scenario with separation of waste (see above)
The additional discharge bays also allow handling incoming waste collection vehicles more quickly, thus reducing the period of inactivity of waste collection vehicles significantly.

With an estimated average discharge time per collection truck of 10 min, approx. 6 trucks can be handled per operation bay and hour.

<table>
<thead>
<tr>
<th></th>
<th>Variant 0</th>
<th>Variant 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of bays</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Total N° of collection trucks per hour</td>
<td>12</td>
<td>42</td>
</tr>
</tbody>
</table>

Table 4-21: Transfer Station – number of transfer bays

This would allow a smooth operation of transfer stations also during “rush-hour” when multiple waste collection vehicles arrive at the transfer station.

Details on operation of the upgraded Beliashvili Transfer Station can be found in 4.6.4.2.

4.5 **RECOMMENDED OUTLINES FOR LONG-TERM SWM CONCEPT (2030)**

4.5.1 **General**

After having assessed and analysed the current situation the following conclusions and recommendations can be given as an outline for definition of a detailed SWM strategy:

- Contracting of operators for waste treatment and recycling only based on careful preparation and negotiation of reliable contract conditions – only technologies which provide evidence at large municipal scale should be applied.

- In the short term (5 years until 2021) landfill tipping is considered as the major disposal option.

- Pilot projects and testing measures in waste utilization should be well studied by City / TSG, and only at full operator’s risk and costs without any obligations for the City.

- The mid-term implementation of waste utilization in Waste-to-Energy plants (Variant C.2) has to be considered as the most realistic, reliable and well proven option for large cities worldwide – therefore also applicable for Tbilisi.

- It could be considered to start with first stage of an MBT plant based on Variant C.1 with sorting and probably a second stage with extraction of a “thermal fraction” with the option to sell this fraction to cement industry.

- In general Variant C has to be analysed in detail and a full size feasibility study focussing on waste treatment by combustion or MBT should be elaborated. Especially the commercial potentials for marketing thermal fraction or sales of energy outputs should be carefully evaluated.

- The landfill operations have to be optimized and improved in short term according to basic standards (EU-Landfill Directive). Major focus – apart from routine landfill operation tasks – shall be given on:
  - extension areas with full functioning baseline system
  - step by step closure of landfill sections with cover, recirculation wells and gas collection system
- functioning leachate collection,
- recirculation of leachate in those volumes which are supporting the biological degradation process
- functioning treatment of the excess leachate, as a result of the collection and recirculation process
- gas collection and treatment with the option of energy re-use, dependent on the methane gas generation.

- The waste collection system is recommended to be upgraded in phases – short term goals: improvement of truck fleet and optimized usage, additional transfer station; mid term goals: more container volume, less visible containers, extended disposal intervals
- Institutional rearrangement of the interface with the customers recommended in the mid term – switch from public containers into provision of containers to customers at a lease base

4.5.1.1 Waste Collection
The following measures /activities are being recommended towards a step by step implementation of a lease bin system combined with public collection points for recyclables (Variant 2):
- Legal review, organization review, technical review of truck fleet and waste bins and conceptual technical design
- Conceptual design of activities (legal and organization changes, adjustments in truck fleet and bins, customer relation measures)
- Decision by City Administration
- Elaboration of an action plan for implementation (5 years)
- Procurement of bins and upgrade of vehicles (recommendable: one tender, which is distributed in annual lots over 5 years)

4.5.1.2 Source Separation
Source separation should be inherent part of every modern solid waste management strategy. Separation at the source of waste generation is considered as a first step into the direction of source separation. The collection variant 2 – residual waste bins at customer premises and recyclables collection points at public yards – is activating this possibility and facilitates the further handling of recyclables.

*Note: The detailed classification / customers instruction which components might be disposed off in the residual waste bin or has to be disposed at recycling points has to made by every city / waste management enterprise itself taking into account legal directives, capability of the available waste treatment facilities and options for selling of recyclables.*

A more difficult situation is being generated by products of modern consumer society which contain a vast array of materials and substances which can cause serious damage to the environment if handled carelessly. Examples of such substances are inter alia all substances with chemical contents which might pollute groundwater such as lubricating oils, fuels and other liquid chemicals or all products which high contain heavy metals, such as batteries. Note: One litre of mineral oil has the potential to make a volume one million litre of water non drinkable.
PROPER DISPOSAL OF WASTE means ensuring that environmentally hazardous substances are systematically “taken out of circulation” and are subjected to proper separate collection and separate treatment.

For these reasons, the potential pollutants (e.g. halogenated organic compounds or toxic inorganic compounds and metals) contained in everyday commodities (from video tapes, CDs, DVDs, batteries, screens, fluorescent light tubes to motor vehicles) must be collected and converted, destroyed, or concentrated and further processed through targeted waste treatment to allow for environmentally sound landfill of residues in a chemically innocuous form (i.e. less reactive, e.g. insoluble in water, incombustible).

Therefore all considered variants for waste treatment have considered these aspects either by separation of recyclables and products with harmful compounds before the major treatment process or by design of the treatment process with the focus on generation of a residual product which creates a low or no negative impact on the environment and can be tipped at landfills.

4.5.1.3 Waste Transport

The evaluation of the current collection and transport system in Tbilisi has given the result that two transfer stations (instead of one station) will provide further optimization of the transport kilometres used per ton of waste.

Transfer stations have to be designed based on following criteria:

Location: Distance to service area for where waste is being delivered
- Short access to superordinate road network
- Residential areas should be in a certain distance, therefore old industry locations should be preferred
- Sufficient unloading capacity to cover peak delivery periods (waiting zone and number of loading boxes
- Provision of sufficient intermediate storage capacity
- Other functions for the locations to be considered (offices, garage, truck washing area

Technology: Choice of transport container system with quick loading and unloading features
- Loading boxes furnished with devices for optimized filling and load control
- No open waste tipping allowed – waste unloading shall take place directly in transport containers
- Intermediate storage of containers in order to compensate peak loads at intake side (collection) and facilitate transfer at convenient times (e.g. avoiding traffic rush hours, synchronize with landfill operation).

Environment: Surrounding area should be as less as possible affected (see above selection of site), major affection by noise, dust and odour
- Reduction of dust and odour emissions, no open waste tipping for intermediate storage
- Noise reduction: operating instructions for truck drivers (“stop engine when waiting”), restriction of operating hours for waste delivery and transport during certain night hours
Taking into account these conditions it can be stated that the location of the current transfer station in Beliashvili is suitable but needs to be refurbished / modernized in order to assure optimized and environmentally sound operations.

The location of the second station is not yet defined but shall be located somewhere in the Southwest of the city. This will enable more efficient waste collection in the service areas and optimized transport to the landfill. It will also support the intention of TSG to close the operation yard Graneli (due to deteriorated infrastructure) and to remove the facilities to the new transfer station which will have then also the function of an operation yard.

The measures are considered as required in the short term and are therefore part of the Investment Proposal. It will be recommended to set up following activities:

- Site assessment and selection of site for second transfer station
- Detailed design of upgrade of current transfer station Beliashvili
- Detailed design of new transfer station for southwest area of city (including facilities dislocated from operation yard Graneli)
- Procurement
- Construction works and installation works
- Operation start

4.5.1.4 Waste Treatment and Disposal

The current negotiations of the City / TSG with an interested supplier (KDV Georgia) emphasize a technology which foresees the transformation of the collected waste into diesel and selling of this product at the national and international fuel market. Comments on this approach have been given in other sections of this report as well as in the Baseline Report and are not anymore discussed in this section.

Due to the high risk of failure in the implementation of this technology the Consultant has decided to include in this section an exit scenario based on currently common international approach for urban agglomerations similar to Tbilisi is being presented. This approach can be implemented by the City / TSG at any time in case of failure of the KDV project.

Brief description of exit scenario: Waste treatment and disposal by use of common urban waste treatment technologies and disposal concepts.

It shall be foreseen that in the mid-term approach (10 years, 2025) the City of Tbilisi shall anyhow receive a comprehensive and sustainable waste treatment solution which is widely independent from market fluctuations and enables widely reduced waste tipping at the landfill in the amount of max. 30 % of the waste generation (by weight). Only waste without hazardous components and low potential to create leachate and landfill gas similar to EU legislation shall be allowed for tipping. The tipping volume will be used by residual products from waste treatment (such as ashes and slags from combustion plants, inert waste or mineral waste with low content of organic carbons). The future treatment plant shall assure a combination of separation of recyclables which can be sold at the national and international recycling market.

As it has been presented in the previous section two major technology streams can be taken in consideration:

**Mechanical biological treatment plants with focus on separation of different fractions and several treatment processes for each fraction (Variant C.1).**

Major components are:
Separation of recyclables and hazardous components by technical means. Sometimes manual sorting is still being applied, however not anymore for household waste but for waste from commerce or from public recyclables collection points.

Separation of a thermal fraction with high heating value (which could be provided / sold to district heating plants, or other plants using combustion technologies, such as cement industry)

Biological treatment of residual organic fraction

Disposal of residual components at an ecological landfill according to EU standards

Waste treatment with focus on Waste-to-Energy by use of combustion technologies and energy re-use (according to Variant C.2)

Major components are:

- Pre treatment of waste (sorting of visible hazardous components, drying of waste in case of huge unsorted household waste volumes)
- Intermediate storage for continuous operation of the combustion stage
- Major combustion stage
- Exhaust treatment according to the applicable standards for air emissions
- Energy re-use stage
- Treatment of residuals from the incineration process (conditioning of ashes, extraction of ferrous and non-ferrous metals\(^9\))
- Disposal of residual components at an ecological landfill according to EU standards

Without making a depth detailed evaluation of both technology options and accompanying environmental and cost benefit analysis a justified recommendation cannot be done within this study.

Typically following sequenced preparatory and implementation approach could be applied with the aim to have a full function solution in the mid-term horizon (2025).

- Detailed variant analysis for waste treatment based on common used urban technologies (such document is still mission for Tbilisi) including selection of best option taking into account legal, technical, commercial and environmental aspects
- Decision by the City for specific mid-term integrated waste treatment option
- Site assessment study for selection of most suitable location
- General design and Environmental Impact Assessment
- Obtained of permits / approvals and public participation process
- International tendering typically based on DBOT model
- Implementation
- Operation start.

\(^9\) the extraction of non-ferrous metals out of slags from incineration process is getting more and more commercially interesting in Europe due to certain demand and therefore currently good prices at the international market for such products.
4.5.1.5 Operation Documentation

The organization of efficient waste management systems with high level of service and at reasonable costs requires a comprehensive set of documentation tools which enable at any time operation data provision for dynamic planning of day-to-day operations and proactive maintenance and investment planning.

Following components are considered as crucial for modern SWM operations:

- Route planning system
- Container register
- Truck monitoring system
- Truck fleet register including maintenance and repair records
- Weighbridge data and container documentation system at transfer station
- Weighbridge data at landfill
- Tipping site documentation (registered tipping volumes by periodic topographic surveys)
- Operation documentation of gas collection, gas treatment and leachate collection, treatment facilities
- Environmental database (gas, leachate)
- Customer complaints database (important for monitoring and adjustment of day-to-day operations)

All components should be operated on digital base with interlinks to the standard MIS of the company.

4.5.2 Institutional Long-Term Concept – Considerations

In the long-term approach it is recommended to consider following general outlines:

1. The current organization structure as city-owned public enterprise can be kept in general, provided that
   - efficient performance control structures are being applied at city level
   - the Company receives detailed annual performance targets to be applied
   - the Company receives certain independence in budget planning
   - other services not related to waste have to be kept strictly separated from waste management services

2. Outsourcing of all operations which require special technological knowledge, such as operation of gas treatment and leachate treatment plants shall be considered as an efficient method instead of expensive upgrade of staff qualifications or – in worst case – inferior operation of technological facilities with commercial damage for the Company as a consequence.

3. Waste utilization as described in previous sections of this report shall be considered anyhow under the frame of DBOT and / or concession models for construction and operations of SW Utilization Plants.

4. The internal monitoring and control systems shall be upgraded to standards as applied in the private sector. Basic principles shall be proactive management of resources and provision of staff, equipment in order to provide efficient services under achievement of high level service standards.
5. **Internal training and qualification programs:** it shall be kept in mind that SWM services require a huge number of low qualified staff and – in relation to that – a small number of qualified staff and experts. Anyhow, also the low qualified staff has to apply to basic standards in technical operations and especially environmental, hygienic and safety standards. This requires continuous monitoring, control and periodic internal trainings which have to be organized by the company.

6. Furthermore **external trainings** have to be organized and coordinated for special kinds of services such as repair and maintenance of facilities, standards in landfill operations, commercial management tools.

### 4.5.3 Recommended timing of packages

The following table shows a tentative timing for the list of short-, mid-, long-term measures addressing on development needs in the SWM system of Tbilisi.

Please note that this list and timing is tentative only and probably needs to be adjusted based on adjustment of the strategy as it has been proposed in previous sections.

<table>
<thead>
<tr>
<th>Waste Collection</th>
<th>Short-term Phase</th>
<th>Mid-term Phase</th>
<th>Long-term Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upgrade of truck fleet - short-term without system change</td>
<td>2021-2022</td>
<td>2023-2024</td>
<td>2025-2026</td>
</tr>
<tr>
<td>Change of Waste collection into lease bin systems for residual waste and PQR. incoming pixels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation/organization review, technical review of truck fleet and waste bins and demonstration/review design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical stage of studies legal and organization changes, adjustments in truck fleet and bins, customer relation resources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tender to City administration</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of a tender for implementation (1 year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement of trucks and upgrade of vehicle fleet (recommendable: one tender which is distributed in annual line over 5 years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lease be considered (fully implemented)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrade of truck fleet for operation of 2 transfer stations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site assessment and selection of site for current transfer stations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detailed design of upgradation of current transfer stations Badabani</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detailed Plans of new transfer station for southwestern area of Tbilisi including facilities dedicated from operations and training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction works and installation Works</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation start with a trainer stand</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Recycling and Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detailed analysis of pilot for waste treatment based on common advanced technologies (this document is still mission for Tbilisi) including collection of cost-benefit analysis into account legal, technical, commercial and environmental aspects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision by City for specific mid-term integrated waste treatment option</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site assessment for selection of most suitable location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detailed design and investigation for pilot implementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtaining of permits/appraisal and public participation process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>International Tendering based on BOC model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation Start</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Disposal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrade of landfill infrastructure - leachate recirculation and treatment of aerobic leachate</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Gas collection and treatment for section 1</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas collection and treatment for section 2</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Extension of landfill section 3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Further closure of compartments and extensions</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4.5.4 Benefits and opportunities of the recommended long-term concept

In the long-term this list of measures will support the City in achieving modern SWM management practice which will provide waste disposal services at high service quality, reliability and at reasonable tariffs which can be afforded by the population and commercial sector.

Therefore it is recommended that most of the measures are being implemented in a multi-year approach in order to achieve the goals without creating huge commercial burdens for the City which cannot be covered by tariff revenues.
Special opportunities are being created by the following effects:

In the short-term (until 2020):

- Stabilization of operations and increase of operation efficiency in waste collection and transport (reduction of truck km per ton collected waste, reduction of fuel per ton collected waste)
- Upgrade of the landfill infrastructure towards EU-standards, especially in respect to leachate and landfill gas management
- Assuring landfill extension according to the short term disposal needs

In the mid-term (until 2025):

- substantial optimization of the waste collection system by switch from street containers to lease bins for the customers (to be stored at their premises) which will lead to further optimization of the operation costs
- establishment of a sustainable solution for waste recycling and waste to energy by use of common technologies and experience from other urban cities worldwide
- substantial reduction of waste tipping at landfill, therefore lower costs for extension and closure, and after care measures

In the long-term (until 2030) the upgrade system will be operated and most probably further adopted in certain aspects which are determined by following factors:

- Legal situation, directives for SWM
- Socio-economic situation which might restrict tariff increases and – as a consequence - further investments in modern technologies
- Level of salaries and social standards for employees working in the SWM sector
- Costs for operation material (mainly fuel for trucks)
- Global and national market situation in recycling products and sales of energy

### 4.5.5 Outlines for Operational Benchmarks until 2030

The following table includes a listing of performance indicators which might be used for description of the performance of the system and its positive or negative developments in the respective time period.

<table>
<thead>
<tr>
<th>Main Development Indicators</th>
<th>Unit</th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Area</td>
<td>%</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>km²</td>
<td>502</td>
<td>502</td>
<td>502</td>
</tr>
<tr>
<td>Covered Population</td>
<td>%</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Inh.</td>
<td>1,113,000</td>
<td>1,145,000</td>
<td>1,210,000</td>
</tr>
<tr>
<td>Amount of solid waste collected (medium scenario)</td>
<td>tons/year</td>
<td>360,000</td>
<td>420,000</td>
<td>610,000</td>
</tr>
<tr>
<td>Amount of waste collected by TSG</td>
<td>%</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Waste Collection / Waste Generation ratio</td>
<td>%</td>
<td>75</td>
<td>80</td>
<td>95</td>
</tr>
<tr>
<td>Waste Collection Indicators</td>
<td></td>
<td>2016</td>
<td>2021</td>
<td>2030</td>
</tr>
<tr>
<td>Source separation in place</td>
<td>%</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>5</td>
<td>70</td>
</tr>
</tbody>
</table>
## Main Development Indicators

<table>
<thead>
<tr>
<th>Type of residual waste collection on household level</th>
<th>Unit</th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public collection points for unsorted waste</td>
<td>%</td>
<td>100</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Lease bin for residual waste + public recycling points</td>
<td>%</td>
<td>0</td>
<td>75</td>
<td>100</td>
</tr>
</tbody>
</table>

## Disposal interval per container on household level

| Public collection points for unsorted waste | -    | 1 - 4 times/day | 1 - 4 times/day | -    |
| Lease bin for residual waste + public recycling points for recycling waste and green waste | -    | -              | once per week   | once per two weeks |

| Total container volume per inhabitant available | l/Inh | 12.5 | 70 - 90 | 100 - 150 |
| Emptied container volume per inhabitant per day | l/Inh/day | 18.0 |
| Produced amount of waste (peak month July) | kg/Inh | 0.9  | 1.0    | 1.4    |
| Produced amount of waste (peak month July) | l/Inh | 7    | 8      | 11     |

## Waste collection routes development

| Waste collection routes development | - | manually supported | software supported |
| Details see comment below |

## Waste Transport Indicators

<table>
<thead>
<tr>
<th>Waste collection vehicles</th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downtime of Waste Collection Vehicles</td>
<td>%</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>System collection with compaction vehicles</td>
<td>%</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>Bell System Collection</td>
<td>%</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Documentation coverage of collected waste per collection vehicle (tons/trip)</td>
<td>%</td>
<td>30 via weighbridge at landfill</td>
<td>100 via weighbridge at landfill and transfer stations</td>
</tr>
<tr>
<td>Driven km per collection vehicle per ton of waste collected</td>
<td>km/ton</td>
<td>13.6</td>
<td>12.2 (-10%)&lt;sup&gt;10&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vehicle operation hour per ton collected</td>
<td>h/ton</td>
<td>1.3</td>
<td>1.2 (-10%)</td>
</tr>
<tr>
<td>Litre of fuel consumed per ton collected</td>
<td>l fuel/ton</td>
<td>4.8</td>
<td>4.3 (-10%)</td>
</tr>
<tr>
<td>Collected amount of waste per trip</td>
<td>tons/trip</td>
<td>3.3</td>
<td>4.0 (+20%)</td>
</tr>
</tbody>
</table>

## Waste transfer vehicles

<table>
<thead>
<tr>
<th>Waste transfer vehicles</th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation coverage of collected waste per transfer vehicle (tons/trip)</td>
<td>%</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Driven km per collection vehicle per ton of waste collected</td>
<td>km/ton</td>
<td>7.3</td>
<td>5.7 (-20%)&lt;sup&gt;10&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>10</sup> Percentages in brackets related to base year 2015.
<table>
<thead>
<tr>
<th>Main Development Indicators</th>
<th>Unit</th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle operation hour per ton collected</td>
<td>h/ton</td>
<td>0.3</td>
<td>0.25 (-20%)</td>
<td>0.23 (-25%)</td>
</tr>
<tr>
<td>Litre of fuel consumed per ton collected</td>
<td>l fuel/ton</td>
<td>3.2</td>
<td>2.6 (-20%)</td>
<td>2.1 (-35%)</td>
</tr>
<tr>
<td>Collected amount of waste per trip</td>
<td>tons/trip</td>
<td>9.1</td>
<td>10.0 (+10%)</td>
<td>12.0 (+30%)</td>
</tr>
</tbody>
</table>

**Waste transport routes to landfill**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection vehicle directly to landfill %</td>
<td></td>
<td>30</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Via transfer station Beliashvili %</td>
<td></td>
<td>70</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>Via new transfer station %</td>
<td></td>
<td>0</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

**Transfer Station Indicators**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of transfer stations No.</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total number of unloading bays at transfer stations No.</td>
<td></td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Transfer vehicles in operation No.</td>
<td></td>
<td>20</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Transfer vehicles with max. capacity of 32 m³ (approx. 11 tons loading capacity) No.</td>
<td></td>
<td>18</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Transfer vehicles with max. capacity of 38 m³ (approx. 13 tons loading capacity) No.</td>
<td></td>
<td>2</td>
<td>10</td>
<td>25</td>
</tr>
</tbody>
</table>

**Waste Separation and Treatment Indicators**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source separation in place -</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td>Type recommended separation container</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste treatment in place -</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td>Type recommended waste incineration plant</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Landfill Indicators**

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2021</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposal at landfill amount of waste disposed at landfill %</td>
<td>100</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>type of waste disposed residual waste residual waste slag from incineration process</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sealing**

| Percentage of new tipping sections with combined base sealing (mineral / HDPE) | % | 100 | 100 | 100 |

**Gas collection and treatment**

| Percentage of closed sections with gas collection and treatment | 0 | 100 | Depending on waste treatment solution |

**Leachate collection, circulation and treatment**

| Widely not functioning | System full in function | System full in function | |

**NOTE on routing:** Without detailed knowledge on the current routing information, development of target values for routing is not possible in a reliable way.
In general the following should be reconsidered concerning optimization of current routing:

The current number of routes and the collection trips within such a route should be reconsidered. Every collection route should be performed in such way, that the collection vehicle is close to its maximum loading capacity. Trips ending after 80% of route which makes a second trip necessary should be avoided in order to increase the collection efficiency.

Details on current routing issues are described in detail in State Audit Office of Georgia “Performance Audit of Municipal Solid Waste Management”, 2015 (www.sao.ge/en/audit/), in section 3 Logistics of Solid Waste Management.

4.5.6 Short-term investment considerations – long list

The following investment packages are to be seen as a result of the assessment phase and consultations with the Client. The packages are indicative and defined in a very general approach and based on the outlines for the SWM strategy as described in 4.4.1 - 4.4.5.

4.5.6.1 Waste Collection

<table>
<thead>
<tr>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground container points in special urban zones</td>
<td>Provision of underground containers including hydraulic system for lifting the container</td>
</tr>
<tr>
<td>Replacement of old containers</td>
<td>Current containers in most of the cases without functioning lids</td>
</tr>
<tr>
<td></td>
<td>Modern container types with automatic closing lid</td>
</tr>
<tr>
<td>Procurement of additional containers</td>
<td>Provision of modern container types with wheels and lids (automatic closure)</td>
</tr>
</tbody>
</table>

Table 4-22 Waste Collection – Investment Outlines

<table>
<thead>
<tr>
<th>Package</th>
<th>Goals to be achieved</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground Container Points in special urban zones</td>
<td>Underground containers with comfortable conditions for waste disposal for population (dust, odour)</td>
<td>Improvement of disposal. Less impact on the vicinity area (odour, dust)</td>
</tr>
<tr>
<td></td>
<td>Reduction of impacts on vicinity (dust, odour)</td>
<td></td>
</tr>
<tr>
<td>Replacement of old containers</td>
<td>Improved containers, less impact on vicinity</td>
<td>Improvement of disposal. Less impact on the vicinity area (odour, dust)</td>
</tr>
<tr>
<td>Procurement of additional containers</td>
<td>Extension of disposal intervals enabled</td>
<td>Optimized disposal, cost for collection could be optimized</td>
</tr>
</tbody>
</table>

Table 4-23 Waste Collection – Investment Goals and Justification
4.5.6.2 Waste Transportation

<table>
<thead>
<tr>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upgrade of truck fleet, replacement of old and repair-intensive trucks</td>
<td>Replacement of old and repair intensive trucks, procurement of optimized truck types suitable for the specific waste collection conditions</td>
</tr>
<tr>
<td>Upgrade of existing transfer station</td>
<td>Refurbishment of site Beliashvili – civil structures, roads and buildings. Installation of modern automatic loading equipment and sufficient number of containers, capacity up to 250,000 ton per year</td>
</tr>
<tr>
<td>Construction of 2nd transfer station</td>
<td>Installation of second transfer station in order to optimize transport to landfill, capacity up to 250,000 tons per year</td>
</tr>
</tbody>
</table>

Table 4-24 Waste transportation – investment outlines

<table>
<thead>
<tr>
<th>Package</th>
<th>Goals to be achieved</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upgrade of truck fleet, replacement of old and repair-intensive trucks</td>
<td>Optimized usage of truck fleet, less operation expenses</td>
<td>Truck fleet analysis shows demand in improvement</td>
</tr>
<tr>
<td>Upgrade of existing transfer station</td>
<td>Improvement of current station. Optimized loading times, less operation expenses for transport</td>
<td>Analysis shows demand in optimization of transport, decrease of km/ton of collected waste can be achieved by modernized station</td>
</tr>
<tr>
<td>Construction of 2nd transfer station</td>
<td>Optimized waste collection and transport to landfill. Currently 30% of transport directly to landfill</td>
<td>Analysis shows demand in optimization of transport, further decrease of km/ton of collected waste can be achieved by additional station</td>
</tr>
</tbody>
</table>

Table 4-25 Waste Transportation – Investment goals and justification

4.5.6.3 Waste Treatment

Investment options are not considered in detail within the short term horizon. As it is presented in the SWM strategy and having in mind the long preparatory period of such investments it is strongly recommended to start within short term substantial preparations in order to achieve a sustainable treatment solution in the mid-term (refer to section 4.4.3.).

4.5.6.4 Waste Disposal

The required investments for the landfill Didi Lilo have been identified for the short term horizon as follows:

<table>
<thead>
<tr>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization of Design</td>
<td>Optimization of landfill configuration according to international standards</td>
</tr>
<tr>
<td>Construction of new compartment</td>
<td>Construction based on optimized design</td>
</tr>
<tr>
<td>Package</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Rehabilitation of leachate system</td>
<td>Installation of recirculation equipment and necessary pipes, chambers</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation of leachate treatment plant</td>
</tr>
<tr>
<td>Installation of landfill gas system</td>
<td>Installation of a horizontal gas collection system in the covered compartment and in the currently operated compartment</td>
</tr>
<tr>
<td></td>
<td>Gas flaring station</td>
</tr>
<tr>
<td>Additional operating equipment</td>
<td>CCTV for control of pipelines, flushing equipment, gas warning equipment, gas detection equipment (FID)</td>
</tr>
</tbody>
</table>

Table 4-26 Landfill Didi Lilo – investment outline

<table>
<thead>
<tr>
<th>Package</th>
<th>Goals to be achieved</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization of design</td>
<td>Design and construction of landfill according to international standards, adapted to local conditions</td>
<td>Sustainable operation and reduction of maintenance costs, Increased total volume</td>
</tr>
<tr>
<td>Construction of new compartment</td>
<td>Provision of conditions for optimal operation and monitoring of the landfill in the future</td>
<td>Protection of the environment, Controlled degradation of deposited waste</td>
</tr>
<tr>
<td>Rehabilitation of leachate system</td>
<td>Controlled and optimized recirculation</td>
<td>Reduction of maintenance and costs, Reliable leachate treatment as needed</td>
</tr>
<tr>
<td></td>
<td>Provision of leachate treatment capability</td>
<td></td>
</tr>
<tr>
<td>Installation of landfill gas system</td>
<td>Reduction of emissions, including odour</td>
<td>Protection of the environment, Odour – nuisance, one cause of non-acceptance</td>
</tr>
<tr>
<td>Additional operating equipment</td>
<td>Protection of operators and the environment, improved operations</td>
<td>Better maintenance and monitoring save costs in the long run</td>
</tr>
</tbody>
</table>

Table 4-27 Landfill Didi Lilo – Investment goals and justification

The possible investments for the construction waste and excavation material disposal site Gldani have been identified as follows:

<table>
<thead>
<tr>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closure of Gldani Site</td>
<td>Completion of measures according to environmental authority</td>
</tr>
<tr>
<td>Construction of new construction waste landfill</td>
<td>Design based on international standards including base lining, weighing bridge, registration, run-off collection and treatment, monitoring</td>
</tr>
<tr>
<td>Installation of a construction materials recycling plant</td>
<td>Equipment to separate, crush, sort etc. construction waste in order to produce re-useable construction material</td>
</tr>
<tr>
<td>Construction of sites for deposit of excavation material</td>
<td>Preparation of sites for the deposit of non-contaminated excavation material, including control at delivery, registration, temporary disposal area for contaminated material (to be</td>
</tr>
</tbody>
</table>
Table 4-28 Construction waste and excavation material disposal – investment outline

<table>
<thead>
<tr>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closure of Glandi Site</td>
<td>Controlled closure after-use control of the site</td>
</tr>
<tr>
<td>Construction of new construction waste landfill</td>
<td>Safe and controlled disposal of construction waste</td>
</tr>
<tr>
<td>Installation of a construction materials recycling plant</td>
<td>Production of recycled construction material, reduction of waste amounts to be deposited</td>
</tr>
<tr>
<td>Construction of sites for deposit of excavation material</td>
<td>Controlled deposit with capability for identifying contaminated material</td>
</tr>
</tbody>
</table>

Table 4-29 Construction waste and excavation material disposal – investment goals and justification

4.6 **OUTLINES OF PROJECT PROPOSAL TO BE FINANCED WITHIN AN EBRD LOAN**

4.6.1 **Prioritized current and short term development needs**

Based on current status of analysis the following draft conclusions on prioritization of investments can be made:

- Investments in two transfer stations (one upgrade, one new construction) are considered as rather important for the efficiency of the waste collection system due to:
  - Daily disposal intervals
  - Operation of small truck types
  - Distance to landfill

- Investments at the current landfill Didi Lilo are considered as required in order to assure future operations according to basic standards (EU-Landfill Directive), gas collection, refurbishment of leachate collection and treatment should be given priority.

- The upgrade of the truck fleet is recommended based on a discerning truck fleet analysis (Annex to Baseline Report) and determination of the collection and transport needs.

- Investments in containers shall be made only after comprehensive reconsideration of the collection strategy – a transformation from public container points to lease container system for customers shall be considered in the mid
term. In the meantime the current container equipment shall be kept in function and place, certain extensions (additional container points) shall be considered in order to reduce collection in areas without containers.

4.6.2 Draft listing for prioritized investments

At the following pages a draft listing of investment packages is included. This listing has been elaborated based on assessment of current situation and exhaustive consultations with the Client.

All figures are to be considered as tentative and might be slightly adjusted after having available further technical details during the design phase.
<table>
<thead>
<tr>
<th>No.</th>
<th>Component</th>
<th>Description</th>
<th>Goals to be achieved</th>
<th>Justification</th>
<th>Amount costs (in EUR)</th>
<th>NPV (€) Commentaries after assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>T3-SW-01</td>
<td>Underground Garbage Points to specified zones</td>
<td>Provision of underground containers with a hydraulic system for lifting the container. Underground containers with comfortable conditions for waste disposal for population. Reduction of impacts on visibility (out of sight).</td>
<td>Underground containers with comfortable conditions for waste disposal for population. Reduction of impacts on visibility (out of sight).</td>
<td>9 - 1 MUSD</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>T4-SW-02</td>
<td>Upgrade of truck fleet, replacement of old and repair intensive tracks</td>
<td>Replacement of old and repair intensive trucks, procurement of optimized truck types suitable for the specific needs collective conditions. Client considers replacement of up to 70 units. Consideration Consultant on priority investments, replacement of those vehicles with remaining lifespan of 1 - 2 years.</td>
<td>Optimized usage of truck fleet, less operation expenses.</td>
<td>13 - 14 MUSD</td>
<td>3 - 4 MUSD</td>
<td></td>
</tr>
<tr>
<td>T4-SW-03</td>
<td>Upgrade of existing transfer station</td>
<td>Rehabilitation of the Hydrotank (oil containers, tanks, and trucks). Installation of modern automatic loading equipment and sufficient number of containers in a capacity up to 23,000 tons per day.</td>
<td>Improvement of transfer station, optimized loading times, and less operation expenses.</td>
<td>1 - 2 MUSD</td>
<td>1 - 2 MUSD</td>
<td></td>
</tr>
<tr>
<td>T3-SW-04</td>
<td>Construction of 2nd transfer station</td>
<td>Installation of second transfer station in order to optimize transfer to landfill, capacity up to 7,140 tons per day.</td>
<td>Optimized loading times, less operation expenses per transport.</td>
<td>2 - 3 MUSD</td>
<td>2 - 3 MUSD</td>
<td></td>
</tr>
<tr>
<td>T3-SW-05</td>
<td>Rehabilitation of leachate system</td>
<td>Installation of reclamation equipment and necessary grates, changes. Rehabilitation of leachate treatment plant.</td>
<td>Controlled and optimized reclamation. Prevention of leachate treatment capacity.</td>
<td>2 - 3 MUSD</td>
<td>4 - 5 MUSD</td>
<td></td>
</tr>
<tr>
<td>T3-SW-06</td>
<td>Construction of new landfill compartments</td>
<td>Construction based on optimized design. Consultants Consideration on Priority Investments: the selection of the future usage of the landfill in terms of annual tipping volume is unclear due to ongoing discussions about recycling.</td>
<td>Design and construction of landfill according to international standards, adapted to local conditions. Prevention of conditions for optimal operation and monitoring of the landfill in the future.</td>
<td>4 - 6 MUSD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>20 - 22 MUSD</td>
<td>0 - 14 MUSD</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-30 Prioritized investments in SWM Tbilisi – first considerations July 2016
4.6.3 Investment Packages – Final Version November 2016

After intensive consultations between the Consultant and the Client during period August to September 2016 the following final list of investment components has been agreed.

This list is proposed to be basis for further negotiations between the City and the EBRD about a loan agreement.

4.6.3.1 General Overview

Please refer to table at next page.
<table>
<thead>
<tr>
<th>No</th>
<th>Component</th>
<th>Description</th>
<th>Goals to be achieved</th>
<th>Justification</th>
<th>PIP (after detailed Consultations between Consultant and TSG) and elaboration of BoQ with Client 16 11 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB-SW-02</td>
<td>Upgrade of truck fleet, replacement of old and repair intensive trucks</td>
<td>replacement of old and repair intensive trucks, procurement of optimized truck types suitable for the specific waste collection conditions</td>
<td>Optimized usage of truck fleet, less operation expenses</td>
<td>Truck fleet analysis shows demand in improvement in General, but the number of trucks (requested to be replaced) has to be critically analysed</td>
<td>5,400,000,00</td>
</tr>
<tr>
<td>TB-SW-03</td>
<td>Upgrade of existing transfer station</td>
<td>Refurbishment of site Bghelashvili — civil structures, roads and buildings; Installation of modern automatic loading equipment and sufficient number of containers, capacity up</td>
<td>Improvement of current station, optimized loading times and less operation expenses</td>
<td>Analysis shows demand in optimization of transport, decrease of km/truck of collected waste can be achieved by modernized station</td>
<td>1,230,000,00</td>
</tr>
<tr>
<td>TB-SW-04</td>
<td>Construction of 2nd transfer station</td>
<td>Installation of second transfer station in order to optimize transport to landfill, capacity up to</td>
<td>Optimized loading times, less operation expenses for transport</td>
<td>Analysis shows demand in optimization of transport, further decrease of km/truck of collected waste can be achieved</td>
<td>2,670,000,00</td>
</tr>
<tr>
<td>TB-SW-05</td>
<td>Rehabilitation of leachate system</td>
<td>Installation of recirculation equipment and necessary pipes, chambers</td>
<td>Controlled and optimized recirculation</td>
<td>Reduction of maintenance and costs, Reliable leachate management and treatment as needed</td>
<td>4,340,000,00</td>
</tr>
<tr>
<td>TB-SW-07</td>
<td>Equipment for landfill operations</td>
<td>Task has been defined after detailed Consultations with Landfill operation staff</td>
<td>Improved landfill operations shall be achieved; Provision of crushed construction waste for establishment of intermediate covers at landfill</td>
<td>Landfill operation staff is currently lacking sufficient equipment</td>
<td>400,000,00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>15,000,000,00</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-31 Project Proposal – final version November 2016 (all figures in USD)
4.6.3.2 Detailed Descriptions

4.6.3.2.1 Upgrade of truck fleet, replacement of old and repair-intensive trucks

General Targets: "Reduction of operation and repair expenses, reduction of fuel consumption"

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit Price [USD]</th>
<th>Total Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply of trucks with hooklift equipment for containers 38 m³</td>
<td>units</td>
<td>8</td>
<td>160,000</td>
<td>1,280,000</td>
</tr>
<tr>
<td>Supply and Installation of loading units for waste collection trucks</td>
<td>pcs</td>
<td>10</td>
<td>20,000</td>
<td>200,000</td>
</tr>
<tr>
<td>7-10 m³ vehicles (for system collection, rear loader with compaction unit), maximum truck length 7.00 m, width 2.10 m</td>
<td>pcs</td>
<td>10</td>
<td>120,000</td>
<td>1,200,000</td>
</tr>
<tr>
<td>13 m³ vehicles (for system collection, rear loader with compaction unit), max width 2.40 m, max length 9.00 m</td>
<td>pcs</td>
<td>16</td>
<td>130,000</td>
<td>2,080,000</td>
</tr>
<tr>
<td>4-5 m³ Vehicles (replacement of certain amount of the small vehicles for street garbage collection)</td>
<td>pcs</td>
<td>14</td>
<td>50,000</td>
<td>700,000</td>
</tr>
<tr>
<td>Contingencies (~5 %)</td>
<td></td>
<td></td>
<td></td>
<td>344,000</td>
</tr>
<tr>
<td><strong>Sub Total Upgrade of Truck Fleet</strong></td>
<td></td>
<td></td>
<td></td>
<td>6,400,000</td>
</tr>
</tbody>
</table>

4.6.3.2.2 Upgrade of existing transfer station

General targets: "Refurbishment of transfer station and surrounding area, acceleration of the unloading process, optimization of the loading of the transfer containers, provision of a transfer container buffer volume"

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit Price [USD]</th>
<th>Total Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refurbishment of asphalt surface in the vicinity of the loading bays</td>
<td>m²</td>
<td>5000</td>
<td>60</td>
<td>300,000</td>
</tr>
<tr>
<td>Existing loading bays - Refurbishment of existing civil structure (reconstruction of concrete structure, construction of roof, adaptation of concrete for installation of electrical equipment and machinery)</td>
<td>LS</td>
<td>1</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Construction of a 3rd loading bay - civil structure including loading ramp, roof structure</td>
<td>LS</td>
<td>1</td>
<td>150,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Installation of loading cranes (for loading and leveling) at loading bays during loading process</td>
<td>pcs</td>
<td>3</td>
<td>25,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Installation of weighing equipment and optic load control unit for each loading bay</td>
<td>pcs</td>
<td>3</td>
<td>8,000</td>
<td>24,000</td>
</tr>
<tr>
<td>Container storage place for up to 15 container places (up to 38 m³) - construction of foundation, tentative dimensions of foundation: 7 x 80 m</td>
<td>LS</td>
<td>1</td>
<td>80,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Container storage place - machinery (metal rails, transport platforms for 15 containers, including hydraulic transmission unit and accessories)</td>
<td>LS</td>
<td>1</td>
<td>180,000</td>
<td>180,000</td>
</tr>
<tr>
<td>Container storage place - operation platforms, roof construction</td>
<td>LS</td>
<td>1</td>
<td>75,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Supply of transfer containers (33 m³ net volume)</td>
<td>pcs</td>
<td>17</td>
<td>5,000</td>
<td>85,000</td>
</tr>
<tr>
<td>Supply of transfer containers (40 m³ net volume)</td>
<td>pcs</td>
<td>10</td>
<td>6,000</td>
<td>60,000</td>
</tr>
</tbody>
</table>
### Description | Unit | Amount | Unit Price [USD] | Total Price [USD]
--- | --- | --- | --- | ---
Supply and construction of weighbridge | unit | 1 | 90,000 | 90,000
Contingencies (~10 %) | | | | 121,000
**Sub total upgrade of existing transfer station** | | | | 1,290,000

#### 4.6.3.2.3 Construction of 2nd transfer station

General Targets: “Reduction of non-productive transfer time for waste collection trucks, acceleration of the unloading process, optimization of the loading of the transfer containers, reduction of transfer trips of waste collection trucks directly to landfill, support in improved operation of Belishvili TS (by reduction of transport traffic there) provision of a transfer container buffer volume”

### Description | Unit | Amount | Unit Price [USD] | Total Price [USD]
--- | --- | --- | --- | ---
Preparation of site infrastructure, electrical supply, water, sewage, telecommunication | LS | 1 | 250,000 | 250,000
Levelling of site, removal of existing structures | m² | 8,000 | 25 | 200,000
Construction of drainage system | LS | 1 | 120,000 | 120,000
Construction of asphalt surface, orientate area size 8000 m² (take over capacity 450 tons / day) including gravel layer for frost protection | m² | 8,000 | 60 | 480,000
Construction of fence | meter | 300 | 75 | 22,500
Entrance door construction | LS | 1 | 30,000 | 30,000
Construction of operation building (base area 200 m²; usable space for offices and sanitary rooms 350 m², 2 floors construction, including sanitary rooms, all house infrastructure installations and furniture) | LS | 1 | 280,000 | 280,000
Construction of garage and workshop 1000 m² | LS | 1 | 150,000 | 150,000
Construction of loading bays - civil structure including loading ramp, roof structure | LS | 2 | 150,000 | 300,000
Installation of loading cranes (for loading and leveling) at loading bays during loading process | pcs | 2 | 25,000 | 50,000
Installation of weighing equipment and optic load control unit for each loading bay | pcs | 2 | 8,000 | 16,000
Container Storage Place for up to 10 container places - Construction of Foundation, tentative dimensions of foundation: 7 x 60 m | LS | 1 | 50,000 | 50,000
Container Storage Place - machinery (metal rails, transport platforms for 10 containers, including hydraulic transmission unit and accessories | LS | 1 | 140,000 | 140,000
Container Storage Place - operation platforms, roof construction | LS | 1 | 50,000 | 50,000
Supply of transfer containers (33 m³ net volume) | pcs | 12 | 5,000 | 60,000
Supply of transfer containers (38 m³ net volume) | pcs | 8 | 6,000 | 48,000
Supply and Construction of weighbridge | unit | 1 | 90,000 | 90,000
Contingencies (~10 %) | | | | 233,500
**Sub total construction 2nd transfer station** | | | | 2,570,000
4.6.3.2.4 Landfill – Rehabilitation of leachate system

4.6.3.2.4.1 Landfill - Construction of recirculation system

General targets: Installation of a stationary system for vertical and horizontal recirculation of leachate into closed landfill section 1 and 2; activation of degradation and methane gas production by controlled irrigation of closed landfill body with maximum 2.5 m³ per hectare and day.

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit Price [USD]</th>
<th>Total Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of recirculation system</td>
<td>unit</td>
<td>40</td>
<td>13,000</td>
<td>520,000</td>
</tr>
<tr>
<td>Construction of recirculation wells in Sections 1 and 2 (at 13.9 hectares in total), assumed up to 3 wells per hectare:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of site (reopening of surface cover) USD 2,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling of vertical well for insertion of leachate (diameter 426 mm) down to maximum 20 m (or minimum distance to base line 5 m) USD 4,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation of filter pipes (diam ~200 mm) and insertion of surrounding gravel pack USD 1,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface shaft DN 800, depth 1.5 m, USD 1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation of inlet pipe, outlets for horizontal and vertical leachate distribution USD 1,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic control unit for time based opening and closure of valves USD 500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinstallation of surface cover USD 2,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction of horizontal recirculation pipes 5 pipes per well, length 30 m, laid in gravel layer</td>
<td>m</td>
<td>6,000</td>
<td>50</td>
<td>300,000</td>
</tr>
<tr>
<td>Recirculation pumping station LS 1</td>
<td></td>
<td>1</td>
<td>25,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Control and distribution chambers unit 5</td>
<td></td>
<td>5</td>
<td>2,500</td>
<td>12,500</td>
</tr>
<tr>
<td>Connecting pipes from pumping station to the wells</td>
<td>m</td>
<td>3,000</td>
<td>50</td>
<td>150,000</td>
</tr>
<tr>
<td>Sub total construction of recirculation system</td>
<td></td>
<td></td>
<td></td>
<td>1,007,500</td>
</tr>
</tbody>
</table>

4.6.3.2.4.2 Landfill - Construction of flushing chambers

General Targets: “The installation of chambers for the periodic flushing of the leachate pipes will support the long term function of the leachate collection at the base of the landfill”

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit Price [USD]</th>
<th>Total Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of flushing chambers at existing wells of section 1 and 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excavation of landfill body at north east edge of landfill</td>
<td>m³</td>
<td>4,000</td>
<td>45</td>
<td>180,000</td>
</tr>
<tr>
<td>Extension of existing leachate drains and Installation of flushing chambers at existing leachate collection pipes of section 1 and 2</td>
<td>units</td>
<td>11</td>
<td>3,500</td>
<td>38,500</td>
</tr>
<tr>
<td>Refilling of waste material</td>
<td>m³</td>
<td>2,000</td>
<td>25</td>
<td>50,000</td>
</tr>
<tr>
<td>Reinstallation of surface cover</td>
<td>m²</td>
<td>250</td>
<td>120</td>
<td>30,000</td>
</tr>
<tr>
<td>Sub total construction installation of flushing chambers at existing wells of section 1 and 2</td>
<td></td>
<td></td>
<td></td>
<td>298,500</td>
</tr>
</tbody>
</table>
4.6.3.2.4.3 Landfill - Construction of leachate storage and treatment plant

General Targets: Provision of sufficient treatment capacity for treatment of excess leachate for further discharge into the facility’s receiving water. Plant capacity will consider also future extension of the landfill. The existing plant will be rehabilitated and extended.

Operation staff will be trained for ensuring proper operation of the plant.

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit Price [USD]</th>
<th>Total Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconstruction of leachate collectors from landfill compartments to leachate storage pond</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrade of leachate storage pond</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension of existing pond to an area of 3,000 m² and operation volume of 6,000 m³</td>
<td>m³</td>
<td>4,500</td>
<td>25</td>
<td>112,500</td>
</tr>
<tr>
<td>Installation of sealing system with connection to current ponds</td>
<td>m²</td>
<td>2,000</td>
<td>65</td>
<td>130,000</td>
</tr>
<tr>
<td>Construction of filter dam section for separation of settling zone from storage zone</td>
<td>m³</td>
<td>250</td>
<td>175</td>
<td>43,750</td>
</tr>
<tr>
<td>Construction of inlet and outlet structure (to recirculation pumping chamber and to Leachate treatment plant)</td>
<td>LS</td>
<td>1</td>
<td>45,000</td>
<td>45,000</td>
</tr>
<tr>
<td><strong>Sub total upgrade of leachate storage pond</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>331,250</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit Price [USD]</th>
<th>Total Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upgrade and extension of existing leachate treatment plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspection of machinery and elaboration of a repair plan for existing LTP (by a professional expert team with practical operation experience with such plants)</td>
<td>LS</td>
<td>1</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Supply of repair material and repair of plant</td>
<td>LS</td>
<td>1</td>
<td>400,000</td>
<td>400,000</td>
</tr>
<tr>
<td>Delivery of additional stage of plant for 15 m³ /day</td>
<td>LS</td>
<td>1</td>
<td>1,800,000</td>
<td>1,800,000</td>
</tr>
<tr>
<td>Training of staff in operation</td>
<td>LS</td>
<td>1</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td><strong>Sub total upgrade and extension of existing leachate treatment plant</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>2,310,000</strong></td>
</tr>
</tbody>
</table>

4.6.3.2.4.4 Landfill – Rehabilitation of Leachate system – Summary of Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit Price [USD]</th>
<th>Total Price [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub total construction of recirculation system</td>
<td></td>
<td></td>
<td>1,007,500</td>
<td></td>
</tr>
<tr>
<td>Sub total construction Installation of flushing chambers at existing wells of section 1 and 2</td>
<td></td>
<td></td>
<td>298,500</td>
<td></td>
</tr>
<tr>
<td>Sub total upgrade of leachate storage pond</td>
<td></td>
<td></td>
<td>331,250</td>
<td></td>
</tr>
<tr>
<td>Sub total upgrade and extension of existing leachate treatment plant</td>
<td></td>
<td></td>
<td>2,310,000</td>
<td></td>
</tr>
<tr>
<td>Contingencies (~10 %)</td>
<td></td>
<td></td>
<td>392,750</td>
<td></td>
</tr>
<tr>
<td><strong>Sub total rehabilitation of leachate system</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>4,340,000</strong></td>
</tr>
</tbody>
</table>
4.6.4 Technical description of investment packages

4.6.4.1 General

In the following a brief technical description of the proposed technical investment is given.

These descriptions are only of tentative and shall be an orientation for further elaborations. Detailed design and specifications have to be developed and elaborated within the procurement phase and – in case of external PIS consultancy services – in close co-operation between future Consultant and TSG technical management staff. This shall support qualitative and targeted investment meeting the needs of TSG.

Especially the current suggested investment into the truck fleet may requires special attention during the actual implementation and updating as it is known by the Consultant that TSG intends to invest into their waste collection fleet by the help of additional funding in the meantime (Status: November 2016).

For vehicles purchased the following requirements should be taken into account, inter alia:

- Georgian traffic and emission standards have to be met, application of European Norms appreciated (EURO 5)
- Left hand drive
- All vehicle chassis’ from the same brand to optimize operation and repair practice as well as spare part purchase
- Standard driver cabin for trucks (without sleeping cabin or second seating row; length approx. 1.65 m +/- 15%)
- Type plate with the information below should be made available:
  - Manufacturer
  - Series or type
  - Serial number
  - Year of construction
  - Maximum permissible lifting load capacity
  - Operation pressure of hydraulic system
- Foundations and surface lacquering

In addition to this, more detailed description is given within the chapters below for each type of vehicle to be purchased

- Vehicles equipped with “hooklift” (roll-on/roll-off) system for handling containers with a volume of up to 38 m³
- Skip container vehicles
- Waste collection vehicles upgrade of truck fleet, replacement of old and repair intensive trucks

As elaborated during the baseline study, many vehicles suffer of stress due to weak steel quality. Therefore during the procurement of the goods described below, special attention should be given to the different steel types to be used for the respective vehicle parts and structures (hooklift and skip systems, container and waste compaction units of collection vehicles):
• Definition of steel grade, mainly
  o Minimum yield stress (ReH) [N/mm² or MPa]: tension until material does not show any persistent distortions
  o Minimum tensile strength (Rm) [N/mm² or MPa]: tension when material is cracking
  o Minimum hardness: mechanical resistance of material against ingression of a block (e.g. acc. Brinell Method)

• Steel types of goods purchased should be labelled according to EN 10025-2 or EN 10149-2 or brand name and key indicator (e.g. yield stress)
  o High-grade steel (e.g. S235 JR + N or S 355 MC): construction of products and product parts which are made for regular use e.g. skips and bins
  o High tensile steel for goods and good parts which are made for heavy duty use
  o Wear resistant steel (extreme hardness resulting of high yield stress and tensile strength leads to high elastic recovery characteristic): For extreme heavy duty use (e.g. bottom section of containers for transportation of demolition waste)

<table>
<thead>
<tr>
<th>Material</th>
<th>Yield stress [N/mm²]</th>
<th>Tensile strength [N/mm²]</th>
<th>Hardness [HBW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S 235 JR</td>
<td>235</td>
<td>360 - 510</td>
<td>approx. 130</td>
</tr>
<tr>
<td>S 355 MC</td>
<td>355</td>
<td>420 - 550</td>
<td>approx. 150</td>
</tr>
<tr>
<td>DOMEX® 460 MC (1)</td>
<td>460</td>
<td>520 - 670</td>
<td>approx. 180</td>
</tr>
<tr>
<td>DOMEX® 700 MC (2)</td>
<td>700</td>
<td>750 - 950</td>
<td>approx. 250</td>
</tr>
<tr>
<td>HARDOX® 450 (3)</td>
<td>1200</td>
<td>1400</td>
<td>450</td>
</tr>
<tr>
<td>RAEX® 450 (4)</td>
<td>1200</td>
<td>1450</td>
<td>450</td>
</tr>
<tr>
<td>XAR® 450 (5)</td>
<td>1200</td>
<td>1400</td>
<td>450</td>
</tr>
<tr>
<td>Brinno® 450 (6)</td>
<td>1200</td>
<td>1500</td>
<td>450</td>
</tr>
</tbody>
</table>

1) DOMEX® is a brand name of SSAB
2) HARDOX® is a brand name of SSAB
3) RAEX® is a brand name of Kloeckner Ogil, KRUKS
4) XAR® 450 is a brand name of Thyssen Krupp Steel Europe
5) Brinno® 450 is a brand name of Haase-Stahl-Unternehmen GmbH.

- Figure 4-24 Example for different steel types common for container production. source: beringer-behaelter.de

4.6.4.1.1 Supply of trucks with hooklift (roll-on/Roll-off system) equipment for containers with up to 38 m³ volume

In the following a short general technical description for waste transfer transport vehicles for waste transport from transfer station to landfill is provided.

Detailed needs and specifications should be developed and elaborated during the procurement phase by the Consultant and TSG technical staff.

General key specifications to be considered are, inter alia:
• Container handling system identical with existing system
• Container handling system compatible with
  o containers purchased within transfer stations update and construction (refer to sections below)
  o containers already in use by TSG
• Hydraulic system with safety installations according to common industrial standards and sufficient surplus load capacity
• Chassis min. 26 tons gross vehicle weight with specified weights of
  o Chassis
  o Roll Off Equipment weight (e.g. 3.0 – 3.3 tons or 3.0 tons +/- 15%)
  o Container weight
  o Net transport capacity (Weight of waste for transport)

• Compatible with container length up to 7 m (see section below for container details)

• Max. tipping angle should be specified (e.g. 49° – 55°)

• Type of hook system should be specified: gravity locking or hydraulic locking (hydraulic preferable due to higher reliability)

• Type of lifting arm, (e.g. fixed or telescope, see sketch below)

![Lifting arm types](source: Meiller Kipper)

Definition of type of securing container during transport, e.g. mechanical lock according to DIN 30 7222. This locking method has three important functions
1. The container is locked onto the vehicle for transport.
2. The tipping movement is ensured by the container connection to the rear "tipper frame" (also called "rocker beam").
3. In accordance with DIN 30722, the locking dimension "X" is selected so that the distance of the theoretic centre of gravity of the container to the locking window always remains constant at 360 mm. This means the container (regardless of whether long or short) is always locked to the vehicle with the centre of gravity at the same position (Meiller Kipper)

![Mechanical lock by Meiller Kipper](source: Meiller Kipper)

• Tipping frame with locking system for sudden unintentional flexion of tipping frame
Definiton of permissible payload during “pick up” phase of container (according to BGI 5005 “Sicherer Einsatz von Abroll- und Abgleitkippern” (Secure Usage of Roll-Off and Slide-Off tipper”, 2005).

\[ N_L = \frac{S}{\psi \times U} \]

without support  \( S = V_A \times r \)

with axle support  \( S = V_A \times r + H_A \times p \)

The payload during loading progress should not be exceeded. This should be done by regulation of the pressure relief valve, done by qualified expert personnel!

Please note the following: This is a non-exhaustive list and a detailed update during project implementation will be necessary. Further the above list only focuses on major items. The brands shown below are exemplary.

The figure below gives a general overview of vehicle capable to carry large volume containers (38 m³) and with the “hooklift” system.
Tipping is only possible with limitations due to the short container overhang.

The maximum container height is dependent on the vehicle and should be chosen such that, in accordance with the German Motor Vehicle Construction and Use Regulations, the overall height of 4,000 mm is not exceeded when the vehicle is unloaded.

The heights are based on a container height of 2,400 mm.

Weight without oil tank, pump, fixing parts, mud guards, additional equipment such as under-ride guard, axle support, internal locking mechanism, etc. Excess weights depending on the chassis.

Exact dimensions and weights will be given, once a chassis has been chosen. For suitable chassis see list of recommended vehicles.

Subject to modification due to new developments.

Figure 4-28: Example Vehicle: Roll-off tipper RK 30K according to German standard DIN 30 722 -2; source: Meiller Kipper

**Technical Data**

- **Technically admissible payload**: max. 30,000 kg
- **Incl. container effective payload**: 18,000 – 27,000 kg
- **Incl. container (depending on the chassis)**
  - **for chassis with a permissible g.v.w.**: from 28,000 kg

**Hydraulic system:**

- **Pump flow rate at 1,115 r.p.m.**: 105 l/min
- **Oil tank capacity (effective)**: 50 l
- **Capacity of the entire hydraulic system**: 155 l

**Operating time:**

- **a) Setting down**: 21 – 33 s
- **b) Tipping**: 33 – 39 s
- **c) Picking up / lowering**: 40 s

**Containers according to DIN 30 722-2**

- **with strap height**: 1,570 mm
- **optional**: 1,370 – 1,480 mm
- **Max. container width according to GVFZQ**: 2,550 mm

See Container data sheet 0395 0851 033 page 1
Mobile compactors according to DIN 30 730
Special containers by arrangement.

Figure 4-29 Technical Data Example Vehicle: Roll-off tipper RK 30K according to German Norm DIN 30 722 -2; source: Meiller Kipper

Below key measures of Roll-off tipper RK 30 K with 7,000 mm max container length as orientation for setting specifications during procurement.
4.6.4.1.2 Modification of existing container cleaning trucks

Note: This package is not part of investment anymore, but was suggested by the Consultant; it is included in this report for the case that in future the Client might decide to modify these trucks by own means.

TSG maintains 10 vehicles with build-ups for washing collection containers (with volumes up to 1.1 m$^3$) in parallel to collection. They are not operated; reported reasons point at the manufacturing quality of the build-ups, however refer also to common organisational problems with the applied method of cleaning collection devices “on the road” (eg. obstruction of and by street traffic).

Some of the vehicles are four, some are seven years old and they show mileages of around 5,000 km. The chassis of all vehicles are in very good condition. Therefore the Consultant suggested to convert eight of the ten container washing vehicles into waste collection vehicles by replacing the present washing build-ups by compaction build-ups (furnished with combined pick-up units for 120/240 l and 1.1 m$^3$ containers). Such conversion represents a standard procedure in technical terms, with TSG central workshop capable in performing all related works. Two washing vehicles would be kept for special occasions.
4.6.4.1.3 Supply and Installation of loading units for waste collection trucks

About half of the transfer fleet operated by TSG (in total 22 vehicles) is in a condition which raises concern in respect to safety: Due to the combined factors

- high mileage\(^{11}\)
- considerable mechanical stress\(^{12}\), together with apparent
- mediocre material (steel) and/or manufacturing quality of the vehicle frames\(^{13}\)

the concerned vehicles are virtually falling to pieces and can thus be qualified as unsuitable for the present purpose (i.e. long haul transport) requiring high speeds (up to 80 km/h).

However, serving as collection devices – with predominantly stop-and-go operation, and speeds rarely higher than 40 km/h – would be acceptable by common safety standards. The required conversion (with a replacement of the present roll-on/roll-off or "hooklift" devices by compaction build-ups\(^{14}\)) represents a standard procedure in technical terms (same as with the conversion of the container washing vehicles described in the previous chapter), to be performed "in house" by TSG.

---

\(^{11}\) Put in service in 2010/2011 and with a yearly performance of 180,000 km the concerned vehicles would show mileages of about 1 million km each in 2017.

\(^{12}\) Caused by permanent operation on rough roads with substantial portions (estimate: 5 %) of the 30 km distance transfer station \(\Rightarrow\) landfill entrance to be qualified as unpaved tracks.

\(^{13}\) The observed problem appears with a certain make only.

\(^{14}\) furnished with combined pick-up units for 120/240 l and 1,1 m\(^3\) containers.
The Consultant suggested to replace 10 hooklift devices (of the vehicles with the poorest status and performance in the sense outlined on the beginning of this chapter) with 10 compaction boxes (nominal capacity ~ 19 m$^3$). The proposed investment component represents an opportunity to extend the life of ten major transport units with an age of only five years by another minimum five years.

4.6.4.1.4 Skip Container Vehicles (Skip Handlers), 2 axles, 18 tons

These type of vehicle is mostly necessary for non-system waste collection as currently only 2 vehicles in operation and therefore to extend services to commercial clients.

General key specifications to be considered and to be taken care of are, inter alia:

- Skip container lifting equipment already installed on the truck vehicle
- Skip container system compatible with
  - containers purchased within this project and
  - containers already in use by TSG
- Hydraulic with safety factors
- Chassis min. 18 tons gross vehicle weight
- Maximum weight of skip container lifting equipment should be specified
- Compatible with containers with volume 13 - 19 m$^3$ (see section below for container details)
- Type of skip container lifting unit should be specified
- Define type of supporting arm for skip handling according to actual needs

Note that the photo shows TSG’s transfer vehicle in worst condition, however no other vehicle showing the lifting arm alone was available at the time photos have been taken.
Figure 4-33 Supporting arm types available for skip handler. Source: Meiller Kipper

- Definition of permissible payload

Please note: This is a non-exhaustive list and a detailed update during project implementation will be necessary. Further the above list only focuses on major items. The brands shown below are exemplary.

The figure below gives a general technical overview of skip container vehicles.

Figure 4-34 Example vehicle: Skip handler AK 16 N according to German standard DIN 30 723; source: Meiller Kipper
4.6.4.1.5 Skip Containers various sizes

For the above described skip handler’s two different types of skip containers should be purchased:

- 8 pcs containers with 13 m³ (+/- e.g. 15% Volume),
- 4 pcs containers with 19 m³ (+/- e.g. 15% Volume).

General key specifications to be considered and to be taken care of are, inter alia:

- Skip container compatible with
  - skip handlers purchased within this project and
  - skip handlers already in use by TSG

- Stackability, which requires
  - a conical shape of the container body, and
  - a support structure avoiding “sticking” (of two stacked containers).

- Type of container e.g.
  - open or with cover/lid
  - with hinged front wall
  - with double doors and substructure

- Dimensions e.g. according to DIN 30720
  - asymmetric or symmetric
  - thickness of
    - base plate e.g. 6 mm
    - walls, e.g. 4mm
  - with or without bottom hole

- Details like inter alia availability of cover hooks, angled scuff rail or reinforced corners should be considered.
Please note: This is a non-exhaustive list and a detailed update during project implementation will be necessary. Further the above list only focuses on major items. The brands shown below are exemplary.

The figures below gives a general overview of skip containers with volumes similar as requested.

Figure 4-36 Typical skip container with volume up to 15 m³ (source: beringer-behaelter.de)

![Typical skip container with volume up to 15 m³](image)

Figure 4-37 Key measures of a standard skip container to be taken into account (source: beringer-behaelter.de)

<table>
<thead>
<tr>
<th>Rauminhalt</th>
<th>Behälter Maße in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>cbm</td>
<td>A</td>
</tr>
<tr>
<td>ca. 4</td>
<td>2700</td>
</tr>
<tr>
<td>ca. 5,5</td>
<td>3000</td>
</tr>
<tr>
<td>ca. 7</td>
<td>3500</td>
</tr>
<tr>
<td>ca. 10</td>
<td>3750</td>
</tr>
<tr>
<td>ca. 12</td>
<td>4000</td>
</tr>
<tr>
<td>ca. 15</td>
<td>4600</td>
</tr>
</tbody>
</table>

Figure 4-38 Example measures for standard skip container (“Behälter Maße”) and volumes (“Rauminhalt”) (source: beringer-behaelter.de)
4.6.4.1.6 Collection Vehicles (for system collection, rear loader with compaction unit)

In the following collection short general technical description for waste collection vehicle with 7 - 14.5 m³ total storage volume is provided.

Detailed needs and specifications should be developed and elaborated during the procurement phase by the consultant and TSG technical staff.

General key specifications are (non exhaustive list, update necessary by PIS Consultant, list only focus on major items, brands are exemplary):

- Rear loading unit compatible with
  - 120 l, 240 l bins (EN 840-1) and
  - 1.100 containers (EN 840-3) currently in use in Tbilisi
  - Future bin types scheduled to be used by TSG (e.g. EN 840-2)

- Hydraulic with safety factors

- Gross vehicle weight

- Chassis with safety factor: gross vehicle weight with specified weights of
  - weight of chassis
  - weight of container handling unit (e.g. 3.0 tons +/- 15%)
  - net transport capacity (waste payload)

- Maximum payload
- Special technical assets as reinforced rear suspension

The tables below give a general overview of vehicle capacities in the requested collection volume range of 7 - 13 m³.

<table>
<thead>
<tr>
<th>Name</th>
<th>Example Product</th>
<th>Collection Volume</th>
<th>Weight of collection structure</th>
<th>Compaction ratio</th>
<th>Gross vehicle weight</th>
<th>Wheel distance</th>
<th>Loading unit cycle time</th>
<th>Unloading time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoeller Micro XL</td>
<td></td>
<td>7 m³</td>
<td>2.5 to</td>
<td>1:2</td>
<td>7.49 to</td>
<td>3.35 m</td>
<td>15 sec</td>
<td>28 sec</td>
</tr>
<tr>
<td>Zoeller Mini</td>
<td></td>
<td>7.5 – 8.5 m³</td>
<td>3.4 – 3.5 to</td>
<td>Up to 1:4</td>
<td>Up to 12 to</td>
<td>3.1 – 3.4 m</td>
<td>17 sec</td>
<td>30 sec</td>
</tr>
<tr>
<td>Zoeller Mini XL</td>
<td></td>
<td>9 - 12 m³</td>
<td>4.2 – 4.8 to</td>
<td>Up to 1:4</td>
<td>Up to 15 to</td>
<td>3.1 – 4.0 m</td>
<td>21 sec</td>
<td>30 – 40 sec</td>
</tr>
<tr>
<td>Zoeller Mini XL H</td>
<td></td>
<td>10 – 14.5 m³</td>
<td>4.2 – 5.2 to</td>
<td>Up to 1:4</td>
<td>Up to 19 to</td>
<td>3.1 – 4.4 m</td>
<td>21 sec</td>
<td>30 – 40 sec</td>
</tr>
</tbody>
</table>

Figure 4-41 Example product: Zoeller Micro XL 7m³ (source: zoeller-kipper.de)
Figure 4-42 Example product Zoeller Mini 7.5 – 8.5 m³ (source: zoeller-kipper.de)

Figure 4-43 Example product Zoeller Mini XL 9 – 12m³; (source: zoeller-kipper.de)

Figure 4-44 Example product Zoeller Mini XL H 10 – 14.5 m³ (source: zoeller-kipper.de)

Measures of the example vehicles are shown in the table below (in accordance with the graphs above):

<table>
<thead>
<tr>
<th>Type</th>
<th>Capacity</th>
<th>A</th>
<th>X</th>
<th>Total length of collection structure</th>
<th>Total length vehicle</th>
<th>Total height</th>
<th>Total width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>m³</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>Micro</td>
<td>7.0</td>
<td>3100</td>
<td>800</td>
<td>4320</td>
<td>6250</td>
<td>2580-2670</td>
<td>2000</td>
</tr>
<tr>
<td>Mini</td>
<td>7.5</td>
<td>3200</td>
<td>500</td>
<td>4300</td>
<td>6180</td>
<td>2760</td>
<td>2150</td>
</tr>
<tr>
<td></td>
<td>8.0</td>
<td>3450</td>
<td>500</td>
<td>4550</td>
<td>6430</td>
<td>2760</td>
<td>2150</td>
</tr>
<tr>
<td></td>
<td>8.5</td>
<td>3650</td>
<td>500</td>
<td>4750</td>
<td>6630</td>
<td>2760</td>
<td>2150</td>
</tr>
<tr>
<td>Mini XL</td>
<td>9.0</td>
<td>3350</td>
<td>500</td>
<td>4700</td>
<td>6580</td>
<td>3000</td>
<td>2300</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>3650</td>
<td>500</td>
<td>5000</td>
<td>6880</td>
<td>3000</td>
<td>2300</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>3950</td>
<td>500</td>
<td>5300</td>
<td>7180</td>
<td>3000</td>
<td>2300</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>4250</td>
<td>500</td>
<td>5600</td>
<td>7480</td>
<td>3000</td>
<td>2300</td>
</tr>
</tbody>
</table>
4.6.4.1.7 Replacement of vehicles for street garbage collection “duty vehicles”

In the following several examples are highlighted for “duty vehicles” with compaction units and volume ranging between of 3.5 and 5 m³.

Detailed needs and specifications should be developed and elaborated during the procurement phase by the consultant and TSG technical staff.

General key specifications are:

- Rear loading unit compatible with
  - 120 l, 240 l bins (EN 840-1) and
  - 1,100 containers (EN 840-3) currently in use in Tbilisi
  - Future bin types scheduled to be used by TSG (e.g. EN 840-2)

- Hydraulic with safety factors

- Gross vehicle weight

- Chassis with safety factor: gross vehicle weight up from 3.5 tons with specified weights of
  - weight of chassis
  - waste collection unit weight (e.g. 2.0 tons +/- 15%)
  - net transport capacity (waste payload)

- Maximum payload

- Special technical assets as reinforced rear suspension

---

![Mini XL-H 10\(\times\)350 500 4700 \(\text{kg}\) 6580 3200 2300\(\text{mm}\)](image)

<table>
<thead>
<tr>
<th>Weight</th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1</td>
<td>350</td>
<td>500</td>
<td>4700</td>
<td>6580</td>
</tr>
<tr>
<td>11.3</td>
<td>365</td>
<td>500</td>
<td>5000</td>
<td>6880</td>
</tr>
<tr>
<td>12.5</td>
<td>395</td>
<td>500</td>
<td>5300</td>
<td>7180</td>
</tr>
<tr>
<td>13.7</td>
<td>425</td>
<td>500</td>
<td>5600</td>
<td>7480</td>
</tr>
<tr>
<td>14.5</td>
<td>440</td>
<td>500</td>
<td>5750</td>
<td>7630</td>
</tr>
<tr>
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Total length already includes driver’s cabin length (refer to below).

**Figure 4-45 Example Product: Measures of Driver Cabin Mercedes Benz “Classic-Space” (source: mercedes-benz.com)**

S-Fahrerhaus ClassicSpace
Figure 4-46: Example Vehicle Micro HG with VW chassis 3.5 – 5 m³ capacity (source: zoeller-kipper.de)

Figure 4-47: Example Vehicle Micro HG 4.5 SL with VW chassis (source: zoeller-kipper.de)

Figure 4-48: Example Vehicle Micro HG 3.5 with VW chassis (source: zoeller-kipper.de)
4.6.4.2 Upgrade of existing transfer station Beliashvili

4.6.4.2.1 General Overview upgrade of existing transfer station Beliashvili

The following has to be considered for upgrading the existing transfer station (see also the figure below):

- Rehabilitation of existing loading bay and construction of a third loading bay
  - Refurbishment of asphalt surface in the vicinity of the loading bays
  - Existing loading bays: Refurbishment of existing civil structure (reconstruction of concrete structure, construction of roof, adaptation of concrete for installation of electrical equipment and machinery
  - Construction of a 3rd loading bay - civil structure including loading ramp, roof structure
  - Installation of loading cranes (for loading and levelling) at loading bays during loading process
  - Installation of weighing equipment and optic load control unit for each loading bay

- Construction of new container storage place
  - Container storage place for up to 15 container places (up to 38 m³) - Construction of foundation, tentative dimensions of foundation: 7 x 80 m
  - Container storage place - machinery (steel rails, transport platforms for 15 containers, including hydraulic transmission unit and accessories
  - Container storage place - operation platforms, roof construction

- Supply of transfer containers (33 m³ and 40 m³ net volume)
- Supply and construction of weighbridge

4.6.4.2.2 Rehabilitation of existing loading bay and construction of a third loading bay

The main objective is to optimize the waste transfer procedures at current waste transfer station in Beliashvili, as described above.

For an overview of the recommended update see overview design and related descriptions below.

*Please note. Measures and design shown in the figures below are only tentative. A detailed design has to be performed during implementation phase.*

---

**Technical data**

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**VW chassis**

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<td>Wheelbase [mm]</td>
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</tbody>
</table>

Figure 4-49 Example Vehicles Micro HG: Technical Data (source: zoeller-kipper.de)
Figure 4-50 General layout proposal of upgrading Beliashvili waste transfer station

Operation of upgraded transfer station: **Pathing of vehicles**

A new waste transfer procedure is recommended to be performed as follows (visualized in the figure above):

- **Waste collection vehicles** (orange path in figure above)
  - Collection vehicles will be weighted (1) and registered (2) after entering the transfer station.
  - In a next step vehicles will be sent by the operation leader to a free loading bay for unloading waste into an empty and ready container (for details refer to figures below).
  - After receiving further instructions (7), the waste collection vehicles leave the site along the orange path

- **Manipulation vehicles** (purple path in figure above)
  - These vehicles (two are required for routine operation and a third one as back-up) will not leave the transfer station and are only foreseen for container manipulation
It is recommended to utilize for this purpose a few of the robust and durable transfer vehicles (Mercedes or MAN) current in operation as the roll-off systems of these vehicles will be in use continuously.

The vehicle will pick up full containers within the loading bays and transport these containers to the container storage place (5) for further manipulation and transport to the landfill.

Then an empty container will be picked up according to the order of operator of the container transfer unit and will be dropped in a free loading bay.

- **Transfer vehicles (blue path in figure above)**
  - Within the updated transfer station, there is no need for transfer vehicles to collect waste directly from the loading bays. This is especially to reduce “downtimes” during loading process and to make waste transfer independent from waste collection.
  - Transfer vehicles enter the transfer station along the blue path (entrance similar to collection vehicles. No weighting of transfer vehicles necessary (weighting takes place at landfill, as currently performed).
  - Transfer vehicle is instructed by the operator (6) of the container storage and rail platform (5) which container he has to pick up for transfer.
  - After receiving further instructions (7), transfer vehicle leaves the site along the blue path.

![Figure 4-51 General design and operation principle of upgraded as well as additional (3rd in Beliashvili) or new waste loading bay](image)

Note: Template only! All figures only for orientation and not for implementation! Detailed design required. Height of roof construction dependent on technical requirements of waste collection trucks. Special attention has to be given on the required minimum free height of waste collection trucks during unloading process. Loading bay shall be accessible for all kinds of waste collection trucks which are in use.

---

16 Suitable are the currently operated transfer vehicles with the license plates QGQ 691, WZW 519 and WZW 521.
Operation of upgraded transfer station: **Operation of loading bays of vehicles**

Following the above description waste is discharged by the collection vehicles into a transfer container mounted on a ‘manipulation vehicle’. This vehicle will carry the filled container to the storage area, change it against an empty container and return to a bay for being filled.

To optimize waste load [tons] and [m³] per transfer container it is recommended to

- install weighting units (container scales, examples see below) within loading bay to meet transfer vehicles net loading capacity (including large and well visible display showing total weight)
- install stationary cranes for waste manipulation within the transfer container for even distribution of waste inside of container. Crane also functions as screening to sort out visible hazardous wastes or construction waste

![Diagram of waste loading bay with stationary crane](image)

**Figure 4-52 General design and operation principle waste loading bay with stationary crane**  
*Note: Template only! All figures only for orientation and not for implementation! Detailed design required. Height of roof construction dependent on technical requirements of waste collection trucks. Special attention has to be given on the required minimum free height of waste collection trucks during unloading process. Loading bay shall be accessible for all kinds of waste collection trucks which are in use.*

The container scale and stationary crane are significant tools to

- prevent waste transfer trips with significant underperformance (transferred waste in tons << actual loading capacity transfer vehicle; see baseline study):
  - Optimization of transferred tons per consumed fuel
- prevent trips with significant overloading of transfer vehicle
  - Reduce stress on and damage of vehicle and container

Operation of upgraded transfer station: **New traverse shifting system and container storage.**
As described above the storage for transfer container is foreseen to operate the component **transfer of waste to landfill** independent from the component **waste collection**.

The manipulation vehicles store full and ready-for-pick-up containers at the traverse shifting system (acting at the same time as temporary storage). Containers will then be covered with a tarp and are ready for pick up by waste transfer vehicles.

![Diagram of traverse shifting system and container storage](image)

**FORD BRINGS EMPTY CONTAINER AND PICKS UP FULL ONE**

Detailed technical approach and design has to be developed within the procurement process. Especially type and approach of the container handling system has to be carefully evaluated in close co-operation with TSG, as there are already many solutions available on the market (an example of a traverse shifting system can be found below).

An alternative could be a lifting unit on rails located below a frame on which the containers are located (refer to figure below).
Note: Taking into account that several technological solutions are available, such component could be tendered in a FIDIC Yellow Book Procedure in order to enable Manufacturers to present their specific technology solution.

4.6.4.2.3 Technical Description of instalments and works for transfer station upgrade

In the following a short description of the instalments and works is given.

Please note: Measures and design shown below are only tentative. A detailed design and technical description has to be performed during implementation phase.

All works should be performed at least according to Georgian Standards, where suitable according to European Standards.

Weight bridge (1) and weighbridge operation building (2):
- It is recommended to install a similar weighting unit and system as already in use at the landfill

Updating and construction of 3rd loading bay (4) and (5)
- Refurbishment of asphalt surface in the vicinity of the loading bays
- Works at the existing loading bays. Refurbishment of existing civil structure
  - reconstruction of concrete structure,
  - construction of roof,
  - adaptation of concrete for installation of electrical equipment and machinery
- Construction of 3rd loading bay - civil structure including
  - loading ramp
  - roof structure
  - container scale including optical load control (visible for at least crane operator and operation leader of transfer station.

The container scale should meet inter alia the following
Suitable for roll off container purchased and currently in use (e.g. roll-off container according to DIN 30 722)

- e.g. length of scale = length of container + 1m
- e.g. width of scale 2.5 m

- Weighing range (e.g. up to 30 tons)
- Weighing increment (e.g. max. 100 kg)

Figure 4-55 weighing plate; source: atp-messtechnik.de

- Loading cranes (for loading and levelling) at loading bays during loading process.

Specifications for the loading cranes should include inter alia,

- Type of grab (polyp gripper or double shell type grab)
- Max. capacity of grab (e.g. 0.5 m³ and 2 tons)
- Max. closing force of grab (e.g. 18kN with 26MPa operation pressure)
- Steel quality of grab
- Gear type (e.g. rotator with 4.500 kg load capacity)

Figure 4-56: Stationary crane with „orange peel grab“ for waste manipulation (source: left: kinshofer.com; right: girke.de)
Figure 4-57: General design of upgraded loading bays. In green: additional structure (3rd bay and access ramp) as well as loading cranes in all three bays
New traverse shifting system, container storage (6) and operation building (7)

- Construction of traverse shifting system and container storage for up to 15 waste transfer containers
  - Construction of foundation,
    - Tentative dimensions of foundation: about 1.5 m height, 8 m width and 80 m length depending on actual size of container purchased and most suitable height for transfer vehicles for manipulation
    - Infiltration ditch surrounding the concrete platforms leading to an small collection chamber connected to the cesspool or waste water collection system
  - Construction of roof and maintenance bridge
    - Roof made of corrugated iron
  - Construction of operation building for traverse shifting unit
  - Machinery:
    - Metal rails and slides for containers in accordance with containers already in operation and purchased
    - Mechanical/hydraulic transmission for operation of traverse shifting system

Figure 4-58 Example of traverse shifting system; (source: recycling-umwelt-technik.de)

4.6.4.2.4 Supply of transfer containers (33 m³ and 40 m³ net volume)

General key specifications to be considered and to be taken care of are, inter alia:

- Transfer container with 33 m³ volume compatible with
  - Transfer trucks in use
  - Transfer trucks purchased within this project and

- Transfer container with 40 m³ volume compatible with
  - Transfer trucks purchased within this project
  - Note: 40 m³ containers are not foreseen for usage of current waste transfer trucks as their maximum net load capacity does not allow such heavy loads to be expected with larger containers

- Type of container to be specified e.g.
  - With or without structural ribs; ribs with round or square bottom-wall conjunction
With or without lid and/or doors

- E.g. container according to DIN 30722 to guarantee quality
  - Definition of e.g. type of locking system, contact roller, hook, doors, mounting kit and hinges; availability of vertical ladder
  - Definition of steel types (Bottom, wall, structural rips, base plate, doors, etc) and strength (e.g. bottom 5mm, walls 4 mm, front wall 4 mm; all steel S 235)

- Container needs primary coat and paint
- Steel type according to transported goods (waste)
  - If purchased for waste, containers should not be used for more heavy duty transport, e.g. construction waste. In case of transportation of large amounts of construction waste additional containers should be purchased manufactured from other steel types

- Definition of type of covering system during transport
  - Lid or tarp with hooks

Please note: This is a non-exhaustive list and a detailed update during project implementation will be necessary. Further the above list only focuses on major items. The brands shown below are exemplary.

The figures below gives a general overview of types of containers with volumes similar as requested.

![Figure 4-59 Container without structural rips and example measures ("Behälter Innenmaße") and volumes ("Raumninhalt") (source: beringer-behaelter.de)](image1)

![Figure 4-60 Container with structural rips and round bottom-wall conjunction and example measures ("Behälter Innenmaße") and volumes ("Raumninhalt") (source: beringer-behaelter.de)](image2)
4.6.4.3 Construction of 2\textsuperscript{nd} transfer station

As described above, the 2\textsuperscript{nd} transfer station serves to increase efficiency of waste collection and transport. Further it is recommended to transfer the currently run-down operation yard at Graneli Street to the new location.

With finalization of this report (December 2016), no suiting property could be presented by TSG. It is strongly recommended by the Consultant to continue the search and to integrate the City Administration into it.

Therefore no general design is provided since, as it will depend strongly on the size and location of the property available.

Works and construction to be performed are scheduled as follows:

- Preparation of site infrastructure as necessary, e.g. electrical supply, water, sewage, telecommunication
- Levelling of site, removal of existing structures
- Construction of drainage system
- Construction of asphalt surface, orientate area size 8,000 m\textsuperscript{2} including gravel layer for frost protection
- Construction of fence
- Construction of entrance area including gates
- Construction of operation building (approximate area \textasciitilde 200 m\textsuperscript{2}; usable space for offices and sanitary rooms \textasciitilde 350 m\textsuperscript{2}, 2 floors construction, including sanitary rooms, all house infrastructure installations and furniture)
- Construction of garage and workshop 1,000 m\textsuperscript{2}
- Construction of loading bays - civil structure including ramp and roof structure  
  \hspace{1cm} o updated design compared to loading bays in Beliaishvili recommended
- Installation of loading cranes (for loading and levelling) at loading bays during loading process (details see section 4.6.4.2)
- Installation of weighing equipment and optic load control unit for each loading bay (details see section 4.6.4.2)
- Container storage area for up to 10 container places - Construction of Foundation, tentative dimensions of foundation: 7 \times 60 m (details see section 4.6.4.2)
- Container storage place – machinery (steel rails, transport platforms for at least 10 containers, including hydraulic transmission unit and accessories; (details see section 4.6.4.2)
- Container storage place – operation platforms, roof construction (details see section 4.6.4.2)
- Supply of transfer containers (33 m³ and 38 m³ net volume; (details see section 4.6.4.2)
- Supply and construction of weighbridge (details see section 4.6.4.2)

4.6.4.4 Rehabilitation of leachate system

4.6.4.4.1 General

As described above a rehabilitation of the leachate system is required.

The proposed investment for the rehabilitation includes:

- Installation of flushing chambers at existing wells of section 1 and 2
- Upgrade of leachate storage pond
- Upgrade and extension of existing leachate treatment plant
- Construction of recirculation system

Please find below brief details to be considered during rehabilitation.

For brief recommendations and suggestions concerning other landfill system sections (e.g. drainage system within landfill body please refer to Annex I Recommendations on Landfill Operation Improvement.

4.6.4.4.2 Leachate Management System: General Description

The technical solutions to manage the leachate must fulfil several aims, including:

- regulation and reduction of the amount of leachate to be treated
- optimum moisture content for the chemical reactions in the landfill in order to produce a sufficient and steady supply of landfill gas
- optimal conditions for the biological degradation of the organic waste after closure
- prevention of environmental pollution

The table below gives a brief overview of the current areas of the landfill and their current status concerning covering.

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</tbody>
</table>

Table 4-32: Overview of the current areas of the landfill and their current status concerning covering

A Leachate Management System consists in general of the following components:

- Leachate collection pipes within the landfill body (including flushing shafts and control shafts)
- Leachate collector pipe to the storage and settling pond
4.6.4.4.3 Leachate Collection and Treatment System

A schematic overview on leachate collection and treatment system is indicated in the following figure:

Figure 4-62: Schematic overview leachate collection and treatment system

In general, the precipitation entering the waste body will be collected in the drainage layer and the leachate drainage pipes located on the landfill base. The leachate drainage pipes discharge the water to the leachate collector from where the water is discharged to the leachate storage pond. A pumping station serves to distribute the stored leachate to the pipes which re-circulate the leachate to the deposit area (details on recirculation see below).

In the accessible components of the leachate management system (collector, pumping station, leachate storage area) a gas warning system (including CH4, H2S, O2) and a protection system against explosive atmosphere (according to EU ATEX Directive) must be installed.

The collection system for section I and II are already in place. It is recommended for section III to consider an alternative approach of leachate collection (see Annex I Recommendations on Landfill Operation Improvement).

4.6.4.4.4 Flushing chambers

As described above investment in installation of flushing chambers at existing wells of section 1 and 2 are recommended.

In general the following general tasks have to be performed:

- Excavation of landfill body at north east edge of landfill
- Extension of existing leachate drains and Installation of flushing chambers at existing leachate collection pipes of section 1 and 2
- Refilling of waste material
- Reinstallation of surface cover

It is recommended to consider the following during implementation of the investment:

- Leachate collection systems should have the capability for flushing with high pressure jetting. This is not only to clean the collection / drainage pipes but also to loosen the gravel layer surrounding the pipes and thus increasing the entrance of leachate into the drainage pipes.
- The leachate collection system should enable a visual inspection using CCTV systems. Regular inspections give an accurate record of the condition of the collection system. The observations during the visual inspection should be recorded using the coding system in BS EN13508 – Part 2.
- The leachate drainage pipes should begin on the top of the landfill slope, outside of the landfill body (on the slope a closed pipe is installed). The pipe should have a removable end cap in order to be able to enter the drainage system with a CCTV camera and with high pressure jetting equipment.
- In order to be able to flush and to inspect pipes, entrance to the leachate drainage pipes from the end chambers and the flushing caps must be possible.
- Access to the chambers and the flushing end caps must be permanently available.

Figure 4-63: Example for leachate drainage with flushing connection (chamber not yet constructed (red circle). during construction phase (source: Hürner AG)

It is further strongly recommended to install these flushing chambers also within the to be constructed section III of the landfill.

4.6.4.4.5 Leachate Storage

As described above investment upgrading into the leachate storage is recommended.

- Extension of existing pond to an area of 3,000 m² and operation volume of 6,000 m³ according to the estimations under the section “leachate volumes” below
- Installation of sealing system with connection to current ponds
- Construction of filter dam section for separation of settling zone from storage zone
• Construction of inlet and outlet structure (to recirculation pumping chamber and to leachate treatment plant
• Constructed as open earth basin with PE-HD sealing.
• Additional security for uncontrolled exfiltration into groundwater with control drainage under the pond construction

4.6.4.4.6 Leachate Treatment Plant

As described above investment in upgrading the leachate treatment plant is recommended. The following is recommended during implementation of the investment:

• Inspection of machinery and elaboration of a repair plan for existing LTP (by a professional expert team with practical operation experience with such plants
• Supply of repair material and repair of plant
• Delivery of additional stage of plant for 15 m³/day
  o Technology and size of plant chosen should take into the account amount and quality of effluent to be treated after first treatment step within the updated storage pond
• Training of staff in operation

Below as example a treatment plant option with two stage reverse osmosis (source: ROTREAT Abwasserreinigung GmbH).

The unit consists of the following components:

1. B 02211-Raw water tank and pH adjustment
2. Pre-filtration
3. Leachate stage ROAW 9122 DT 10 with 10 modules, incl. a control system (PLC) and computer to show the state of operation and for data storage.
4. Permeate stage ROAW 9135 DT 3 with 3 modules. This unit is controlled by the PLC of the ROAW 9122 DT 10

Figure 4-64: Schematic overview of leachate storage
• Emergency Outlet structure (Overflow Protection) into river creek

4.6.4.4.6 Leachate Treatment Plant

As described above investment in upgrading the leachate treatment plant is recommended.

The following is recommended during implementation of the investment:

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• Supply of repair material and repair of plant
• Delivery of additional stage of plant for 15 m³/day
  o Technology and size of plant chosen should take into the account amount and quality of effluent to be treated after first treatment step within the updated storage pond
• Training of staff in operation

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4. Permeate stage ROAW 9135 DT 3 with 3 modules. This unit is controlled by the PLC of the ROAW 9122 DT 10

Figure 4-64: Schematic overview of leachate storage
• Emergency Outlet structure (Overflow Protection) into river creek
5. Permeate storage tank
6. NaOH tank
7. Tanks for cleaning agents
8. Acid tank and dosing station
9. Container

Figure 4-65 Typical Layout of a two stage reverse osmosis plant

Raw water/leachate inlet: 20 m³/day.

Modules:
- Leachate stage: 10 modules
- Permeate stage: 3 modules

Power consumption of the main drives:
- PP 16011-high pressure pump leachate stage: 4 kW
• PK 16111-inline pump leachate stage: 4 kW
• PP 26011-high pressure pump permeate stage: 4 kW
• PK 13011-filter pump: 1 kW
• HZ 11011-heating cleaner tank: 3 kW
Average power consumption: 14 kWh/m²
Required connection power: 25 kW

1.) Raw water tank (Material PE-HD) and pH adjustment
To avoid uncontrolled precipitation on the membranes and to guarantee Nitrogen-separation, the pH-value of the raw leachate has to be adjusted. Usually it is settled between 6 and 6.5 by dosing and mixing sulfuric acid (H2SO4 96%).

2.) Pre-filtration
The landfill leachate is pre-filtered by means of a sand filter (FS 13111), followed by parallel cartridge filters (FC 14x21) with an absolute removal rate of 10 µm.

Pre-filtration of the raw leachate is done in a multi-layer backwashable flow filter system (sand filter) followed by cartridge filters. These cartridge filters are absolute rated according to OSU-F-2 Filter Performance Test. The necessary upstream pressure is generated by the internal upstream pressure pump. Raw leachate or permeate can be used for backwashing the sand filter.

Backwashing is started automatically at a pressure drop in the sand filter or cyclically after a certain (adjustable) period of operation. Backwashing can also be started manually.

The cartridge filters (fine filters) are installed downstream of the sand filter and guarantee an optimum protection for the RO-stage. They have to be changed when the pressure loss has reached a value of 2 bar – 2.5 bar. The necessity for change is indicated on the control panel.

3.) Leachate stage (section stage 10)
The modular parts of the leachate stage RO 9122 DT 10 are connected in parallel on a frame construction. The unit is installed as an in-house installation in a standardised container. It is also possible to move a unit from a container to an indoor area at a later time without making technical alterations.

The leachate stage consists of the following components:
• Measurement devices
• Control box, local control
• Low voltage distribution
• Frequency transformer
• Process control
• Control panel, operation flow scheme
• High pressure pump
• Module block section with inline pump
• Cleaning tank with rinsing pump
• Pneumatic control valves
• Piping: material low pressure: PVC, material high pressure: stainless steel 1.4571
- Pressure air supply
- Dosage system for Cleaner A
- Dosage system for Cleaner C

The unit control is designed as an in-situ control. A central unit control station can be added if required. Peripheral devices can be connected without problems. The maximum distance between the unit and the central unit control system may be 1,200 m.

After pre-filtration the leachate, at an inlet pressure of 30 bars - 65 bars, is pumped into the distribution line by the high pressure pump. At the end of the distribution line (concentrate) the motorised pressure control valve is installed.

The modular parts are connected in series to the distribution line. The high-pressure-resistant inline pumps of the modular units transfer the leachate from the distribution line through the DT modules.

The concentrate emerging from the modules flows back into the distribution line. The permeate can be fed into the 2nd RO stage (permeate stage).

The feeding of raw water can be adapted in a flexible way to varying leachate quantities. The leachate storage facilities at landfills (lagoons or tanks) usually are sufficient so that raw water feeding can be designed according to the average annual leachate production. If necessary, the plant is operated discontinuously. Shutting down the plant for a longer period is also possible without problems.

If the nominal permeate flow can no longer be achieved by pressure control, raw water feeding is adjusted (decreased) until the admissible minimum permeate flow is reached. After reaching the minimum permeate flow, the cleaning cycle of the module is started.

Concentration of waste water aims at minimising the concentrate volume that has to be disposed of. But concentration of leachate is limited due to the water solubility of hardness-forming ions. For a first design a permeate yield of 75% can be assessed, i.e. 20 - 25% of the concentrate has to be disposed of. To achieve higher permeate yields, the high pressure technology has to be applied.

The inline pump provide for the necessary flow velocity inside the DT modules, i.e. the cross-flow velocity across the membrane cushions. The optimal raw water feed volume per DT module is between 750 l/h and 1,000 l/h. The efficiency of the inline pumps is sufficient to supply up to twelve DT modules connected parallel in one unit.

4.) Permeate stage (section stage 20)

The permeate stage RO 9135 DT 3 is installed on the same frame construction as the leachate stage. With regard to concept, design, and control these two stages form one unit.

- The main components are:
  - High pressure pump
  - Module block section
  - Pressure control valves
  - Measurement devices
  - Permeate storage with permeate rinsing pump

A permeate stage is required if the quality of the treated water from the 1st RO stage does not meet the discharge requirements. The permeate from the 1st RO stage is once again filtered through membranes. The dissolved water components that have
passed through the 1st RO stage are again reduced by about 80% - 90% so that the discharge requirements are safely met.

The permeate from the leachate stage (1st RO stage) is fed directly into the permeate stage. The high pressure pump supplies the feed water to the DT modules at an operating pressure of 30 bars - 65 bars. The concentrate pressure control valve controls the water withdrawal rate. The resulting concentrate is recycled to the leachate stage.

The permeate yield of this stage is in the range of 90% of the feed water flow. Its quality is constantly controlled by measuring the conductivity. The permeate is then fed into the permeate tank.

Regarding construction and material qualities the permeate stage (high pressure pump, DT modules, pipe and tube connections) is largely equivalent to the leachate stage. This results in high longevity (corrosion is nearly excluded) and easy maintenance with identical spare parts.

The permeate from this stage is fed into the permeate tank. This intermediate tank is equipped with a permeate pump and float switches. During shutdown and before chemical membrane cleaning the RO plant is washed via the permeate tank. Permeate can also be used for filter backwashing.

During operation there always will be enough water stored in the permeate tank for washing and cleaning purposes. Cleaning of parts of the unit can also be carried out via the permeate pump.

5.) B 09711-Permeate storage tank (Material: PE HD)
Stores the permeate from the permeate stage, pH is adjusted by dosing NaOH.

6.) B 00211-NaOH tank (Material: PE HD)
With regulated dosing pump

7.) B 01211, B 01311-Tanks for cleaning agents (Material: PE HD)
With dosing pumps

8.) B 00111-Acid tank and dosing station (Material: PE HD; double walled)
The acid is automatically added to the leachate at B 02211 by means of a regulated pump while the pH-value is regularly checked.

4.6.4.4.7 Leachate Re-Circulation
As described above investment in upgrading the leachate re-circulation system is recommended.

Leachate from the storage is re-circulated onto the landfill using the pumping station and a pressure pipe system to re-circulate the leachate to discharge points and/or horizontal injection wells.

Leachate recirculation helps to reduce leachate storage and treatment costs, increases landfill gas generation, and decreases the long term pollution potential.

Essentially the landfill is converted to an active in-situ bioreactor whereby anaerobic microbes are enhanced, accelerating the treatment of leachate and the organic stabilization process of the landfill.

Advantages:
- waste stabilization
- increased gas production
- decreased disposal cost
• accelerated waste settlement

The figure below gives a general overview of the operation:

Schematical Leachate Re-Circulation Design Proposal

Figure 4-66 Schematic overview leachate re-circulation system

The following is recommended during implementation of the investment:

• Construction of recirculation wells in sections 1 and 2 (at 13.9 hctrs in total), assumed up to 3 wells per hectare; in total about 40 wells
  o Preparation of site (reopening of surface cover)
  o Drilling of vertical well for insertion of 426 mm down to maximum 20 m (or minimum distance to base line 5 m)
  o Installation of filter pipes (~DN200 mm) and insertion of surrounding gravel pack
  o Surface shaft DN 800, depth 1.5 m,
  o Installation of inlet pipe, outlets for horizontal and vertical leachate distribution
  o Automatic Control Unit for time based opening and closure of valves
  o Reinstallation of surface cover

• Construction of horizontal recirculation pipes; 5 pipes per well, length 30 m, laid in gravel layer

• Recirculation pumping station (see below)

• Control and distribution chambers

• Connecting pipes from pumping station to the wells

Below a design example of a re-circulation well:
The maximum leachate recirculation amount is recommended with 2.5 m³/ha and day (old landfill part and new landfill sections after closure). The recirculation will be done in intermittent operation with a 10 minutes trickling period followed by a pause of 50 minutes.
4.6.4.4.8 Leachate Pumping Station
With the help of the leachate pumping station the leachate from the leachate storage pond is recirculated to the operational area of the landfill in order to reduce leachate volume.

The leachate pumping station consists in principle of two chambers:
- valve chamber
- pump chamber with two separate pump sumps

The valve chamber contains:
- control valves to direct the discharge of leachate to either of the pump sumps
- access staircase
- access space for equipment
- utility lines

All connections and wall penetrations to the collector and the pump chamber are gas tight.

The pumping chamber contains:
- two underwater pumps in separate pump sumps
- a work podest above the separation wall
- ventilation system
- access with ladders to each sump
- pressure pipes
- utility lines

The walls of the pump sumps are protected by a PE-HD coating layer against corrosion due the contents of the leachate.

The recommended maximum pumping capacity will be 2 x 3 l/s:
- 45 m³/d leachate re-circulation (2.5 m³/ha re-circulation and future 19 ha re-circulation area) and intermediate operation of 4 h operation/d (10 minutes trickling period followed by a pause of 50 minutes per well): ~ 3 l/s + reserve pump.
- The geodetic operation head is about 30 m, and an additional hydraulic operation head of at least 3 bars has to be considered (in order to enable distribution of water. The total operation head is recommended with 60 m.

4.6.4.4.9 Leachate Volumes
In the following an estimation of leachate volumes is given on basis of the climatic water balance of Tbilisi. The table below shows the climatic water balance which is the basis for the quantitative leachate calculation.
Based on the calculation of the climatic water balance (average annual precipitation – potential evaporation), the annual leachate volume is estimated as follows:

- **Leachate from Old Landfill Section 1**: 1/3 of Climatic Water Balance, 34 mm per m²; results in 2.448 m³ p.a.
- **Leachate from Old Landfill Section 2**: 1/3 of Climatic Water Balance, 34 mm per m²; results in 2.278 m³ p.a.
- **Leachate from new Landfill**: 100% of Climatic Water Balance (open tipping area 1 hectare), 104 mm per m²; results in 1040 m³ p.a.

This amount is dependent on the size of the open deposit area and will differ from operation year to operation year.

**The storage pond should be capable to store the heavy rainfall precipitation:**

- **Heavy Rainfall**: 50 mm
  - Runoff from old landfill sections by heavy rainfall (13.9 hctrs): 25% of precipitation, which results in 1,738 m³
  - Runoff from new landfill (open tipping area 1 hectare): 100% of precipitation, which results in 500 m³
  - Taking into account an additional safety factor the recommended storage pond volume for heavy rainfall shall be subsequently 3,000 m³.

The total storage pond volume is recommended to take over at least 80 – 90% of the Annual leachate generation (5,800 m³).
4.6.4.5 Equipment for landfill operations

4.6.4.5.1 General

The following equipment investments are recommended by the Consultant and requested by the Client:

- Mini weather station
- Gas emission measuring equipment
- Radiation device for waste inspection
- Semi mobile unit for shredding of construction and demolition waste

It is recommended that with procurement of the devices
- operational maintenance training and
- advanced troubleshooting repair training
is included (on site or suppliers location).

4.6.4.5.2 Gas emission equipment

The intended use of the equipment should be clearly defined.

The equipment is to measure landfill gas concentration in closed spaces such as manholes and chambers. This should be mobile gas warning equipment such as handheld, single reading monitors.

These units should monitor methane as well as carbon dioxide and oxygen.

There are many companies that provide of these type of meters, e.g. LANDTEC, Elkins Earthworks, Crowncon, Draeger etc.

In following an example from LANDTEC gives an idea about the capabilities and specifications needed for a mobile handheld detector:

![Landfill Gas Detector (LANDTEC)](http://www.landtecna.com/?product=gem5000-complete-package)

"The Next Generation of GEM™ Instrument

The GEM™5000 is designed specifically for use on landfills to monitor Landfill Gas (LFG) Collection & Control Systems. The GEM™5000 samples and analyzes the methane, carbon dioxide and oxygen content of landfill gas with options for additional analysis.

GEM5000 Complete Package Includes:
Instrument, hoses, heavy duty water trap filter, soft case, A.C. battery charger, electronic manual accompanies software, LANDTEC System Gas Analyzer Manager (LSGAM) software, USB download cable and hard-case. Reads: Methane, Carbon Dioxide, Oxygen, temperature (when used with optional probe), atmospheric pressure, differential pressure and calculates gas flow. NAV and Plus model packages also include more features such as GPS and additional gas measurements.

**NOTE:** This is solely an example and not a recommendation!

### 4.6.4.5.3 Radiation device for waste inspection

In the following briefly key characteristics of a semi mobile unit for shredding of construction and demolition waste are outlined.

During procurement the following should be considered, inter alia:

- Type of detector (e.g. shielded sodium iodide [NaI(Tl)] scintillation detectors)
- Range of detectors
- Sensitivity of detectors
- Lead shielded detectors
- Temperature range
- Indoor and/or outdoor
- Ethernet compatible
- Type of display (e.g. LCD)
- Audible and visual alarming system

![Figure 4-70: Example for radiation device (source: Thermo Fisher Scientific)](image)

### 4.6.4.5.4 Mini-weather station

A large variety of mini weather stations with very different configurations and accuracy are available. The first decision is what sensors should be included in the station, for example:

1. VECTOR WIND DIRECTION
2. VECTOR WIND SPEED
3. AIR TEMPERATURE
4. HUMIDITY
5. RAINFALL
6. SOIL TEMPERATURE
7. SOLAR RADIATION
8. AIR PRESSURE

For each sensor consideration to the required specifications should be given, for example:

1) VECTOR WIND DIRECTION
   Range: 0 to 360 °
   Accuracy: + 2 ° obtainable in steady winds over 5 m/s
   Threshold: 0.6 m/s
   Max wind speed: >75 m/s
   Operating range: -20 to + 70 ° C
   Resolution: Sensor + 0.2°, datalogger 5°

2) VECTOR WIND SPEED
   Range: 0 to 75 m/s (145 knots)
   Accuracy: 2% + 0.1 m/s
   Threshold: 0.3 m/s
   Operating range: -30 to + 55 ° C
   Resolution: Sensor 0.8m, datalogger better than 0.01 m/s

3) AIR TEMPERATURE
   Range: -40 to + 60 ° C
   Accuracy: + 0.2 °C between 0 and 60°C
   Sensor: Thermistor
   Resolution: Sensor has an analogue output so its resolution is dependent on the datalogger, the datalogger resolution is better than 0.01°C

4) HUMIDITY
   Range: 0-100% RH
   Accuracy: + 2% RH
   Sensor: Capacitor
   Operating range: -40 to + 60 ° C
   Resolution: Sensor has an analogue output so its resolution is dependent on the datalogger, the datalogger resolution is better than 0.01 %RH

5) RAINFALL
   Resolution: 0.2 mm per tip
   Accuracy: + 5% (24 to 36 mm/hr)

6) SOIL TEMPERATURE
   Range: -20 to + 100 ° C
   Accuracy: + 0.2 °C at 0 to 60°C
   Sensor: Thermistor
   Resolution: Sensor has an analogue output so its resolution is dependent on the datalogger, the datalogger resolution is better than 0.01°C

7) SOLAR RADIATION
   Range: 400-1100 nm
   Operating range: -20 to + 70 ° C
   Accuracy: + 5% traceable to Met Office
   Resolution: Sensor has an analogue output so its resolution is dependent on the datalogger, the datalogger resolution is better than 0.01 w.m-2

8) AIR PRESSURE
   Range: 500 – 1,050 mbar
   Resolution: Better than 0.1 mbar
   Accuracy: Absolute error @ 20°C and 1000mbar typically 0.5mbar (max 1 mbar), Error over 0-50°C typically 1.5mbar (maximum 3.6mbar)
   Resolution: Sensor has an analogue output so its resolution is dependent on the datalogger, the datalogger resolution is better than 0.05 mbar

4.6.4.6 Semi mobile unit for shredding of construction and demolition waste

In the following briefly key characteristics of a semi mobile unit for shredding of construction and demolition waste are outlined.

During procurement the following should be considered, inter alia:

- Key characteristics, e.g.
  - mobility: wheeled (to be towed) or track system
  - potential transportation ability e.g. with hooklift truck
  - hydraulically driven (via diesel unit as a part of the unit)
- Operation area, e.g.
- concrete
- building rubble
- asphalt
- brick

- Type of crushing unit:
  - e.g. single-toggle jaw crusher
  - e.g. feeding hopper and pre screener
  - discharge belt
    - length e.g. 6 m
    - belt-width 0.8 m
    - max height
    - with magnetic separator

- Total weight (up to e.g. 13 tons)
  - in case of hook lift transportation in accordance with maximum capacity of hook lift vehicle

- Maximum feeding size (Input size): e.g. 400 x 400 mm

- Final particle size / e.g. maximum 60 mm

- Performance/ Capacity, e.g. 25 - 60 tons /h (depending on crushing gap and feeding material)

- Drive Unit, e.g. min 80 kVA Diesel; Euro IV standard

![Example Wheeled Crushing Plant: BM 600 (source: Apollo Maschinenbau)](image)

4.6.5 Potential cost savings – Assumptions

In general the current OPEX can be described as follows:

<table>
<thead>
<tr>
<th>Expense Category</th>
<th>Amount (GEL)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employee’ salary expenses</td>
<td>38,840,182</td>
<td>65.0%</td>
</tr>
<tr>
<td>Bank service</td>
<td>3,645</td>
<td>0.0%</td>
</tr>
<tr>
<td>Secondment expenses</td>
<td>14,721</td>
<td>0.0%</td>
</tr>
<tr>
<td>Office expenses</td>
<td>408,563</td>
<td>0.7%</td>
</tr>
<tr>
<td>Rental payment</td>
<td>3,125</td>
<td>0.0%</td>
</tr>
<tr>
<td>Utility expenses</td>
<td>300,608</td>
<td>0.5%</td>
</tr>
<tr>
<td>Expense Category</td>
<td>Amount (GEL)</td>
<td>%</td>
</tr>
<tr>
<td>----------------------------------</td>
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</tr>
<tr>
<td>Communication expenses</td>
<td>96,069</td>
<td>0.2%</td>
</tr>
<tr>
<td>Material expenses/procurement</td>
<td>321,519</td>
<td>0.5%</td>
</tr>
<tr>
<td>Audit expenses</td>
<td>8,642</td>
<td>0.0%</td>
</tr>
<tr>
<td>Fuel consumption (Petrol, diesel)</td>
<td>4,866,930</td>
<td>8.1%</td>
</tr>
<tr>
<td>Depreciation expenses</td>
<td>5,783,727</td>
<td>9.7%</td>
</tr>
<tr>
<td>Maintainance expenses</td>
<td>2,407,077</td>
<td>4.0%</td>
</tr>
<tr>
<td>Tax expenses</td>
<td>3,668,891</td>
<td>6.1%</td>
</tr>
<tr>
<td>Other total expenses</td>
<td>29,314</td>
<td>0.0%</td>
</tr>
<tr>
<td>Insurance expenses</td>
<td>51,175</td>
<td>0.1%</td>
</tr>
<tr>
<td>Legal expenses</td>
<td>9,514</td>
<td>0.0%</td>
</tr>
<tr>
<td>Production inventory expenses</td>
<td>921,801</td>
<td>1.5%</td>
</tr>
<tr>
<td>Auxiliary materials (oil, liquid)</td>
<td>319,050</td>
<td>0.5%</td>
</tr>
<tr>
<td>Other operational expenses</td>
<td>1,691,209</td>
<td>2.8%</td>
</tr>
<tr>
<td>Total operational expenses</td>
<td>59,745,762</td>
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<tr>
<td>OPEX per ton of collected waste</td>
<td>161 GEL/ton</td>
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</table>

Slight cost savings in OPEX are to be expected as a major result from optimization of transport km per ton of collected waste (transfer stations) but it has to be noted that the amount of cost savings will be rather limited having in mind that 65% are Employees expenses and only around 10% are variable expenses allocated to waste collection and transport services. Furthermore it has to be considered that other cost positions will increase in future due to improved operations:

- higher expenses for adequate operation and maintenance of truck fleet (current expenses are relatively low)
- higher expenses at the landfill as a result of modernized leachate collection and treatment system

Following cost savings can be activated:

- Fuel expenses reduced by optimized routing and additional transfer station: Reduction from 19 kilometres per ton of waste to 15 kilometres per ton of waste
- Fuel expenses reduced by modernized and more efficient trucks: Reduction from 38 to 34 litres per 100 kilometres
- Reduced maintenance efforts mainly with positive effect on personnel expenses

In total, the potential of cost savings by the investment program can be estimated by 3%, which would mean 157 GEL/ton.

Following cost increases have to be considered:

- Additional costs for electricity (utility expenses) and maintenance material for operation of 2 transfer stations, leachate treatment plant and recirculation PS
- Additional costs for improved maintenance and spare part procurement of new truck fleet

These cost increases are assumed with 2 - 3%.
Therefore it has to be expected that the OPEX per ton of collected waste will not decrease but can be kept more or less at the current level (161 GEL/ton of collected waste) but the level of service in terms of collection quality and environmental, health and safety standards can be substantially improved.

### 4.6.6 Greenhouse gas emissions reduction and impact of investments – First Assumptions

The project investments will support following direct reductions in GHG emissions:

- Reduction of GHG emissions by modernization of truck fleet
- Reduction of GHG emissions as a result of reduction of transport km per ton of collected waste

These investment will result in a reduction of GHG Emissions caused by waste collection and transport from 19 kg/ton of collected waste to 14.5 kg/ton of collected waste (refer to following table). In total this results in a 15 years horizon to 28,000 tons of CO2 Equivalents which can be reduced by the EBRD investment in comparison to a prolongation of the current situation.

The investment in leachate management at the landfill will support at the landfill the biological degradation processes which will create indirectly positive effects on GHG Emissions at the landfill, provided that a full scale gas collection and treatment system will be constructed and operated (not part of the current EBRD investment). Therefore reduced GHG Emissions at the landfill have not been considered for this analysis.
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</thead>
<tbody>
<tr>
<td>Emissions by use of trucks and cars</td>
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<td></td>
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<tr>
<td>Estimation of GHG emissions for waste collection of solid waste</td>
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</tbody>
</table>

Table 4-34: Assumed GHG Emissions for waste collection and transport
4.6.7 Other Benefits and opportunities after implementation of investments

It has to be stated that the waste management operations are currently being organized by use of all available equipment and resources. There is not much space for extension of operations and/or reaction on unforeseen defects of essential facilities. All such incidents affect immediately negatively the level of service and/or operational standards and compliance with environmental, health and safety.

With the current investments the Company will create following benefits:

- managerial resilience against unforeseen operational developments (defects in truck pool)
- improvement of the level of service in general (organization of special disposal services facilitated)
- improvement of environmental, hygienic and safety standards at the landfill

4.7 Tentative Time Schedule for Implementation

TSG has urgent needs in modernization of the truck fleet; therefore it is assumed that the loan agreement shall be signed in early 2017 and substantial investments in Modernization of the truck fleet are being implemented in second half 2017.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component</strong></td>
<td><strong>PIP</strong></td>
</tr>
<tr>
<td>TB-SW-02 Upgrade of truck fleet, replacement of old and repair intensive trucks</td>
<td>6,400,000</td>
</tr>
<tr>
<td>TB-SW-03 Upgrade of existing transfer station</td>
<td>1,290,000</td>
</tr>
<tr>
<td>TB-SW-04 Construction of 2nd transfer station</td>
<td>2,570,000</td>
</tr>
<tr>
<td>TB-SW-05 Rehabilitation of leachate system</td>
<td>4,340,000</td>
</tr>
<tr>
<td>TB-SW-07 Equipment for landfill operations</td>
<td>400,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15,000,000</td>
</tr>
</tbody>
</table>

**Table 4-35: Waste Management System Tbilisi / Tbilservice group: Proposal on Investment Programme 2017 - 2019 – Approved Version November 2016**

Recommendations:

The equipment is recommended to be started in the second half of 2017.

The rehabilitation of the transfer station will require certain preparations and technical assessments, therefore a start of this package is considered only for late 2017.

Same should be considered also for the second transfer station. It has to be specially mentioned that the City has not yet made a decision about the location of this plant. It is recommended to select a suitable site latest in early 2017 in order to enable planning and design process for the facilities and tendering procedure. Construction start shall be in 2018.
The major components at the landfill are recommended to be implemented in 2018. This considers also the fact that currently several construction works for closure of sections, gas collection and extension of tipping area will be implemented in 2017. This will avoid a logistic overlap with other running construction works at the landfill.

4.8 DRAFT PROCUREMENT PLAN

Find attached draft Procurement Plan at following page.

Following has been considered:

- Prequalification is only foreseen for the package leachate at landfill. This is based on the consideration that leachate treatment is a task which requires special expertise which is available only in specialised companies. It is foreseen to use Yellow Book Procedure for the works in this component.

- The consultancy support services shall be tendered as soon as possible in order to assure project start latest by early summer 2017.

- Local design services will be required for the design of the transfer stations.

- The truck investments shall be started as soon as possible in order to assure major part of supplies within 2017.
### Tbilisi Solid Waste Management Project

**DRAFT PROCUREMENT PLAN (December 2016)**

<table>
<thead>
<tr>
<th>No</th>
<th>Contract Description</th>
<th>Estimated Contract Value (USD)</th>
<th>Financing by EBRD (USD)</th>
<th>Financing by others (USD)</th>
<th>Contract Type</th>
<th>Prequalification Method</th>
<th>Time Schedule (mm/yy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TB-SW-02 Upgrade of truck fleet, replacement of old and repair intensive trucks</td>
<td>6,400,000.00</td>
<td>5,312,000.00</td>
<td>not yet defined</td>
<td>G</td>
<td>Prequalif</td>
<td>na</td>
</tr>
<tr>
<td>2</td>
<td>TB-SW-03 Upgrade of existing transfer station</td>
<td>1,290,000.00</td>
<td>1,070,700.00</td>
<td>not yet defined</td>
<td>W</td>
<td>Open</td>
<td>na</td>
</tr>
<tr>
<td>3</td>
<td>TB-SW-04 Construction of 2nd transfer station</td>
<td>2,570,000.00</td>
<td>2,133,100.00</td>
<td>not yet defined</td>
<td>W</td>
<td>Open</td>
<td>na</td>
</tr>
<tr>
<td>4</td>
<td>TB-SW-05 Rehabilitation of leachate system</td>
<td>4,340,000.00</td>
<td>3,602,200.00</td>
<td>not yet defined</td>
<td>W</td>
<td>Open</td>
<td>07/17</td>
</tr>
<tr>
<td>5</td>
<td>TB-SW-07 Equipment for landfill operations</td>
<td>400,000.00</td>
<td>332,000.00</td>
<td>not yet defined</td>
<td>G</td>
<td>Open</td>
<td>na</td>
</tr>
<tr>
<td></td>
<td>Total Capital</td>
<td>15,862,300.00</td>
<td>12,450,000.00</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part B: Technical cooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Total TC</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

**Table 4-36: Draft Procurement Plan, December 2016**

Note: Dates need to be adjusted based on real dates of effectiveness of loan agreement.
5 **FINANCIAL ANALYSIS**

Refer to separate report.
6 OUTLINES FOR PROJECT IMPLEMENTATION PLAN

6.1 PROJECT IMPLEMENTATION UNIT – PIU

It is recommended to establish within the borrowers structure (City as borrower, TSG as operational beneficiary) a PIU which consists at least of following functions:

- PIU Director
- Accountant and Disbursement Specialist
- Procurement Expert
- Technical Expert for Waste Operations

The PIU shall be responsible on borrowers’ side for the implementation of the project. This includes also close cooperation with PIS and CDP Consultants. Tasks will be the same as usually determined in the Banks Implementation Support Agreements which are being signed in parallel to the Loan Agreement.

6.2 PROJECT IMPLEMENTATION SUPPORT – PIS

The PIS Consultant will be responsible to provide Project Implementation Support to the Borrower in the following fields, as usually determined in Banks projects:

- Support of borrower in technical and commercial and legal project management
- Planning of components, elaboration of technical specifications
- Preparation of tender documents and support in the approval process
- Support of borrower in tender procedures and establishment of contracts
- Supervision of implementation
- Support of borrower in approval of invoices and disbursements
- Support of borrower in hand-over and integration of technical components into company’s day-to-day operations

6.3 LOCAL DESIGN SERVICES

Local design services will be required for design of leachate collection and storage facilities and recirculation facilities. This design will be provided by a licensed institute and will be approved by local authorities.

Note: The leachate treatment plant will be tendered by Yellow Book based on precise functional description of required treatment standards and effluent quality.

6.4 CORPORATE DEVELOPMENT PROGRAM – CDP

Corporate Development Support is recommended for this project with special emphasis on following general goals:

- Improvement of the Company’s MIS (probably establish new modern MIS)
- Integration of operational documentation into MIS (waste collection and transport, weighing data
This Report consists of 144 pages and 23 pages attachments and has been prepared by:

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