Greater Amman Municipality

Environmental and Social Impact Assessment Report for the Amman and Amman-Zarqa Bus Rapid Transit (BRT) Systems

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1. INTRODUCTION

The city of Amman faces a number of key transportation challenges; Amman has a population of about four million inhabitants and is expected to grow to over five million by 2025. The growth in travel demand is concentrated in a number of specific growth areas and on the axes which serve and link those areas. The road system which serves the growth centres and the major axes is already overloaded and even moderate growth may result in significant congestion.

Amman currently has a poorly developed public passenger transport system and a relatively low public transport mode share of 14% (mostly Taxis which have a mode share of 9%) [1]. The majority of public transport trips are made by car-based services, either shared taxi or regular taxi. Currently, there is no rapid transit or high capacity passenger transportation in Amman. The current public transport network is small, does not adequately serve the urban area, and is not yet subject to a permanent and stable regulatory framework.

The Amman-Zarqa corridor is a heavily used transport corridor with an estimated 150,000-200,000 daily trips between the two cities [2]. The City of Zarqa, located about 20 km to the northeast of Amman, currently has a population of about 1 million and is expected to grow to over 1.39 million by 2025. Existing demand is high and is predicted to rise in future years. Public transport mode share along the corridor is over two thirds of the current demand, however, this demand is distributed on a multitude of modes, including large buses, medium buses, and service taxis. Current public transport on the corridor are crowded, unreliable, and do not provide an adequate alternative to the use of private vehicles.

In order to face this growth of population and mobility in the Amman-Zarqa metropolitan area, the Ministry of Transport of the Hashemite Kingdom of Jordan plans to develop a mass public transport system between these two cities and inside Amman city. Several studies have been carried out, allowing the determination of the main characteristics of the project.

The BRT projects for Amman and Amman -Zarqa have been developed separately in terms of design and construction, but the government and GAM plan to integrate the operations of the two systems. This ESIA study focused on the updated design and construction plans of the BRT in Amman and the integrated operation of the entire BRT system (including Amman - Zarqa section). It covers the updated Amman BRT project design and mentions the Amman-Zarqa design as it is described without changing any of the assumptions in the previously approved Amman - Zarqa BRT ESIA.

1.1 BACKGROUND TO THE BRT PROJECT

The BRT system will consist of three corridors; two corridors (BRT 1 and BRT 2) are proposed inside Amman, another corridor (BRT 3) is also proposed between Amman and Zarqa. Each corridor will include terminals, stations and the roadway within which the BRT running way is placed. The BRT project will utilize the existing bus terminals at Al-Mahattah and Zarqa and new terminal will be constructed near Swuayleh Roundabout. For BRT 1 and BRT2 stations will be constructed every 500 meters and only 4 stations will be constructed along BRT 3

All stations along the three corridors will be placed where passengers can transfer from/to feeder-trunk lines or major points of demand. BRT stops are linear, one-mode stops to alight/board or reverse direction. The Bus Rapid Transit project will exclusively dedicate lanes along each corridor for high speed services in a feasible and practical manner. Enclosed stations with height matching vehicle floors will provide level boarding. Ticketing for the BRT system will initially be based on smart card and paper systems.

For BRT 1 and BRT 2 , busses will have exclusive use of the running ways. Although median-running ways for the BRT would mostly be selected, there are several locations (e.g. at interchanges, terminals and the University of Jordan) where a side running bus-way will be more desirable if it can be achieved because it will provide better access for passengers.

For BRT 3 the proposed project constitute rehabilitation and re-construction of existing main artery road (Autostrad) connecting Amman with Zarqa, and accordingly the existing road bridges and junctions, to accommodate dedicated road lines for the operation of the BRT. Most of the proposed works are planned within the Right of Way (ROW) of the existing road.

Lateral side platform stations within the median bus-way may be necessary if low floor buses are used. If high floor buses are to be used then central platforms will be needed so that the driver (who would be on the same side as the door) can see waiting passengers when stopping. It is desirable to have bus passing lanes at stations but in many instances will be unachievable due to width constraints.

A depot to support BRT operations will be part of the BRT system. The requirements for a BRT depot will depend on the operational arrangements proposed for the system but is not part of this ESIA.

The BRT system is expected to be integrated with the existing public transport services and any changes to these services due to future transport strategies and regulations.

1.2 PURPOSE OF THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

Development projects in Jordan are required to prepare an environmental and social impact assessment (ESIA) to ensure compliance with Law No. 6 for 2017 and the regulations issued under the authority of this law. The Law requires that all projects that are likely to produce negative impacts on the environment undertake an evaluation of their potential environmental impacts and develop plans and measures to reduce these impacts.

Regulation No. 37 for 2005 – Regulation on Environmental Impact Assessment provides direction for conducting environmental impact assessments for different types of projects and lists the main issues that should be covered by the EIA. It also categorizes types of projects and the corresponding environmental assessment that would be required. Based on Appendix 3 of Regulation 37, the BRT project is categorized under those projects that require an initial environmental assessment. According to the regulation, if the initial environmental assessment reveals that significant environmental impacts are expected from the project, a full and comprehensive environmental impact assessment will then become warranted.

The terms of reference for preparing this Environmental and Social Assessment (ESIA) require an identification and evaluation of the environmental and social impacts and proposing mitigation measures appropriate to these impacts. Specifically, this ESIA is expected to:

a. **Describe, analyze, and characterize the environmental and social aspects of the area of influence of the Project.** The Environmental Assessment must cover potential impacts, e.g., loss of trees, increased pollution levels, health and safety, etc., and appropriate mitigation measures and management arrangements as part of the preparation and implementation of an Environmental Management Plan.

b. **Identify special management areas that are environmentally or socially sensitive.** The ESIA should address the BRT corridors, terminals and interchanges.

c. **Prepare Environmental and Social Impact Assessment (ESIA) and Environmental Management Plan (EMP).** The Environmental Management Plan will summaries anticipated environmental and social impacts of the project and will provide details on the measures, responsibilities and scheduling to mitigate these impacts, as well as costs of mitigation and monitoring. The EMP will provide a critical link between the mitigation measures specified in the ESIA and the integration of such measures during the implementation and operation of the project.

1.3 APPROACH AND METHODOLOGY AND SCOPE OF ESIA

The ESIA describes the existing environmental conditions in the project's area of influence and predicts the key environmental impacts that are expected to affect the natural and human environment. This covers the main BRT routes and their surroundings. It also presents measures and plans that will reduce likely negative impacts to acceptable levels.

It became evident during the course of the environmental assessment process that there would be no need for resettlement of displaced people as a consequence to implementing or operating the BRT project. This is mainly due to the fact that the BRT alignment follows existing roads and highways and the project's stations, depot(s) and facilities will all be constructed on land owned by GAM or within the existing ROW.

For BRT 1 and BRT 2 land acquisition will be required for approximately 13 Dunam this area is distributed over 20 locations of thin land stripes that are immediately adjacent to roads that shall have the BRT project. In general, the project will cause no significant infringement on private properties, local communities or their land.

Some land acquisition may be required for BRT 3, specifically for detours and diversions during the project construction, this impact cannot be assessed at this stage given that detailed construction traffic management plan are required from each contractor.

The general approach followed in conducting the ESIA for the BRT project is based on the extensive experience of the study preparers working on infrastructure projects in Jordan. It establishes the basis upon which project implementation would proceed on environmentally sustainable principles.

It was deemed that no formal consultations with the general public will be needed for the purpose of preparing the ESIA. However, consultations, discussions and meetings with key stakeholders, mainly governmental departments, were conducted by the project team, and relevant feedback was used to inform the study.

1.3.1 ESIA Methodology

This ESIA study is based on compiling and updating the outcomes of previous ESIAs which were previously developed for the Amman BRT and Zarqa BRT separately in addition to developing original content related to Air and noise field monitoring, Noise modeling, CO2 emissions calculations, and Socioeconomic effects with focus of the effects on the current public transportation in the BRT corridors. The existing ESIA's that were updated are:

- Environmental & Social Impact Assessment Study of Amman Bus Rapid Transit, prepared by Sigma Group,2007

- Environmental & Social Impact Assessment Study of Amman – Zarqa Bus Rapid Transit, prepared by Dar Al Omran, 2016

The work methodology for developing the new ESIA consisted of:

- **Review of Information and Details of the BRT Project**

The background of the BRT project was established to confirm its scope and activities. This included definition of the objectives, history, activities and the current status of the project area.

- **Review of the Regulatory and Institutional Framework for Environmental Assessment in Jordan**

This consisted of reviewing and updating the local Jordanian regulations and the World Bank requirements to describe the regulatory and institutional setting for preparing environmental assessments in Jordan. The review included obligations and commitments through regional and international conventions, treaties and agreements in addition to other legislation applying to the project such as traffic, air quality, noise, and occupational health and safety requirements.

- **Air Quality and Noise Monitoring**

A mobile Air Quality Monitoring (AQM) station, equipped with US-EPA approved analyzers was used to monitor and assess the air quality by continuously measuring the concentrations of; Sulfur Dioxide (SO2) Nitrogen Oxides (NOX, NO & NO2) Carbon Monoxide (CO) and Particulate Matter (PM10) at three different locations along the project alignment.

Spot noise monitoring was carried out at three location in order to determine the ambient baseline sound level profile, measurements were undertaken using data logging Sound Level Meter Model.

- **CO_2 Reduction Calculation**

Carbon foot print of the total traffic on the BRT corridors were calculated for the year 2018 for all the BRT routes both for baseline conditions assuming no BRT project and for the BRT project.

- **Noise Impact Modeling and Assessment**

Noise modeling was developed for the three BRT routs. Efforts were focused on identification of sensitive receptors around the BRT routes and estimate the total noise exposure from traffic at those receptors for both baseline conditions assuming no BRT project and for the BRT project.

- **Assess Likely Impacts and Prescribe Mitigation Measures**

Potential environmental impacts that may arise from the construction and operation of the BRT project were assessed in a systematic process. The assessment

considered whether the impacts are positive or negative; their spatial magnitude and severity; impact duration and time scale; project phase that the impact occurs in; sensitivity of the affected environment; and whether the impact is reversible or not.

Following the assessment of impacts, practical measures were prescribed for each phase of the project in order to minimize adverse environmental impacts and enhance environmental and social benefits.

- **Prepare an Environmental Management and Monitoring Plan**

An Environmental Management Plan (EMP) was prepared to provide control strategies to ensure that there is no unacceptable environmental harm due to the project. The EMP contains guidelines for undertaking specific activities during the construction and post-construction operations of the project.

- **Prepare Environmental and Social Impact Assessment Report (ESIA)**

The Environmental and Social Impact Assessment report details the findings of the environmental assessment process.

1.3.2 Methodology for Baseline Surveys

Baseline information were compiled for the field surveys developed in the previous ESIA's with updating the results, desk studies for obtaining updated data, and new air and noise measurements which were all undertaken to evaluate the local environment, its features and particular sensitivities.

This study covered the BRT routes, terminals and other related facilities that are planned as part of the BRT scheme. Following is a description and methodology for each the baseline conditions.

Ecology and Biodiversity

Study of the ecology and biodiversity enabled the assessment of the direct and indirect impacts of the BRT project on the terrestrial biological environment in the project area. This study included the following components:

- Bio-geographical zones
- Fauna and Flora of the project area. This included vegetation cover, vegetation communities, rare and endangered plant species, rodents, mammals, birds, and reptiles
- Sensitive habitats and areas that support species of particular importance

The assessment explored any inter-relationships between wildlife species and their physical environment in order to assess the effects of the expected impacts on biodiversity in the affected areas.

The methodology used to survey the existing biodiversity in the project area was based a literature review that covered reviewing and updating available information about the projects biological environment based on the previous ESIA studies [2,3]

Soil, Geology and Water Resources

Study of the soil, geology, surface and groundwater resources in the project area enabled the assessment of impacts from project activities on these features and proposing mitigation measures.

The methodology used to study the soil, geology and water resources was based on the following:

- Literature review: This covered reviewing and compiling the available information about the projects area soil type, geology and water resources based on the previous ESIA studies [2,3].
- Updating the available information on rainfall and climate.

Socio-economic Conditions

Assessment of socio-economic conditions in the project area was based on developing new content related to the socio-economic baseline conditions and related to the effects of the BRT on the existing public transportation lines, available data from the previous EIA studies [2,3] in addition to the updated land acquisition plan for the latest project design. The data primarily covers issues that are directly relevant to the project.

Cultural Resources

Information on sites of archeological and cultural heritage significance within project was compiled from the previous EIA studied [2,3] in order to identify if any of these sites may be affected by the project construction and/or operation.

Noise and Air Quality

An up to date air quality data records were obtained from the Ministry of Environment (MoE), these data were analyzed to characterize the air quality in the area influenced by the BRT scheme. Field monitoring of ambient air quality and noise were also conducted for the purpose good documentation of the baseline Air quality prior to the BRT project. The main parameters tested were noise, SO2, O3, NO2, PM10 and CO. This enabled predicting public health and occupational health and safety impacts from project construction on the ambient air quality in the area along the BRT routes.

1.4 ESIA REPORT ORGANIZATION

This report is organized into the following sections:

1. Introduction
2. Description of the Project
3. Legislative and Institutional Framework
4. Description of the Existing Environment and Socioeconomic Condition
5. Identification and Assessment of Impacts and Proposed Mitigation Measures
6. Environmental and Social Management and Monitoring Plan
7. Guidance for the Bus Depot site selection
8. Appendices

The following appendices are included with the main report:

Appendix A: Buses, Coasters and Serfeeses affected by BRT.

Appendix B: Air and Noise Monitoring Report.

Appendix C: CO2 Calculation

Appendix D: Noise Impact Assessment Sheet

2. DESCRIPTION OF THE PROJECT

The proposed Bus Rapid Transit system will consist of three distinct lines that will utilize existing roads, highways, expressways, and streets in Amman and Zarqa. The following sections describe the three proposed BRT lines, their routes and primary project features.

2.1 BRT LINE 1 (AL MAHATTAH TO SWUAYLEH)

This BRT line will extend from Al Mahattah terminal to Swuayleh via Sports City and the University of Jordan (Queen Rania Street). As shown in Figure 2-1 Line 1 is approximately 15.5 km long and has the following alignment: Mahattah Terminal– (crossing of Jaysh Street) – Isstiqlal Street - Prince Hamzah Bin Al Hussein Street-Habes Al-Majali - Aqsa Street - Shaheed Street - Queen Rania Street-Swuayleh Roundabout.

According to surveys undertaken in 2007 [3], Line 1 carries the second highest public transport demand in Amman. It provides direct service to the University of Jordan campus as well as other nearby colleges. The corridor's length is divided by the Sport City roundabout/interchange into two almost equal sections of approximately 8 km in length.

The northern section of the corridor (along Queen Rania Street) is a major 6-lane divided arterial with additional auxiliary lanes and/or service road in some locations. The southern section of the corridor is made up of Al Shaheed Street (4-6 lanes), Aqsa Street (4 lanes), Habes Al Majali (4 lanes), Prince Hamzah Bin al Hussein (4 lanes).

2.2 BRT LINE 2 (AL MUHAJEREEN TO SPORT CITY)

This BRT line will extend from Museum Square to Sports City via Princess Basma Street. It is a partial orbital route that connects Al Muhajereen terminal to Sports City, where it will provide interchange opportunity with Line 1. As shown in Figure 2-2 Line 2 is approximately 8.5 km long and follows the alignment of Museum Square – Ali Bin Abi Taleb Street – Princess Basma Street – Al-Kindi Street – Nasser Bin Jameel Street – Sports City.

Line 2 passes through a variety of land uses connecting the central area with the business district and Sports City. Along Princess Basma Street, Line 2 passes through an area with significant development potential giving this route an important connecting role in the present as well as in the future when its importance will intensify as development takes place.

2.3 BRT LINE 3 (AMMAN TO ZARQA)

This BRT corridor has been selected from four alternative corridors, Autostrad corridor was chosen as the Amman – Zarqa corridor because it is the best suited corridor for interurban relations. This BRT line will connect Al Mahattah terminal in Amman to the Old Bus Terminal in Zarqa via Amman-Zarqa AutoStrad (Al Shaheed Street). As shown in Figure 2-3 Line 3 is approximately 19.3 km long and has the following alignment: Mahattah Terminal – King Abdullah I Street – Army Street – Ein Ghazal Interchange – Army Street – Marka Bridge – Pepsi Interchange – Amman Corridor Interchange – Damascus Highway Interchange – Zarqa Terminal.

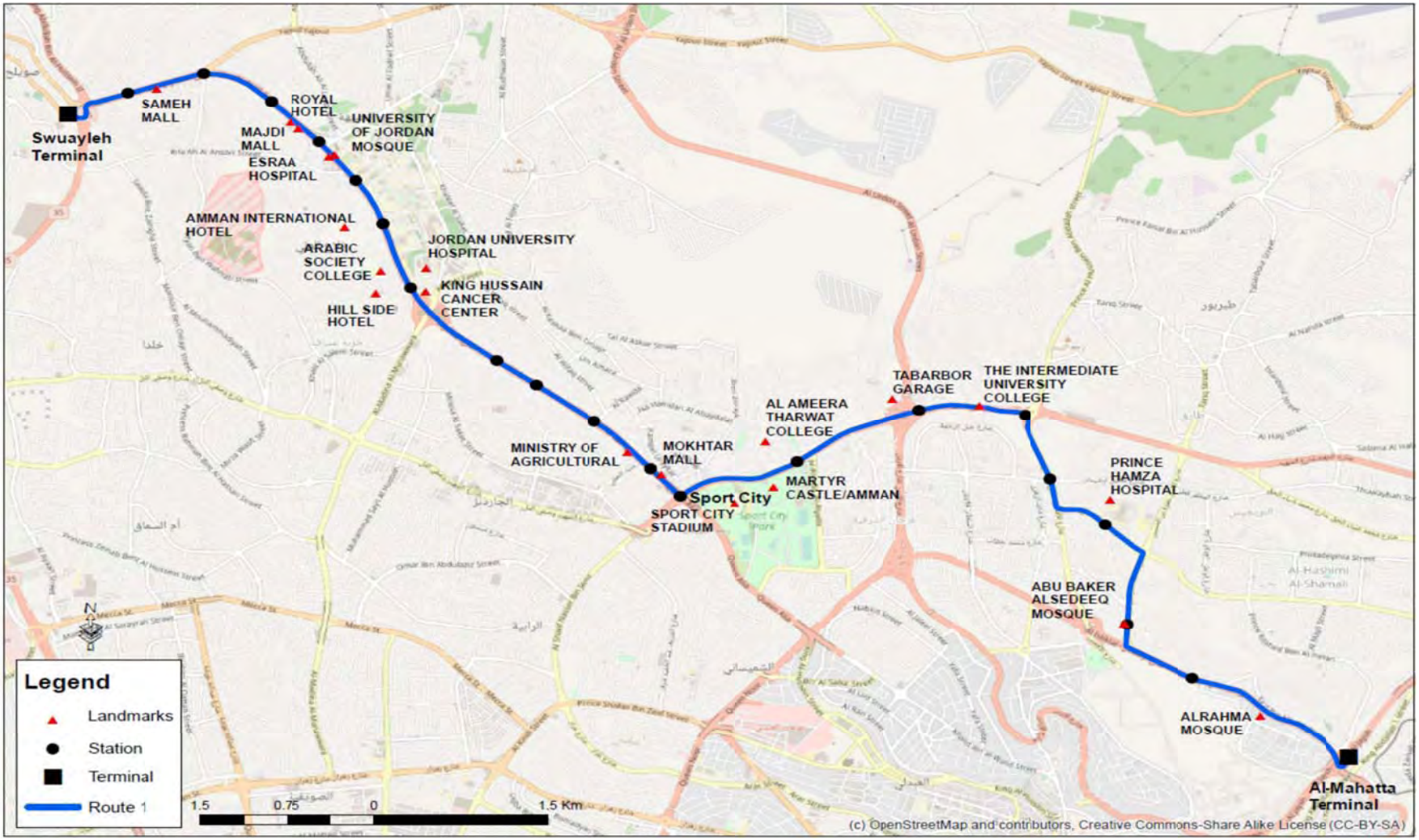


Figure 2-1: BRT Line 1 (Al Mahattah to Swuayleh)

Figure 2-2: BRT Line 2 (Al Muhajereen to Sport City)

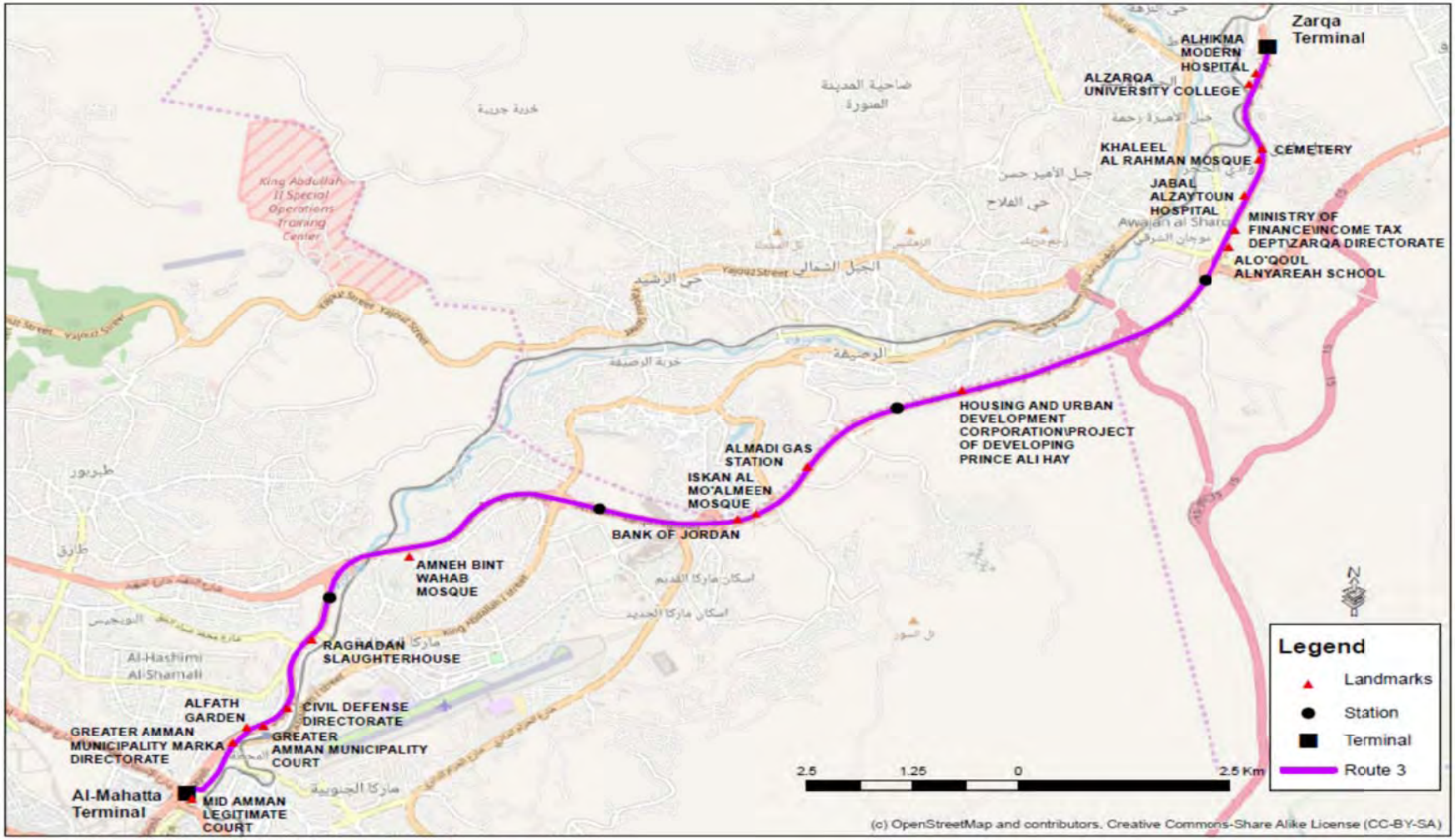


Figure 2-3: BRT Line 3 (Al Mahattah to Zarqa)

2.4 BRT STATIONS AND TERMINALS

The BRT Line 1 and BRT Line 2 will include stations located approximately 500m apart along the entire length of each of the two designated routes. These stations will be above-ground except at the University of Jordan where Line 1 BRT will be provided with below-grade station. The stations will use a simple design and will be constructed within the ROW of the roads.

For BRT line 3 only four intermediate stations will be constructed between Al Mahattah Terminal and Zarqa Terminal.

- Marka Road station
- Balqa University station
- Russaifa station
- South Zarqa station

Each station is located in the middle of the road and is accessible to pedestrians through pedestrian bridges. Lifts and stairs link both sides to the platform. The station is a paid area with controlled access. Two articulated BRT vehicles can dwell at the same time in each direction. A parking place that can accommodate an articulated BRT vehicle is set at each end of the station. Feeder lines are necessary to bring passengers to BRT stations. Figure 2-6 below shows the stations location along BRT Line 1, 2 and 3

2.5 INTERSECTION SOLUTION PROJECTS ALONG BRT 1 AND 2 ALIGNMENT

Sport City Tunnel

This project involves construction of two highway ramp bridges for general traffic (with a total combined length of around 500m), the construction of U-shape underpass for BRT, the construction of a BRT running way comprising two segregated lanes, the construction of an at-grade bus station over the existing underpass the installation of a complex traffic signalling system, the construction of sidewalks, the construction of several retaining walls and the construction of an appropriate storm water drainage system in the area. Works will also include the demolition and relocation of utilities (see Figure 2-4).

Press Tunnel

This intersection consists of construction of an overpass at the Press (Sahafeh) tunnel on Queen Rania Street. The overpass will be dedicated for the BRT use only. In addition to the overpass, which will only serve BRT traffic, a BRT stations will be established as part of this project (see Figure 2-5).

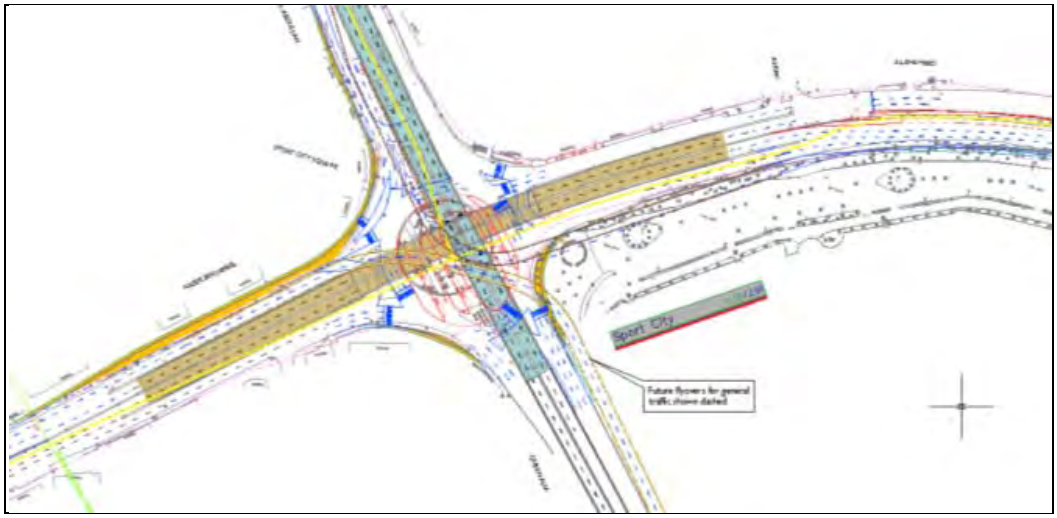


Figure 2-4: Sport City Intersection

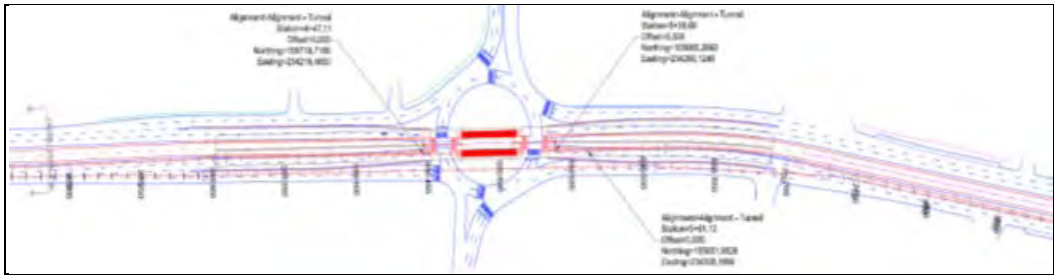


Figure 2-5: Press Tunnel

Figure 2-6: Stations Locations on BRT Lines 1, 2 and 3

3. LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

This section outlines the policies, law and regulations relevant to socio-economic and environment issues in the Hashemite Kingdom of Jordan and describes relevant international conventions and treaties signed and ratified by Jordan and incorporated into the national law.

Environment is defined by the Environmental Protection Law No. 6 for the Year 2017, as the surroundings which include the living and nonliving beings, the materials contained, and what surrounds it, such as air, water, soil, and interactions of any of them, as well as the establishments built by the human being.

The protection of environment, ensuring health environment and conserving nature is not luxury, in fact it is a basic right for all people, and certainly it is the right of future generations. Thereto, the government of Jordan prepared in the last decades many environmental legislations and policies to ensure the protection of environment and to ensure the sustainability of its resources.

3.1 POLICIES AND STRATEGIES

This sub-section presents the national policies and strategies in Jordan that may have an impact on the environmental aspects of the BRT project. These are mainly related to environment, health, natural resources, education, urban planning and nature conservation.

3.2 GAM POLICIES

GAM's strives to develop Amman to become a green, modern, and resilient city while continuing to provide the essential services to the city inhabitants. In the year 2017 GAM launched its first city wide strategy. This strategy focuses of developing green economy projects and on developing resilient of the city to resist modern day challenges. This strategy involved 5 pillars, 16 goals and 54 actions including:

- An integrated and smart city this includes improving the mobility systems, promote walkability, institutionalize planning in the city, and connect the city digitally.
- An environmentally proactive city this includes management and fulfilling climate change commitments, improve energy efficiency and energy security, apply green building codes and guidelines, manage water resources efficiency, and improve waste management system
- An innovative and prosperous city this includes leverage of existing human capital to create employment, support entrepreneurs, start-ups and incubators, empower women
- A young and equal city this includes integrates and engages young people equally, and support our youth through cultural campaigns.

- A united and proud city this includes promote a sense of belonging amongst citizens and promote participation and engagement

The BRT is one of the projects that fulfills several of these objectives.

GAM's policy on transit is well stated in the Metropolitan Growth Plan (MGP) on transit. It states that "MGP seeks to substantially enhance transit service in Amman with the goal of greatly increasing transit ridership and attracting a broad cross section of citizens. Transit planning emphasizes the creation of transit routes with high-quality, reliable, predictable, comfortable, and efficient services". The MGP calls for facilitating the development of "a safe and modern transit system" in the city.

On bus transit, the MGP states that "Major bus service will be provided within designated corridors that have suitable transit-supportive high-density and mixed-use development in place". The plan is to enable these designated corridors to expedite the efficient movement of buses using exclusive transit lanes.

3.3 TRANSPORT POLICIES

The National Transport Policy of Jordan for the years 2015-2017 has been formulated by the Ministry of Transport. It lists one of the four main national goals as "Improve quality and preservation of the environment". The Strategy for public transport includes a policy theme that calls for promoting social mobility by improving the mobility of urban and rural population with a key program for developing environmentally sustainable public transport services.

3.4 WORLD BANK POLICIES

Transportation is normally the Bank's third (and sometimes second) largest sector in terms of yearly loan and credit totals. The operations of the World Bank are guided by a comprehensive set of policies and procedures that address the Bank's core development objectives and goals, the instruments for pursuing them, and specific requirements for Bank-financed operations. The World Bank requires environmental assessment (EA) for projects to help ensure that they are environmentally sound and sustainable. The Bank's Operational Policy 4.01- Environmental Assessment of January 1999 - applies to the BRT project.

With respect to World Bank's Safeguard Policies,**Error! Reference source not found.** Table 3-1 summarize applicable policies to the BRT project:

Table 3-1: World Bank Safeguard Policies Relevant to the BRT Project

APPLICABLE WORLD BANK SAFEGUARD POLICIES		
Policy	**Summary of Core Requirements**	**BRT Project Compliance**
OP/BP 4.01 Environmental	Seeks to ensure sound and sustainable environmental assessment (EA) of projects proposed for the World Bank for financing in	The BRT project is expected to comply. This environmental assessment clearly

APPLICABLE WORLD BANK SAFEGUARD POLICIES		
Policy	**Summary of Core Requirements**	**BRT Project Compliance**
Assessment	order to assist in decision making. The EA should be initiated as early as possible in project processing and integrated closely with the economic, financial, institutional, social and technical analyses of the proposed project.	demonstrates that environmental and social impacts from the BRT project were identified, analyzed and addressed through a systematic process.
OP/BP 4.04 Natural Habitats	Seeks to ensure that World Bank-supported infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society. The Bank does not finance projects that degrade or convert critical habitats. The Bank supports projects that affect noncritical habitats only if no alternatives are available and if acceptable mitigation measures are in place.	The BRT project is expected to comply as the project does not degrade any natural habitats or threaten species.
OP/BP 4.12 Involuntary Resettlement	This policy is triggered in situations involving involuntary taking of land and involuntary restrictions of access to legally designated parks and protected areas. The objective of this policy is to assist physically or economically displaced persons in their efforts to improve or at least restore their standards of living.	Project complies. The BRT lines are mostly located within existing roads/highways that is owned by the government. A few privately-owned plots will be affected. Fair and just compensation will be offered to affected parties.
OPN 11.03 Cultural Property (Draft OP 4.11)	Investigate and inventory cultural resources potentially affected. Include mitigation measures when there are adverse impacts on physical cultural resources. This is to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.	Project is expected to comply: No historic or culturally important features are expected to be affected on the project sites or its surroundings provided proper mitigation is applied by the project developer.
OP: Operational Policy, BP: Bank Policy, OPN: Operational Policy Note		

3.5 RELEVANT LAWS AND REGULATIONS IN JORDAN

The Environment Protection Law (Law No. 6 for the year 2017), the MOE is entrusted with the responsibility of the protection and monitoring of all environmental elements in coordination with concerned government bodies, national, regional and international organizations. In addition, the law mandates the MOE to draft necessary by-laws, instructions, standards, etc. for environmental elements, which includes water, air, land, noise control, etc.

Article 5 of this law (Environmental Protection Law) stated that:

a. For the purpose of environmental licensing, the establishments are classified based on the risk of its activities on the environment, provided that such establishments shall be determined by regulations issued for this purpose.

b. Before obtaining the environmental licensing, the establishment should submit an environmental impact assessment study that is prepared by one of the consultants who are approved by the ministry.

c. The licensed establishment should inform the ministry before any modification or expansion to obtain an advanced approval from the ministry according to the regulations issued for this purpose.

d. The Minister can obligate the establishment to execute an environmental audit study in case the establishment's activities cause / can cause any environmental harm.

e. An environmental audit study shall be executed by all the establishments that are created prior to the provisions' enforcement of this law, and all the establishments are practicing any high-risk activities, and all the establishments that have environmental effects or might cause environmental effects, according to the provisions of this law and regulations that are issued under it and the establishments did not obtain the environmental approval from the Ministry.

f. The obtained environmental authorization shall be renewed according to the regulations of the environmental licensing system.

The law also gives the ministry the right to environmentally supervise these projects, were any violation to the provisions of the regulations and instructions relating to the protection of environment or non-compliance with the approved mitigation measures makes the project subject to penalties.

The EIA regulation No. 37 of the year 2005 provides with categorization of the projects as per of the nature of the project and the obligations for preparing comprehensive or preliminary EIAs. The regulation also describes to the EIA procedures and scope of work.

Jordanian Air Standards and Regulations, Ambient air quality standards have been established in Jordan for certain pollutants that are considered to be harmful to the public and the environment. These standards define the maximum allowable concentrations and number of exceedances for pollutants over a given averaging period. Some of the air pollutants that have standards (JS 1140/2006) are shown in **Table 3-2**:

Table 3-2: Jordanian Ambient Air Quality Standards (JS 1140/2006)

Pollution	Averaging Period	Maximum Limit		Number of Allowable Exceedances
		ppm*	µg/m^3**	
SO2	1-hour	0.3	786	3 times during any 30 consecutive days per year
	24-hours	0.14	367	1 time during any 12 months

Pollution	Averaging Period	Maximum Limit		Number of Allowable Exceedances
		ppm*	µg/m^3**	
NO2	Annual	0.4	105	---
	1-hour	0.21	395	3 times during any 30 consecutive days per year
	24-hours	0.8	151	3 time during any 12 months
	Annual	0.5	94	--
CO	1-hour	26	29,786	3 times during any 30 consecutive days in the year
	8-hours	9	10,311	3 times during any 30 consecutive days in the year
O3	8-hours	0.08	160	--
	1-hour	0.12	240	--
PM10	24-hours	--	120	3 times during any 12 months
	Annual	--	70	--

* ppm: parts per million

** µg/m^3: microgram per cubic meter

Jordanian Noise Standards and Regulations, The Ministry of Environment issued a regulation in 2003 titled "Prevention and Protection from Noise" which defines the permissible limits for noise emissions as shown in **Table 3-3**. This regulation also lists prohibited noise-generating activities. It states that operating construction equipment including heavy machinery should be limited to the period of time from 8 AM until 6 PM. It should be noted that such limits apply outside the construction sites while noise limits set by the Ministry of Labor regulate the noise environment inside work sites.

Table 3-3: Maximum Permissible Noise Limits in Jordan (dBA)

Location	Noise Level (dBA)	
	Day Time	Night Time
Residential zones inside cities	60	50
Residential zones inside suburbs	55	45
Residential zones inside villages	50	40
Residential zones where: there are workshops or commercial activities, or business and administrative zones, or downtown	65	55
Industrial areas (light industries)	75	65
Places of education, worship, medical centers, hospitals	45	35

Source: Ministry of Environment Regulation on Noise, 2003

Furthermore, other major indirectly related Jordanian laws, Regulations, Instructions and standards are presented hereinafter:

- Natural Resources Law No.12-1968 (and its amendments)
- Quarries Law No.1/1971
- Water Authority Law No. 18-1988 and its amendments
- The Public Health Law No. 47/2008 (and its amendments)
- The Agriculture Law No.44 – 2002
- Municipalities Law No.29-1955 (and its amendments)
- Antiquities Law No. (21) of 1988
- Traffic Law No. 49, 2008.
- Passenger Transport Regulation Law No. 19, 2017
- Civil Defense Law (No. 18, 1999)
- Renewable Energy and Energy Management Law No.13/2012
- Organization cities , villages and building Law No.79-1966 (and its amendments)
- Mining Bylaw No.131/1966
- Groundwater Control By-Law No. 85/2002
- Wastewater Collection and Disposal By-Law No.66/1994
- "Hazardous & Harmful" Materials Usage and Management Regulation No.24 /2005
- Soil Protection Regulation No.25/2005
- Environmental Protection and Pollution Prevention in Emergency Cases Regulation No.26 /2005
- Solid Wastes Management Regulation No.27 - 2005
- Land use Planning Regulation No.6-2007
- Axial Loads Bylaw No.47/2001
- Instruction For The Management of Consumed Oil and its usage -2003
- Instructions for the Protection of Water Sources Used for Drinking -2012
- Instructions for the Disposal of Non-Domestic Wastewater to the Wastewater Collection System-1988
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1979
- Regulations for protection of birds and wildlife and roles covering their hunting (No. 113, 1973)
- UN Convention on Biological Diversity (CBD 1994)
- JS1140-2006: Air Quality
- JS286-2008: Water- Drinking Water
- JS893 -2006: Water - Usage of Reclaimed Domestic Wastewater

3.6 REGIONAL AND INTERNATIONAL TREATIES

Jordan has entered in and signed a number of international and regional agreements with other countries and entities, **Table 3-4** some relevant regional and international treaties to the EIA study of this project.

Table 3-4: Relevant Treaties, Conventions and International Agreements

Treaty / Convention / Agreement	Description	Year in force
The United Nations Framework Convention on Climate Change	Calls for stabilization of greenhouse gases, and requires Parties to prepare greenhouse gas inventories.	1994
Vienna Convention for the Protection of the Ozone Layer (The Ozone Convention)	Regulates domestic production and consumption of greenhouse gases.	1985
Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	Combats desertification and mitigates the effects of drought.	1994
The United Nations Convention on Biological Diversity (Bonn Convention)	Calls for identification and monitoring of biodiversity components and for establishment of protected areas and emergency response plans	1993

3.7 INSTITUTIONS FRAMEWORK

Various governmental institutions are involved in a way or another in environmental protection, where the prime responsibility is assigned to the Ministry of Environment, however, other governmental institutions are also involved including the Ministry of Public Health, Ministry of Water and Irrigation, Ministry of Agriculture, Ministry of Tourism, Ministry of Energy and Mineral Resources/the Energy and Mineral Regulatory Commission, Ministry of Planning, in addition to GAM. Each of these institutions has articles in their respective laws granting them the responsibility to maintain and monitor some aspects of environmental quality.

Similar to environment protection, responsibilities for implementation of social related regulations falls with the mandate of many governmental organizations including the Ministry of Social Affairs, Ministry of Labor, the National Centre for Human Rights (NCHR), etc.

Other than the Project Owner; the Ministry of Transport, the following sections present governmental, semi-governmental and non-governmental organizations directly and indirectly regard to the implementation of the subject BRT Project. Directly related organizations include:

3.7.1 Greater Amman Municipality

GAM mandate to serve the city inhabitants is wide spread and includes several types of responsibilities including traffic management on Amman roads, sanitation of the city, organization of construction activities, road maintenance, and public transportation. More specifically GAM's responsibilities include:

GAM's Traffic Department

The Traffic Department at GAM has the following main responsibilities:

- Planning and organizing traffic in the streets in the Municipality's boundaries.
- Implementing and auditing of the Municipality policy of using and operating the road network and upgrade efficiency.
- Improving the traffic situation to help citizens travel easily, safely and quickly using the state of the art technology methods. Operating and maintaining traffic equipment and control of the traffic lights, paints, signs, lighting roads, cameras, traffic tickets) and whatever may arise.
- Preparation of engineering designs to ensure the smooth flow of traffic at intersections and streets and critical sites.
- Collecting and organizing information and traffic statistics and traffic studies.
- Preparation of traffic awareness programs for drivers and pedestrians.

GAM's Traffic Department is expected to be involved in project monitoring during both the construction and operational phases of the BRT project. During construction, the Department will be involved in planning, organizing and monitoring traffic on detours and roads adjacent to active construction sites. When the BRT lines become operational, the Department will monitor the flow of vehicle and pedestrian traffic and collecting and analyzing data and information on traffic on BRT lines.

GAM's Environment and Public Sanitation Department

The Environment and Public Sanitation Department is responsible for upgrading the environmental and health conditions in Amman by ensuring public cleanliness in the City. It follows up and supervises all activities related to the disposal and management of solid waste including collecting and transferring, establishing converter stations, and final waste disposal. This Department will be involved in monitoring solid waste disposal during the construction phase of the BRT as well as ensuring proper collection, transfer and disposal of wastes generated from users of the BRT service.

GAM's Public Works Department

The Public Works Department will play a major role during the construction phase of the BRT project. The Department supervises the Municipality's tenders involving construction projects and monitors contractors' works to verify the extent of their

compliance to the tender provisions. It also follows up on the removal of obstacles that impede implementation of contracts, in coordination with the concerned departments in GAM. The Department has the authority to monitor the quality of performance, to take laboratory samples, and to prepare financial payment schedules for the completed works.

GAM's Road Maintenance Department

This department will play an important role in when the BRT system is operational as it is in charge of maintaining a suitable condition of the roads particularly in the following areas which fall within the Department's scope:

- Implementing plans for providing the asphalt mixture for streets.
- Treating water collection in the streets that can be solved by asphalt pavement.
- Amend the levels of the services of rainwater manholes and related infrastructure.
- Removal of snow from street in winter.
- Participate in GAM’s operation room in cases of emergency.

GAM's Public Transportation Department

As the department that is responsible for organizing transportation of citizens within the boundaries of the Municipality, this department will be involved in monitoring the operation of the BRT lines including its efficiency and any public transportation problems that arise from the operation of the BRT.

3.7.2 The Ministry of Environment (MOE)

Under the provision of Article 3 and Article 4 of The Environment Protection Law (Law No. 6 for the year 2017), the MOE is the considered the concerned authority in Jordan for environment protection on national, regional and international level. In addition, all sectors, whether governmental, non-governmental organizations or the public, have to implement the procedures, instruction, etc. issued by the MOE. Also, they have to coordinate with the MOE in relation to environmental issues when dealing with the donors.

Throughout the Environment Protection Law, there are references to working in “co-ordination and co-operation of the relevant authorities.” A significant component of environmental management capacity in Jordan is dependent on the success the MOE has in working in cooperation with other ministries and the private sector that have technical capacity and experience to monitor and verify environmental performance in particular sectors. For example, the Ministry of Water and Irrigation and the Ministry of Health monitor water quality, with some of the data collected by private industry.

3.7.3 The Ministry of Public Works and Housing (MPWH)

The MPWH is responsible for the construction and maintenance of infrastructure in Jordan including the major transportation infrastructure (highways, road, etc.) that connect the main cities, towns, residential areas, industrial zones, tourist sites, etc. together. In addition, it is responsible for connecting Jordan to its neighboring countries by major highways. The Road Studies Directorate established Environment Unite to ensure compliance with the roads projects environmental obligations. Furthermore, the MPWH is responsible for constructing and maintaining government buildings and the capacity development of the building sector in Jordan. . Specifically, MPWH responsibilities include:

- Setting transportation plans (construction and maintenance) for cities, towns, villages and rural areas.
- Designing and supervising the construction of government buildings.
- Conducting testing on construction material to ensure adherence to standards and specification.
- Conducting research and studies on roads and buildings.
- Drafting legislation and standards related to buildings and roads.
- Upgrading criteria and methods for construction design and maintenance.
- Coordinating with concerned parties on road and buildings related issues

3.7.4 Ministry of Municipal Affairs (MMA)

(MMA) is concerned with this project since it is in charge of urban planning and solid waste management. MMA operates in the region through the Municipalities which also provides with other municipal services. The proposed project falls within the mandate of Greater Amman Municipality, Russeifah Municipality and Zarqa Municipality.

3.7.5 The Ministry of Agriculture (MOA)

Given that a number of trees planted along the alignment of the proposed project and are assessed to be impacted (translocate or cut), therefore MOA was identified as stakeholders. The responsibilities of MOA include:

- Management of public rangelands and forests.
- Protection of soil, pastureland and flora.
- Pesticide and fertilizers permitting.
- Protection and management of wildlife [delegated to Royal Society for Conservation of Nature (RSCN)].

3.7.6 Ministry of Tourism and Antiquities (MoTA) / Department of Antiquities (DoA)

Is considered with this project since it is responsible for:

- Develop and implement the archaeological policy of the country with regards to identification, supervision, protection, maintenance, register and restoration of archaeological sites
- Promote archaeological sites on national and international levels
- Conduct public awareness about archaeological sites in accordance to prevalent laws and regulations

3.7.7 Ministry Of Interior and its subordinates

The Ministry of Interior (MoI) and its subordinates, including the Governorate of Capital City (Amman), Governorate of Zarqa, Russifa District (Liwa'a), Marka District (Liwa'a), Public Security Directorate and the Civil Defense Directorate are connected to this project for many reasons and for different roles.

The governorates administrations (Governors and District Directors) represent the local government in the study area and do have development, security, regulatory and overall administrative responsibilities. This include receiving and addressing public/locals grievances and complains which do not fall under juridical mandate, security matters under the criminal law, public health and safety issues, agricultural and forestry violations, assaults on electricity wires and other infrastructures, follow up the implementation of development projects, etc.

The Public Security Directorate, and more specifically the Traffic Police Department, is responsible for regulating traffic, raising public awareness, take part in the planning for transport and traffic policies and plans, enforcement of related laws and regulations, etc.

As for the Civil Defense Directorate, it is responsible for providing rescue and safety services to people and properties, their mandate constitute several precautionary, proactive and reactive tasks to enhance security and safety of the public and properties all over the kingdom.

3.7.8 Department of Lands and Surveys

The Department of Lands and Survey plays a vital role in preserving land property rights and solving any conflicts concerning rights in land or water. DLS represents Jordan’s land information bank and it operates under the administration of the Ministry of Finance.:

4. DESCRIPTION OF THE EXISTING ENVIRONMENT AND SOCIO-ECONOMIC CONDITION

4.1 STUDY AREA

- The project is located within the boundaries of the city of Amman and between Amman and Zarqa, Jordan as demonstrated on **Figure 4-1**. The proposed three BRT routes connect between the western and the eastern parts of the city with the following general alignment for each line:
- BRT Line 1: Swuayleh terminal Mahattah via Sports City and University of Jordan (Queen Rania Street) with a total length of about 15.5 km.
- BRT Line 2: Al Muhajereen to Sports City via Princess Basma Street with a total length of about 8.5 km.
- BRT Line 3: Mahattah terminal to Zarqa, with a total length of about 19.3 km.

Figure 4-1: Location Map of the Proposed Project Area

For the purpose of describing the existing environmental conditions in the areas that will be likely affected by the construction and operation of the BRT project, the study area comprises the bus corridors and their surroundings. This includes sites located at or near depots, terminals or other related facilities that are planned to be constructed and operated as part of the BRT scheme.

The BRT lines are part of the roads that Greater Amman Municipality (GAM) and Ministry of Public Works and Housing (MPWH) are responsible of, as shown in **Figure 4-2** . The BRT line 1 is mostly GAM responsibility, but a small portion from it (in Sweileh) is MPWH responsibility. As for the BRT line 2 is entirely GAM responsibility, and the BRT line 3 is divided between both GAM and MPWH, where from Mahattah to Zarqa is MPWH responsibility and the rest is GAM responsibility.

Figure 4-2: BRT Lines on GAM and MPWH Roads

4.2 PHYSICAL ENVIRONMENT

4.2.1 Climate

The climate in Jordan varies between arid in the southern parts of the country to Mediterranean in the highlands. Winter is cold and humid with low temperatures including moderate frosts during the nights while summer is warm and dry. According to the 50-years mean annual rainfall map, rainfall in Jordan ranges between 100-500 mm. The highest mean monthly volumes are in December, January, February and March. Average evaporation constitutes approximately 90% of the total rainfall, while the average estimated infiltration rate is approximately 4-10%.

Amman Governorate is characterized by a Mediterranean climate with a cold winter and mild to hot summer. The climate of the study area is semi-arid and belongs to the Mediterranean climate zone with large seasonal and daily temperature variations. The average daily temperature varies between 5 to 15 Ċ during winter and can drop down below zero during winter nights. While in summer, the temperature varies between 25 to 35 Ċ, and can increase up to 40 Ċ at mid-day during July and August. Annual rainfall varies between 250 to 600 mm within Amman Governorate.

While the Zarqa Governorate is characterized by an arid climate with mild cold winter and hot summer. The average daily temperature ranges 10 to 25 Ċ during winter and can drop down below zero during winter nights. While in summer, the temperature varies between 25 to 35 Ċ, and can exceed 40 Ċ at mid-day during July and August. Annual rainfall varies between 150 to 300 mm within the governorate.

Monthly temperature values (mean, minimum and maximum) and the average mean monthly rainfall in Amman are presented in **Figure 4-3** and **Figure 4-4**, respectively.

As can be seen, precipitation occurs periodically during the winter months from October to May and is normally associated with the frontal system moving inland from the Mediterranean Sea. Generally, rainfall decreases from West to East and from South to North and increases with rising elevations.

Table 4-1 presents the key weather features in Jordan based on long-term averages.

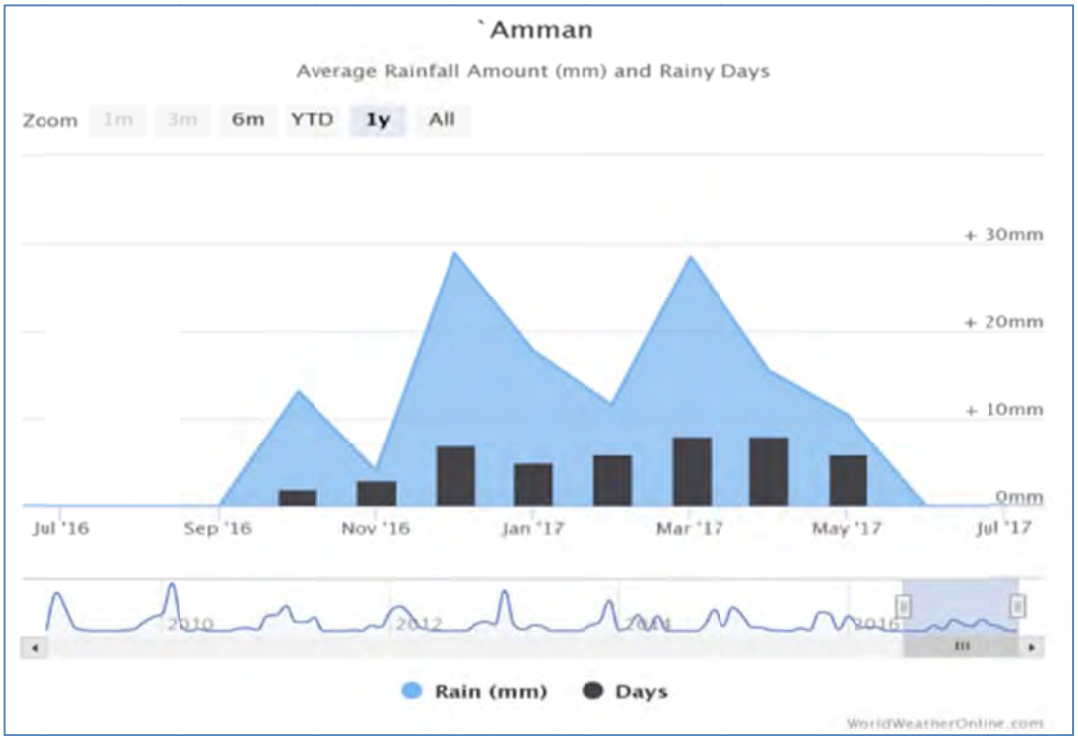


Figure 4-3: Monthly Temperatures in Amman

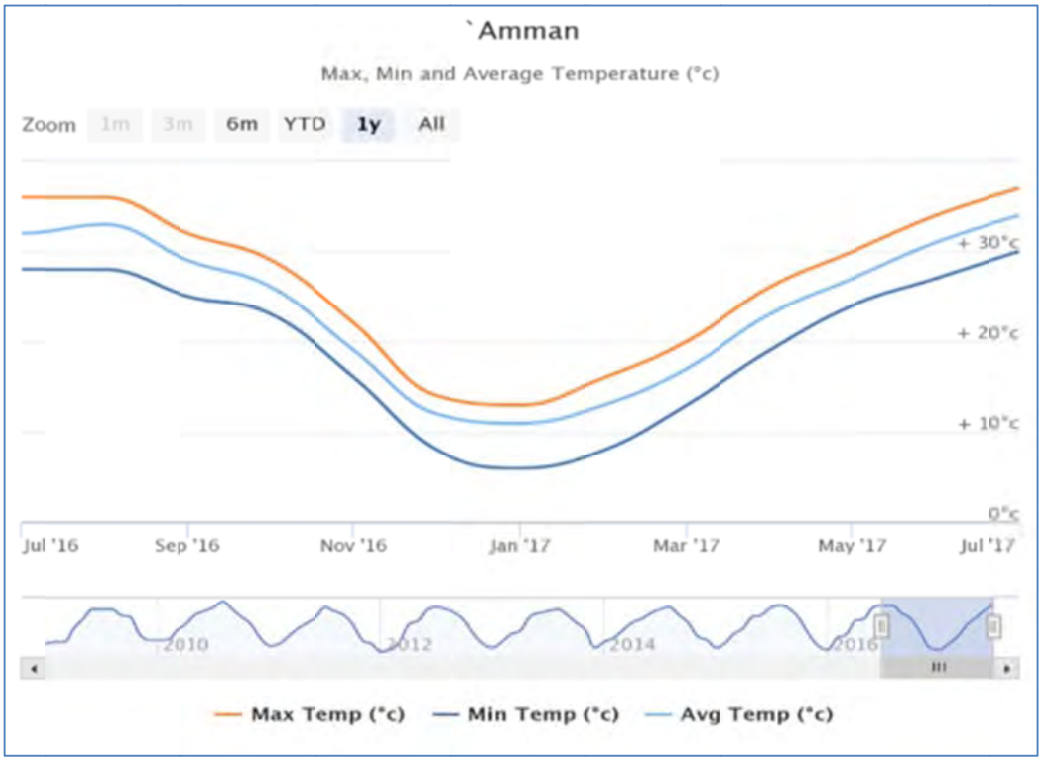


Figure 4-4: Monthly Mean Rainfall in Amman

Table 4-1: Climatologic Characteristics

	Jan	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep	Oct.	Nov.	Dec.	Yearly	Period
Mean Maximum Temperature (°C)														
Amman Airport*	12.7	13.9	17.6	23.3	27.9	30.9	32.5	32.7	30.8	26.8	20.1	14.6	23.7	1985 2014
Mean Minimum Air Temperature (°C)														
Amman Airport	4.2	4.8	7.2	10.9	14.8	18.3	20.5	20.4	18.3	15.1	9.8	5.8	12.5	1985 2014
Total Rainfall Amount (mm)														
Amman Airport	60.6	62.8	34.1	7.1	3.2	0	0	0	0.1	7.1	23.7	46.3	245	1985 2014
Mean Relative Humidity (%)														
Amman Airport	74.1	71.9	64	51	43.3	42.9	45.1	50	54.4	57	62.3	71.4	57.3	1985 2013

* Amman Airport meteorological station is the most representative for BRT routes

4.2.2 Morphology, Topography and Soils

The morphological setting within Amman area is hilly to mountainous, with gentle to steep slopes. The elevation varies between 1000m (ASL) in Suwalieh area to about 700m (ASL) in Amman downtown close to Al-Mahattah area. The natural wadi/drainage systems within the project area (over the years) were mainly disturbed by the rapid urban development in Amman city. Thus, drainage systems for the

majority of the wadis in Amman, Zarqa and Russeifah including the project area were “buried/ modified” by the different implemented and going construction projects.

Major man-made topographical features are the so-called Phosphate mountains in Russeifah which are mainly dirt (cut materials) resulted from phosphate mining which have been piled accumulatively in the area over decades of exploitation, and decades after, without proper rehabilitation. Other environmentally deteriorated areas include Russeifah landfill and transfer station and the scrap yards.

The project area contains a wide range of soil types, reflecting the wide range of physical characteristics. Xerochrepts and chromoxererts are the major soils with the typic subgroup predominantly in the western half of the area and calcixerollic in the eastern half. Lithic subgroups are occurring on the shallow eroded areas of the steeper slopes and, in particular, the hill tops and upper slopes from which most of the residual soils have been eroded.

The soil covers in both the capital Amman and the city of Zarqa are highly impacted by urban development. In many areas, the natural soil cover was excavated as part of urban development projects such as the construction of infrastructure, houses, roads, highways, services and commercial facilities.

4.2.3 Geological and Structural Setting

Lithostratigraphy

The Exposed geology within the project area ranges in age from the Triassic age (Zarqa Group) to recent. Following is the lithological succession from top to bottom. As obtained from [2,3] :

- **Alluvial Deposits:** Its lithological composition is very heterogeneous, with conglomerates, gravels, sands, silts and clays in some places mixed together, interbedded and/or intercalated.
- **The Belqa Group:** The group consists of a sequence of clastic and non-clastic, predominantly carbonate rocks. It is well exposed and forms extensive outcrops in a large area of Amman Governorate. The group is conformable with the underlying Ajloun group, but is regarded as a separate group because of the occurrence of abundant chert, and can be divided into the following five units:
- The Wadi Shallalah Formation (B5): consists mainly of limestone, chalky limestone, chalk and marl.
- The Rijam Formation (B4): consists of limestone, chalky limestone, marls and chert. The marls are locally bituminous. It outcrops in the northeastern part of the basin, and continues to outcrop beyond the basin, extending north and northeast across the borders with Syria.
- The Muwaqqar Formation (B3) consists of chalk and marl with limited brown and black chert, and limestone.
- The Amman Formation B2: consists of a cyclic deposit of chalk, phosphate, limestone and Chert. Its thickness ranges between 25 m to 90 m in Amman area.

- Wadi Ghudran Formation (B1): consists of a sequence of chalk and marl, and forms the lowest lithological unit of the Belqa group. It is recognized as a unit in Northern Jordan. It thins southwards and is then included in the overlying B2 unit.
- **The Ajloun group**: the Ajloun group is a carbonate sequence. It consists mainly of a repetition of limestone, marl, dolomitic limestone, shale and dolomite. Within the Amman- Zarqa Basin, only 5 units are recognized. These units are described from top to bottom as follows:
  - The Wadi Sir Formation (A7): represents the uppermost unit of the Ajloun group. The A7 consists of massive bedded limestone containing chert nodules in the upper part. The formation is 90m thick in Amman.
  - The Shueib Formation (A5-6): consists of marly limestone, shale and marl. Its thickness ranges from 40m in Zarqa to 100m in Na'ur. At Ain Ghazal in Amman, it consists of 121m of marl with thin limestone bands.
  - The Hummar Formation (A4): consists of light grey and dark grey dolomitic limestone. Its thickness ranges between 40m-60m in Amman area.
  - The Fuheis Formation (A3): consists of marl intercalated with marly limestone and limestone. It is about 80m thick at Fuheis area.
  - The Na'ur Formation (A1-2): consist of thick, nodular grey limestone and dolomitic limestone beds, separated by marl and shale. The formation is about 220m thick near the town of Na'ur.
- **The Kurnub Sandstone K Group:** This group is dominated by the sandstone rocks and divided into two formations, the Arda Formation (K1) and the Subeihi Formation (K2).
- **Zarqa Group (Z):** The oldest exposed rocks in Amman Governorate (Triassic/Jurassic age).This group is divided into four formations. The Lithological sequence of this group consists of sandstone, limestone dolomite, marl and shale.

Going micro-scale, the local geology of the project area is dominated by the outcrops of the B2/A7 formation/s and the A1-6 Formations of the Balqa and Ajloun groups. **Table 4-2** below represent the lithological formations of the study area.

Table 4-2: Lithological Succession of the Central Parts of Jordan

ERA	PERIOD		EPOCH	Series	Formation	Lithology
CENOZOIC	Quaternary		Holocene Pleistocene	**Alluvium**	Fuviatile Lacst&Eolian	soil, sand, gravel
	tertiary	Paleogene	Eocene	**Balqa**	W. Shallah	Limestone, chalk, marl
			Paleocene		Rijam	Chert, limestone, chalk, marl
					Muwaqar	marly limestone
					Amman	chert, limestone, phosphate
		upper	Meastrichtian Campanian Santonian		W.Ghudran	chalk, marl, marly limestone
MESOZOIC	Cretaceous	upper	Taronian	**Ajloun**	Wadi Sir	Limestone, dolomite, chert
					Shuieb	Limestone, marly limestone
			Cenomanian		Hummar	Dolomite, dolomitic limestone
					Fuheis	Marl, marly limestone
					Naur	Limestone, dolomitic limestone
		Lower	Albian	**Kurnub**	Subeihi	Sand and shale ,Clay and sandy and Limestone
			Aptian Neocomian Berriasian		Aarda	Sandstone Marl and shale
	Jurassic		Tithomian Kimmeridgian Oxfordian			
					Azab	Limestone, marl, sandstone and shale
	Triassic			**Zarqa**	Ma'in	Limestone, shale, sandy limestone, marl and evaporates

Tectonics

The structural setting within the central parts of Jordan can be summarized as the following:

- Folding: represented by (i) the Sweilih Anticline, with a NE-SW strike, and (ii) Amman- Zarqa Syncline (30 km long by 10-15 km wide), with a NE-SW strike,

and extends from the southwestern side of Greater Amman to a point about 6.60 km southeast of Zarqa.

- Faulting: Several faults striking in different directions have been mapped in the areas of the B2/A7 and the underling carbonate aquifers (A4 and A1/2). In these localized fault zones, fracturing, solution channels and karstification have developed.

4.2.4 Water Resources

The project area is located within the Amman – Zarqa water basin. It is characterized by a dense and complicated Wadi system. Most of these wadis drain flood flow after the rainy events during the winter period. The layout of such wadis has been modified and changed by urban development projects in the governorate. As in other parts of Jordan, groundwater is one of the sources for water supply in Amman As obtained from [2,3].

Sources of the supplied water in the areas served and crossed by the BRT lines include: (i) Groundwater abstracted from tens of wells drilled inside and outside the governorate; (ii) Surface water resources through King Abdullah Canal and treated in the Zai water treatment plant; (iii) surface water from the Zara – Ma'in Mujib area and treated in the Sweimeh water treatment plant; and (iv) Major springs (after treatment) such as Ras Al-Ain and Wadi Es-sir springs.

The rock units, which have been geologically described in the previous section, form a sequence of aquifers and Aquitards. These aquifers are classified (from the oldest to the youngest) as the follows:

- The Deep aquifer system and represented by the Kurnub sandstone group.
- The middle aquifer system and represented by:
  - The Na'ur (A1/2) and Hummar (A4) aquifers of the Ajloun group
  - The Amman - Wadi Sir (B2/A7) of the Balqa/Ajloun groups.
- The Shallow aquifer system represented by the Rijam/Shallalah aquifer (B4/B5) of the Balqa group.

The following **Table 4-3** represents the hydrogeological and hydrochemical characteristics of the hydrogeologic strata in the Amman area.

Table 4-3: The Hydrogeologic and Hydrochemical characteristics of the Hydrogeologic Strata within the Project Area

Aquifer/Aquitared	Geology/Lithology	Hydraulic Characteristics	Water Quality
The Rijam Wadi Shallalah Aquifer (B4/B5)	Of the Balqa group. The aquifer materials consist of chalk, chert and limestone which are jointed and fractured with solution channels and cavities	• The Transmissivity ranges between 6 – 230 m^2/d. • Values of hydraulic conductivity in the range of 0.05 - 5 m/d were	The groundwater salinity is usually below 450 mg/l (< 700 μS/cm) if the groundwater is not affected by pollution. With rising salinity, sodium and chloride

Aquifer/Aquitared	Geology/Lithology	Hydraulic Characteristics	Water Quality
	in the carbonates portions	estimated. • Specific yield is 0.01 and the storage coefficient 1x10-5.	increase in absolute and relative contents.
The Muwaqqar Aquitard (B3)	This aquitard, consisting of a thick sequence of chalk and marl. It has a low permeability and forms a confining layer to the A7/B2 aquifer and B4/5 aquifer and is therefore regarded as an aquitard.		
B2/A7 aquifer	The most important aquifer in the central and northern parts of Jordan. It has a large and continuous extent, and a relatively high permeability. It receives the highest amount of modern recharge and is considered to be the principal source of fresh water for domestic and irrigated agriculture in the central and northern parts of Jordan	• Transmissivity: 9.0-900.0 m2/d. • Storage Coefficient: 0.01-0.30 • Water levels have been declining in recent years, suggesting that the aquifer may be overexploited. • Recharge to this aquifer is about 40 – 45 MCM/Y	Prior to excessive abstraction, the TDS value ranged from 260 to 680 mg/l, and the water type was calcium and magnesium bicarbonate. Nowadays, a salinity build-up is occurring. In some private wells, TDS currently exceeds 3000 m g/l
The Shueib Aquitard (A5/6)	Of the Ajloun Group. the Shueib formation is a well-known aquitard. The shale and marl formation confines the underlying Hummar aquifer and separates it from the overlying B2/A7 aquifer.		
The Hummar Aquifer (A4)	Of the Ajloun Group. Consists of limestone, dolomitic limestone and dolomite	• A productive local aquifer in the Amman-Zarqa basin. Elsewhere, its productivity is limited. • Water levels have been declining in recent years, suggesting that the aquifer may be overexploited. • Transmissivity: 230-2800 m^2/d • Storage Coefficient: 0.01-0.10 • Estimated recharge is approximately 5 MCM/y.	Good and is suitable for all uses (230-525 mg/l). However, organic and industrial pollution is becoming a threat to this valuable source.
The Fuheis Aquitard (A3)	Of the Ajloun Group. Consist of Olive- green marl intercalated with marly limestone, which confines the Nau'r aquifer.		
The Nau'r Aquifer (A1/2)	Of the Ajloun Group. Consist of Limestone, dolomitic limestone The base of the Nau'r Aquifer consists of marl which confines the underlying Kurnub. Recharge occurs in the areas outcropping west and southwest of	• Transmissivity: 4-10 m2/d. • Storage Coefficient: 0.0006 • Estimated amount of recharge within the Amman - Zarqa basin area is about 4.5 MCM/y, much of which emerges	The water quality remains good. Wells drilled in 1999 encountered water with TDS between 500 and 600 ppm.

Aquifer/Aquitared	Geology/Lithology	Hydraulic Characteristics	Water Quality
	Amman.	as spring flow.	
The Kurnub Aquifer (K)	A regional aquifer in Jordan. Recharge is limited to small outcrop areas in Baqa, Jerash and the Zarqa River in the Amman Zarqa basin. The aquifer is also recharged by leakage from the overlying carbonate aquifers. The aquifer is separated from the underlying Zarqa aquifer by green shale and marls of the upper Zarqa formation, and is confined by the overlying Nau'r marls.	• Transmissivity: 3.0-1700 m^2/d • Storage Coefficient: 0.001-0.10	The greater part of the Kurnub water is of good quality. TDS values of 600- 700 mg/l.
The Zarqa Aquifer (Z)	The aquifer is composed mainly of sandstone, marls, dolomite shale and limestone. It outcrops mainly in the deeply eroded wadis in the Zarqa Valley area. Recharge to the aquifer occurs in the outcropping areas such as Jerash, Baqa, and along the Zarqa River.	• Transmissivity: 27-290 m^2/d • Storage coefficient: 0.0001-0.02	The Zarqa aquifer is generally brackish.

Groundwater is the only source for domestic water supply to both Amman and the Zarqa governorates (which is the case for the other parts of Jordan). Due to the fact that, the Amman – Zarqa basin include more that 50% of the population of Jordan, the abstraction from the said basin was 156 MCM during the year 2013 with a deficit of about 68 with relation to the basin safe yield. The depth to the groundwater level varies between 100 to 250 m depending on the target aquifer and the surface morphology.

The renewable groundwater amounts on average to 88 million cubic meters per year in this basin. The two main aquifers in the Amman–Zarqa basin [the Amman/Wadi Sir formation (B2/A7) and the Hummar (A4) formation] are both exposed in the high rainfall region. Rainfall reaches 400 mm/year to the west of Amman, whereas it does not exceed 150 mm/year in the study area.

Aquifers under abstraction vary between the B2/A7 aquifer, the A1-2 aquifer, the A4 aquifer and the Kurnub aquifer. Depth to water level these wells vary between 120m to 180m below ground level (BGL). In Amman area, groundwater flow for the B2-A7 and the A1-6 aquifers is mainly towards the northeast, while for the Kurnub aquifer it

is mainly towards the northwest. Part of groundwater wells within the project area are governmental used for domestic purposes, while the others are used by some of the nearby industrial and services facilities.

In general, the quality of the groundwater within the Amman Zarqa basin varies depending on the extraction rate from the groundwater wells; the type of the aquifer geological starts (especially karstic or non-Karstic), the depth to the groundwater and the ongoing human activities (industrial or agricultural) and the implemented method for managing the resulted liquid and solid wastes.

Within the Zarqa area, the groundwater quality analyses results (undertaken in several locations by different entities including the Water Authority of Jordan) show a general increasing trend in salinity, NO3 and NH4 concentration, in addition to the presence of E. coli in some wells.

4.3 BIOLOGICAL ENVIRONMENT

The information presented in this section on the biological environment is based on observations from field visits conducted by experts in ecology, biodiversity, flora and fauna [2,3]. It is substantiated by published research and reports and by the experience of the team in the existing features of the biological environment in the project area.

Very few areas within the project site still enjoy a pristine nature. Most parts have been subject through the years to human interference and alterations. The main human land use changes experienced by the project area include urbanization, establishing road networks and building residential and commercial development, mostly at the expense of natural habitats.

4.3.1 Bio-geography

The proposed area of the BRT Lines 1, 2, 3 is considered transitional in terms of biogeography where, topography (and subsequently soil) is a main factor for determining its characteristics. As **Figure 4-5** shows, the project area enjoys a Mediterranean, very arid bio-climate where typical Mediterranean elements can be observed. Natural tree elements are rare across all BRT corridors with Mediterranean and Irano Turanian herbaceous vegetation poorly present.

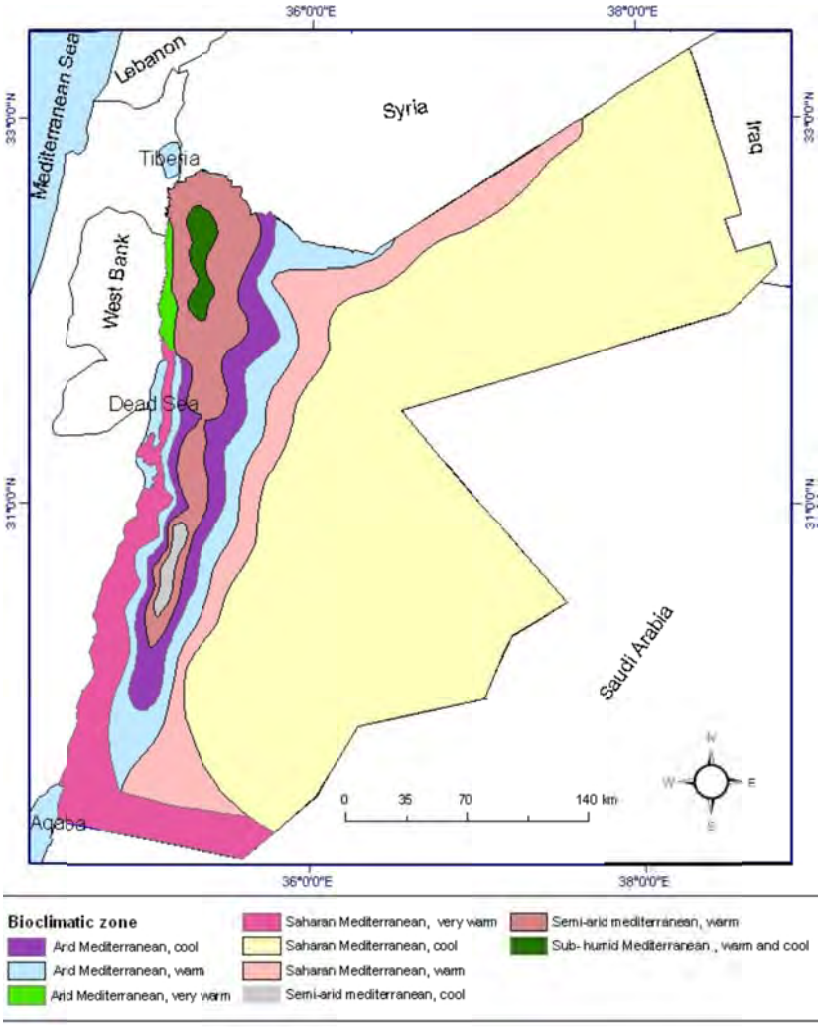


Figure 4-5: Bio-Geographic Zones of Jordan Including the Phyto Distributions

Several vegetation types that correspond to the above-mentioned bioclimatic regions can be observed within the project area and its surroundings including road shoulders and on slopes of hills adjacent to BRT Lines 1, 2, 3.

1. The Mediterranean: This region extends from the northern mountains to the south near Petra. It is it is characterized by its distinctive terra rosa and rendzina soil type, the soil is of the yellow type to rose, lime stone parental rock, loamy with many rocky outcroppings. Oak (Quercus sp.), juniper (Jumiperus phoenica) and pine forests (Pinus halepensis) are found along these relatively narrow mountain strips.

2. The Irano-Turranean: surrounds the Mediterranean one. It extends over the lower half of the Jordan valley and reaches Ras Al Naqab in the south. The soil is loess and/or calcareous and supports scattered vegetation (e.g. Artemesia harb-alba, Anabasis sp. and Retama raetam). The vegetation type under this biogeographically zone is commonly referred to as the steppe vegetation.

4.3.2 Flora, Fauna and Avifauna

No significant biological value exists along both sides of the BRT lines 1, 2, 3 due to the heavily disturbed natural habitats and the highly dense population. Main alterations to natural habitats are the result of increased urban and commercial activities that occupy vast areas on both sides of the lines 1, 2, 3.

The diversity of flora in the project area on both sides of the BRT lines is very low in BRT line 3 but higher in BRT lines 1 and 2. Other biodiversity characters such as fauna have long disappeared from the site. No significant faunal elements were observed along the lines except urban birds such as Domestic Sparrows (Passer domesticus), Palestine sunbird (Nectarina osea) **Figure 4-6**, Black Bird (Turdus merula) **Figure 4-7,** Bulbul (Pycnonotus xanthopygos) **Figure 4-8**, Collared Dove (Streptopelia decaocto), Blue Jay (Garrulus glandarius) **Figure 4-9**, Crested Lark (Galerida cristata) **Figure 4-10**, ravens (Corvus corax) in addition to reptiles. Most of the birds observed during the field survey use the trees planted on sidewalks and the median sections of the roads.

Figure 4-6: Palestine Sunbird

Figure 4-7: Blackbird

Figure 4-8: Yellow-vented Bulbul

Figure 4-9: Blue Jay

Figure 4-10: Crested Lark

Mammals

The distribution of mammals in the study area are detailed in **Table 4-4** below in their scientific name. According to the International Union for Conservation of Nature (IUCN), majority of the species are of least concern status or lower risk.

Table 4-4: Mammal Species Observed in the Study Area

Type of Mammal	Common Name	Location	Status*
Paraechinus aethiopicus	Desert Hedgehog, Ethiopian Hedgehog	Wadi edh Dhuleil	No Result
Crocidura suaveolens	Lesser White-toothed Shrew	Wadi Zarqa	LR1
Rousettus aegyptiacus	Egyptian Fruit Bat	Zarqa River	LC2
Vulpes vulpes	Red Fox	Az Zarqa	LC
Hyaena hyaena	Striped Hyaena	Wadi edh Dhuleil	LR
Rattus rattus	Black Rat	Found in all cities, villages and agricultural areas	LR
Mus musculus Linnaeus	House Mouse	Common all over the country especially where there are human settlements	No Result
Cricetulus migratorius	Grey Hamster	Wadi Az Zarqa	LR

Source: Zuheir S. Amr, "Mammals of Jordan", 2000, United Nations Environment Programme and *The 2006 IUCN Red List of Endangered Species Website (www.iucnredlist.org), 1: LR: Lower Risk. 2: LC: Least Concern

Trees and plants

Both exotic and native plants and trees had been introduced in the median section of the roads along the BRT lines and on both shoulder and sidewalks of the streets. Exotic plants include Casuarinas, Eucalyptus and Washingtonia (see **Figure 4-11**) while native trees are Karup, Oleander, Arabian palms and others.

The introduction of exotic trees has created an artificial condition that does not reflect the natural landscape, vegetation or ecosystem of the project area. This has also attracted certain faunal species that are not traditional to the area. It is recommended that landscaping plans should tend to use natural trees and vegetation for the rehabilitation of sites where construction activities have resulted in the removal of existing trees and vegetation.

Introduced and exotic trees and vegetation occurring in the median of BRT Line 1 are shown in **Table 4-5.**

Table 4-5: Trees and Vegetation occurring in the Median of BRT Line 1

	Tree / Plant	Status	Approximate number of trees	Approx. Age
BRT Line 1	Washingtonia spp.	Introduced / Exotic	600	5-10 years old
	Arabian Palm Dates	Introduced / Indigenous	50	Around 7 years old
	Oleander	Naturally grown	25	------
	Pine	Indigenous / Introduced	350	3-7 years
	Eucalyptus	Introduced / Exotic	50	5-10 years
	Populous	Natural / introduced	50	5-7 years
	Acacia	Introduced / Exotic	75	5-7 years
	Quercus Oak	Introduced / Exotic	100	5-7 years
	Other decorative	Introduced / Exotic	100	3-7 years

Figure 4-11: Populous and Exotic Washingtonia spp. in the median along BRT Line 1

Introduced and exotic trees and vegetation occurring in the median of BRT Line 2 are shown in **Table 4-6.**

Table 4-6: Trees and Vegetation occurring in the Median of BRT Line 2

	Tree / Plant	Status	Approximate number of trees	Approx. Age
BRT Line 2	Washingtonia spp.	Introduced / Exotic (imported from Americas)	500	5-10 years old
	Arabian Palm Dates	Introduced / Indigenous	35	Around 7 years old
	Oleander	Naturally grown	15	3-5
	Aleppo Pine	Indigenous / Introduced	60	3-7 years
	Eucalyptus	Introduced/ Exotic (imported from Australia)	35	5-10 years
	Populous	Natural / introduced	80	7-10 years
	Karup	Indigenous / introduced	30	10-20 years
	Quercus/Oak	Introduced / Exotic (imported from Europe)	40	10-20 years
	Other decorative	Introduced / Exotic	70	5-7 years

Trees were identified within the middle road island of the whole Autostratd corridor, and along the sides in Russiefah and Ain Gazal, and it is mainly of Washingtonia palms, few Eucalyptus, pine trees and other species. A total of 1520 trees were observed along the proposed alignment. This includes trees in the right side and the left side of the highway in addition to trees within the island separating the left and right sides. Most of the trees identified are above 10 years old and many of the trees in the sections between Ain Ghazal Bridge and Al Mahata are much older.

Introduced and exotic trees and vegetation occurring in the three alignments of BRT Line 3 are shown in **Table 4-7:**

Table 4-7: Trees and Vegetation occurring in the Three Alignment of BRT Line 3

	Tree / Plant	Number of Trees in the Right Alignment	Number of Trees in the Middle Alignment	Number of Trees in the left Alignment
BRT Line 3	Phoenix Washingtonia	12	312	10
	Ceratonia Siliqua	22	26	7
	Eucalyptus	29	93	57
	Nerium Oleander	10	483	27
	Cupressus	115	19	6
	Polypodiaceae	27	69	7
	Olives	8	-	-
	Fig		-	1
	Other	-	180	-

4.4 AIR QUALITY

Two sets of data are utilized for air quality baseline documentation one is obtained from the MoENV record and one is actual measurements performed by the project team.

4.4.1 Existing Condition of Air Quality (MoENV records)

Air quality is routinely monitored by the MoE in Amman, Zarqa and Irbid, where the concentration of the pollutants (NO2, SO2, O3, CO and PM10) are measured daily. As shown in **Figure 4-12** there are 7 air monitoring station between Amman and Zarqa. However the BRT line passes near to three stations which were used; these stations are Greater Amman Municipality (GAM), North Travel Complex in Tabarbour (TAB), and Health Center in Wadi Al-Hajar (HAJ).

Table 4-8 and **Table 4-9** below present the average monthly concentration of the pollutants for years 2016 and 2017 at the three stations, except for the O3 as it is not available in these stations.

Table 4-8: The Monthly Rate of the Pollutants Concentration against Jordanian Ambient Air Quality Standards for Year 2016

Month	Station	NO2 (ppb)	JS	SO2 (ppb)	JS	CO (ppb)	JS	PM10 (µg/m3)	JS
January 2016	GAM	25.12	✔	5.88	✔	2385.35	✔	77.87	✔
	TAB	20.78	✔	-		1866.87	✔	107.83	✔
	HAJ	9.82	✔	7.74	✔	2130.84	✔	120.37	X
February 2016	GAM	26.5	✔	14.37	✔	2876.66	✔	77.8	✔
	TAB	22.64	✔	-		2204.28	✔	74.08	✔
	HAJ	10.94	✔	6.3	✔	2510.14	✔	98.69	✔
March 2016	GAM	21.39	✔	12.36	✔	2035.84	✔	67.15	✔
	TAB	20.21	✔	-		2577.42	✔	90.92	✔
	HAJ	11.17	✔	3.99	✔	2643.3	✔	92.83	✔
April 2016	GAM	25.21	✔	14.07	✔	2741.53	✔	83.32	✔
	TAB	27.14	✔	-		3059	✔	86.41	✔
	HAJ	13.1	✔	4.94	✔	3204.37	✔	98.01	✔
May 2016	GAM	16.09	✔	10.57	✔	2313.23	✔	60.51	✔
	TAB	21.94	✔	-		3173.52	✔	84.05	✔
	HAJ	11.18	✔	3.27	✔	3484.32	✔	68.73	✔
June 2016	GAM	12.68	✔	11.58	✔	2961.53	✔	61.13	✔
	TAB	19.19	✔	-		3621.37	✔	83.81	✔
	HAJ	9.73	✔	3.33	✔	4078.13	✔	64.05	✔
July 2016	GAM	8.87	✔	9.52	✔	2980.81	✔	40.28	✔
	TAB	19.01	✔	-		3923.65	✔	61.29	✔
	HAJ	11.04	✔	2.2	✔	4411.84	✔	45.06	✔
August 2016	GAM	15.09	✔	8.45	✔	3497.9	✔	50.06	✔
	TAB	31.08	✔	-		4282.81	✔	67.91	✔
	HAJ	19.03	✔	1.56	✔	3329.58	✔	54.65	✔
September 2016	GAM	26.18	✔	11.18	✔	4009.93	✔	56.54	✔
	TAB	34.76	✔	-		4612.7	✔	65.96	✔
	HAJ	15.32	✔	4.57	✔	1314.67	✔	59.57	✔
October 2016	GAM	31.42	✔	26.14	✔	5283.97	✔	102.85	✔
	TAB	30.06	✔	-		5126.71	✔	99.16	✔
	HAJ	22.94	✔	12.67	✔	1726.35	✔	108.46	✔
November 2016	GAM	33.57	✔	25.38	✔	5694.93	✔	123.18	X
	TAB	33.75	✔	-		5150.5	✔	110.93	✔
	HAJ	21.03	✔	12.89	✔	1988.37	✔	114.49	✔
December 2016	GAM	29.5	✔	12.53	✔	4299.48	✔	79.85	✔
	TAB	25.17	✔	-		4247.9	✔	78.91	✔
	HAJ	16.83	✔	8.72	✔	2750.68	✔	96.98	✔

Jordanian Ambient Air Quality Standards (JS 1140/2006)

NO2 80 ppb SO2 140 ppb CO 9000 ppb PM10 120 µg/m3

Source: Ministry of the Environment

Table 4-9: The Monthly Rate of the Pollutants Concentration against Jordanian Ambient Air Quality Standards for Year 2017

Month	Station	NO2 (ppb)	JS	SO2 (ppb)	JS	CO (ppb)	JS	PM10 (µg/m3)	JS
January 2017	GAM	31.4	✔	12.3	✔	2306	✔	73	✔
	TAB	23.6	✔	-		1738	✔	71.1	✔
	HAJ	17.1	✔	8.53	✔	2835	✔	86.9	✔
February 2017	GAM	33	✔	15.6	✔	2733	✔	79.8	✔
	TAB	24.8	✔	-		1894	✔	69.1	✔
	HAJ	18.2	✔	8.88	✔	3087	✔	102	✔
March 2017	GAM	30.8	✔	7.01	✔	2265	✔	66.3	✔
	TAB	25.7	✔	-		2313	✔	80.8	✔
	HAJ	18.6	✔	5.27	✔	3205	✔	98.2	✔
April 2017	GAM	28.7	✔	5.36	✔	2256	✔	62.8	✔
	TAB	25.2	✔	-		2480	✔	90.8	✔
	HAJ	17.3	✔	4.84	✔	3289	✔	107	✔
May 2017	GAM	28.8	✔	6.28	✔	2544	✔	49.4	✔
	TAB	24.6	✔	-		2785	✔	74	✔
	HAJ	18	✔	6.03	✔	3567	✔	89.2	✔
June 2017	GAM	28.1	✔	3.72	✔	2790	✔	40.8	✔
	TAB	22.3	✔	-		3069	✔	52.3	✔
	HAJ	16.2	✔	4.24	✔	3832	✔	50.5	✔
July 2017	GAM	31.6	✔	5.03	✔	3085	✔	51.7	✔
	TAB	26.1	✔	-		3561	✔	67.7	✔
	HAJ	16.5	✔	4.19	✔	4094	✔	54.2	✔
August 2017	GAM	29.5	✔	3.16	✔	3320	✔	47	✔
	TAB	24	✔	-		3899	✔	71.4	✔
	HAJ	14.1	✔	3.23	✔	4363	✔	46.9	✔
Jordanian Ambient Air Quality Standards (JS 1140/2006) NO2 80 ppb SO2 140 ppb CO 9000 ppb PM10 120 µg/m3									

Source: Ministry of the Environment

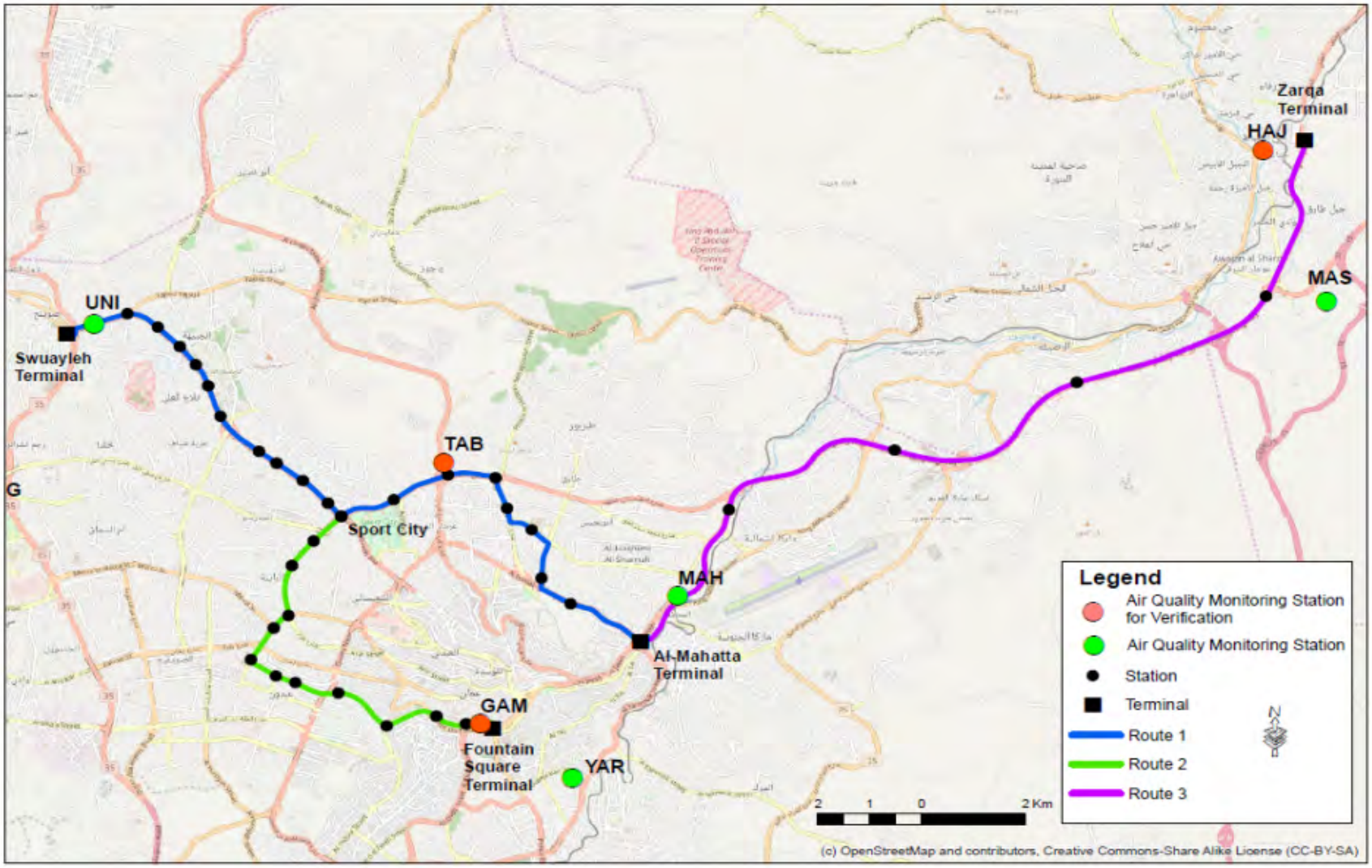


Figure 4-12: Location of Air Quality Measurement Stations in the Project Area

4.4.2 Results of Air Quality Monitoring

A summary of the ambient air quality measurements performed are presented in **Table 4-10**, **Table 4-11,** and **Table 4-12** for GAM, TAB, and HAJ stations during the period from15 October 2017 to 18 October 2017, full results of air quality monitoring are presented in Appendix B.

Monitoring Results for Grater Amman Municipality (GAM) Location

Ambient air quality monitoring was conducted at Grater Amman Municipality (GAM) near the MoEnv monitoring station in the period from 15 October 11:00 to 16 October 2017 10:30. As shown in **Table 4-10** below the 24h average concentration of NO2, SO2, and PM10 were 36.64 ppb, 6.53 ppb, and 68.75 µg/m^3 respectively, also the 8h average concentration (day and night) of CO and O3 were 2.12 ppm and 13.87 ppb respectively. Thus, no exceedances in NO2, SO2, PM10, CO and O3 concentrations were recorded according to JS: 1140/2006 during the monitoring period.

Table 4-10: Comparison of Measured Air Quality Parameters Verses MoEnv Based Line Data and Jordanian Ambient Air Quality Standards - GAM Station

GAM Station	Engicon Avg 24 hr	MoEnv Avg Yr 2016	MoEnv Avg Yr 2017	JS (1140/2006)
NO2 (ppb)	36.64	22.64	30.24	80.00
SO2 (ppb)	6.53	13.50	7.31	140.00
CO (ppm)	2.12	3.42	2.66	9.00
PM10 (µg/m^3)	68.75	73.38	58.85	120.00
O3 (ppb)	13.87	NA	NA	80.00

Monitoring Results for Tabarbour Bus Station (TAB) Location

Ambient air quality monitoring was conducted at Tabarbour Bus Station (TAB) in the period from 16 October 11:45 to 17 October 2017 11:30. As shown in **Table 4-11** below the 24h average concentration of NO2, SO2, and PM10 were 42.02 ppb, 31.42 ppb, and 82.31 µg/m3 respectively, also the 8h average concentration (day and night) of CO and O3 were 2.39 ppm and 33.67 ppb respectively. Thus, no exceedances in NO2, SO2, PM10, CO and O3 concentrations were recorded according to JS: 1140/2006 during the monitoring period.

Table 4-11: Comparison of Measured Air Quality Parameters Verses MoEnv Based Line Data and Jordanian Ambient Air Quality Standards - TAB Station

TAB Station	Engicon Avg 24 hr	MoEnv Avg Yr 2016	MoEnv Avg Yr 2017	JS (1140/2006)
NO2 (ppb)	42.02	25.48	24.54	80.00
SO2 (ppb)	31.42	NA	NA	140.00
CO (ppm)	2.39	3.65	2.72	9.00
PM10 (µg/m3)	82.31	84.27	72.15	120.00
O3 (ppb)	33.67	NA	NA	80.00

Monitoring Results for Wadi and Hjar (HAJ) Location

Ambient air quality monitoring was conducted at Wadi and Hjar (HAJ) in the period from 17 October 14:00 to 18 October 2017 14:00. As shown in **Table 4-12** below the 24h average concentration of NO2, SO2, and PM10 were 23.26 ppb, 13.30 ppb, and 147.17 µg/m3 respectively, also the 8h average concentration (day and night) of CO and O3 were 1.71 ppm and 13.59 ppb respectively. Thus, no exceedances in NO2, SO2, CO and O3 concentrations were recorded according to JS: 1140/2006 during the monitoring period, on the other hand, PM10 was found to exceed JS: 1140/2006 as the recorded PM10 concentration was 22.64% higher than the Jordanian standard.

Table 4-12: Comparison of Measured Air Quality Parameters Verses MoEnv Based Line Data and Jordanian Ambient Air Quality Standards - HAJ Station

HAJ Station	Engicon Avg 24 hr	MoEnv Avg Yr 2016	MoEnv Avg Yr 2017	JS (1140/2006)
NO2 (ppb)	23.26	14.34	17.00	80.00
SO2 (ppb)	13.30	6.02	5.65	140.00
CO (ppm)	1.71	2.80	3.53	9.00
PM10 (µg/m3)	147.17	85.16	79.36	120.00
O3 (ppb)	13.59	NA	NA	80.00

Figure 4-13 to **Figure 4-27** are graphical presentation of the obtained air quality-monitoring results for GAM, TAB, and HAJ monitoring stations during the period from15 October 2017 to 18 October 2017.

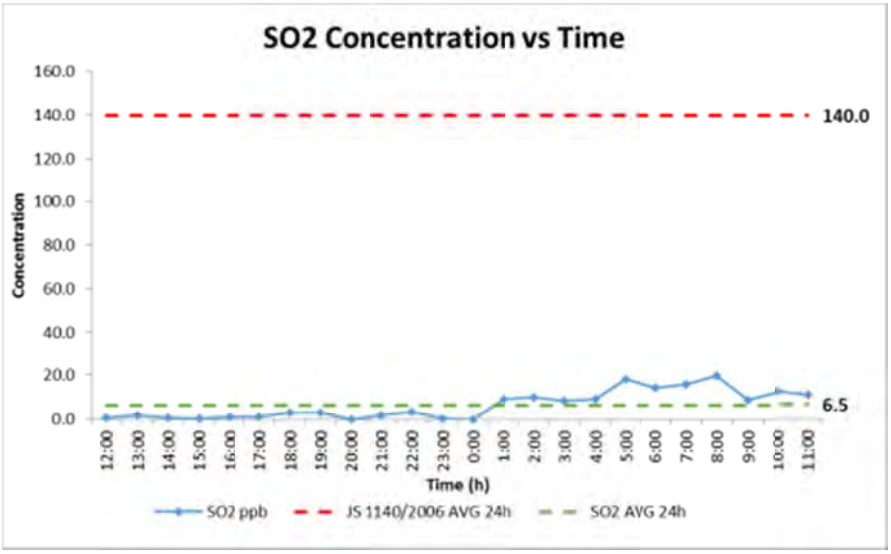


Figure 4-13: SO2 Concentration vs Time – GAM

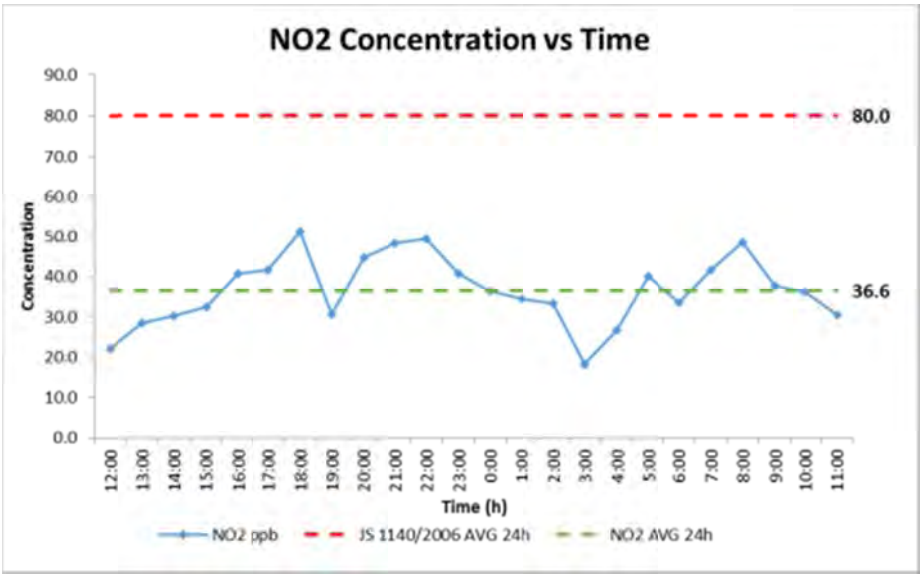


Figure 4-14: NO2 Concentration vs Time – GAM

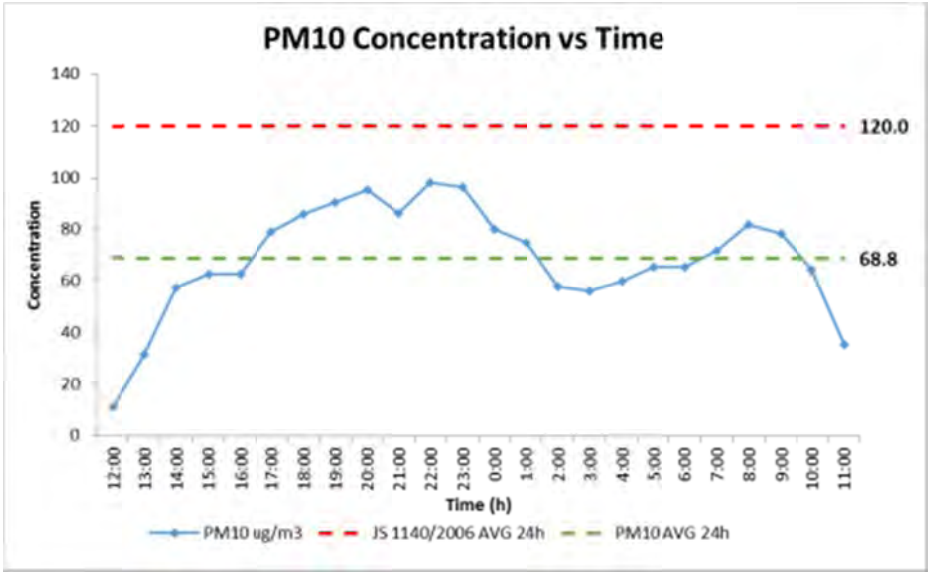


Figure 4-15: PM10 Concentration vs Time – GAM

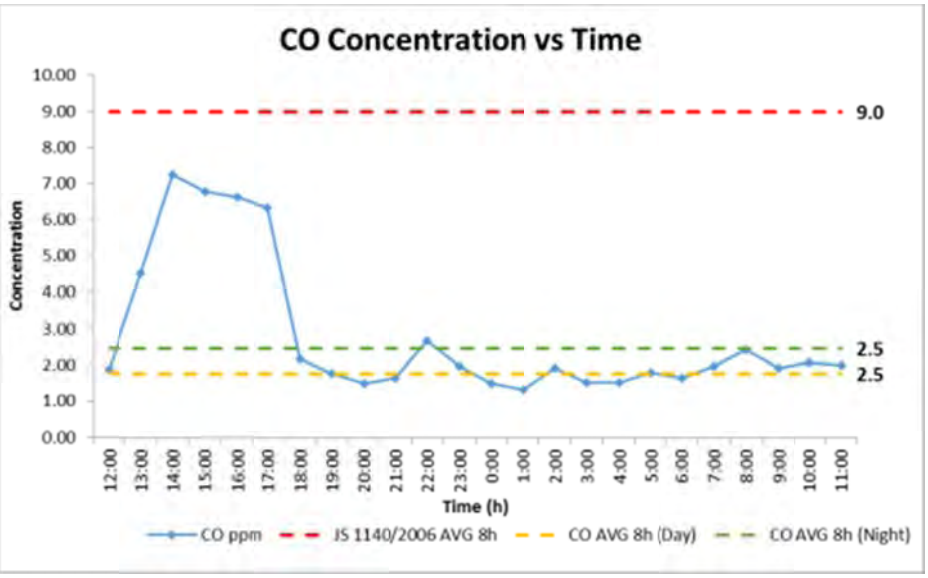


Figure 4-16: CO Concentration vs Time – GAM

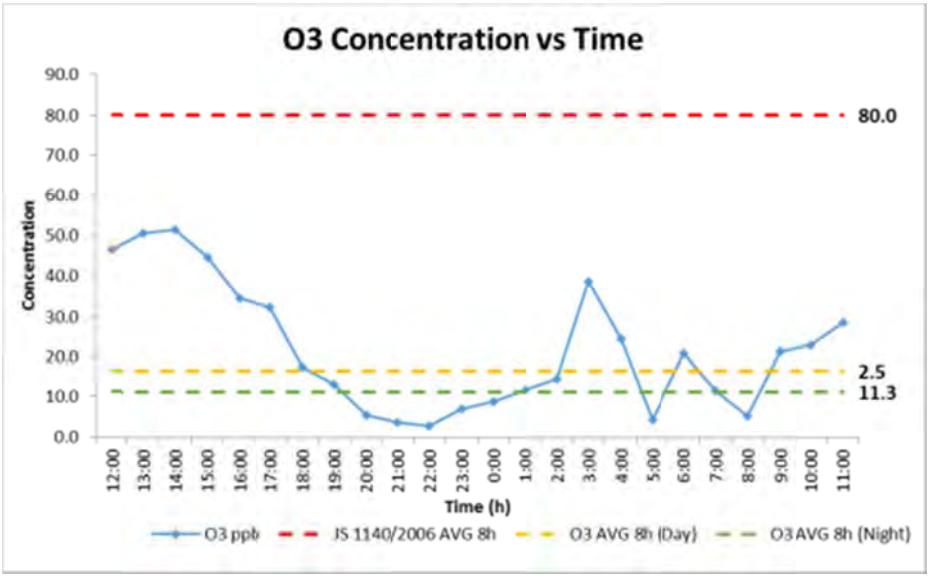


Figure 4-17: O3 Concentration vs Time – GAM

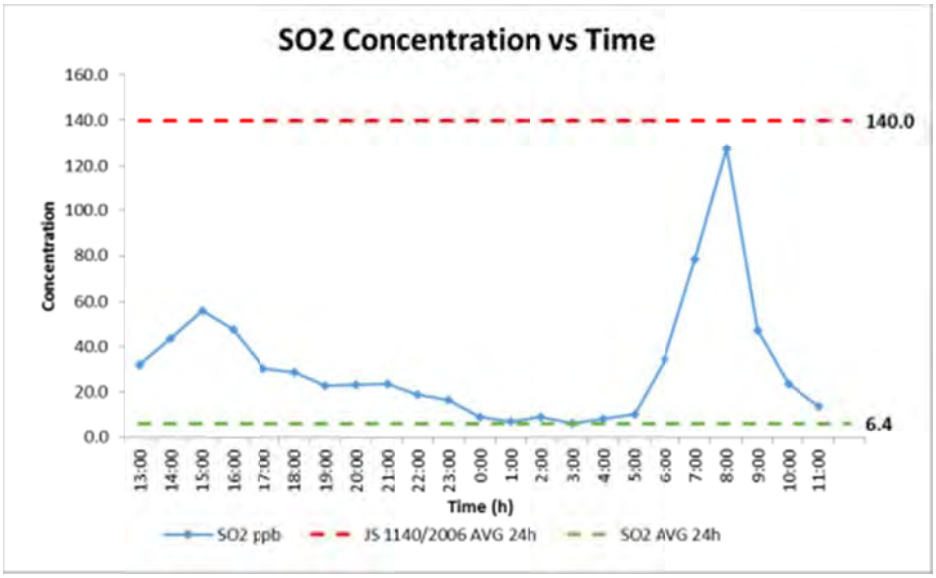


Figure 4-18: SO2 Concentration vs Time – TAB

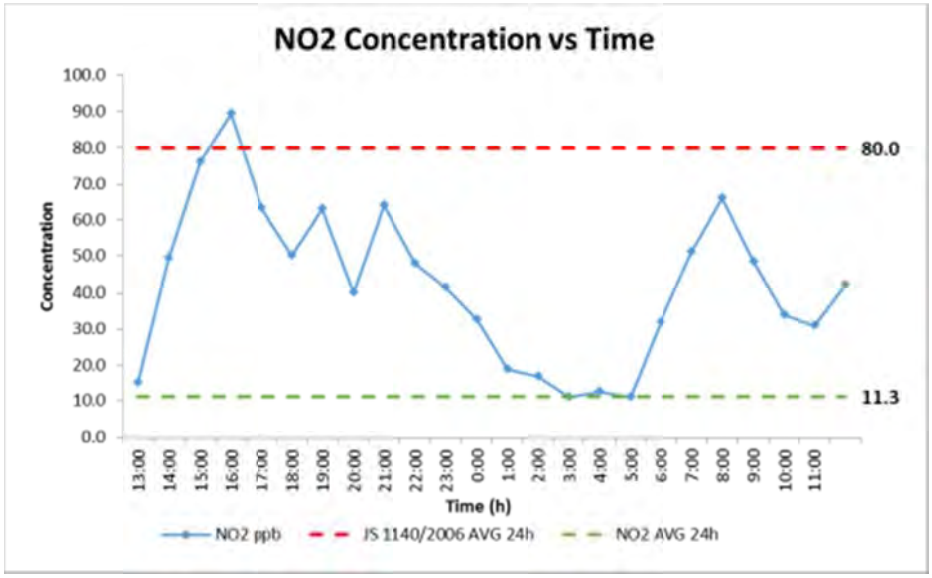


Figure 4-19: NO2 Concentration vs Time – TAB

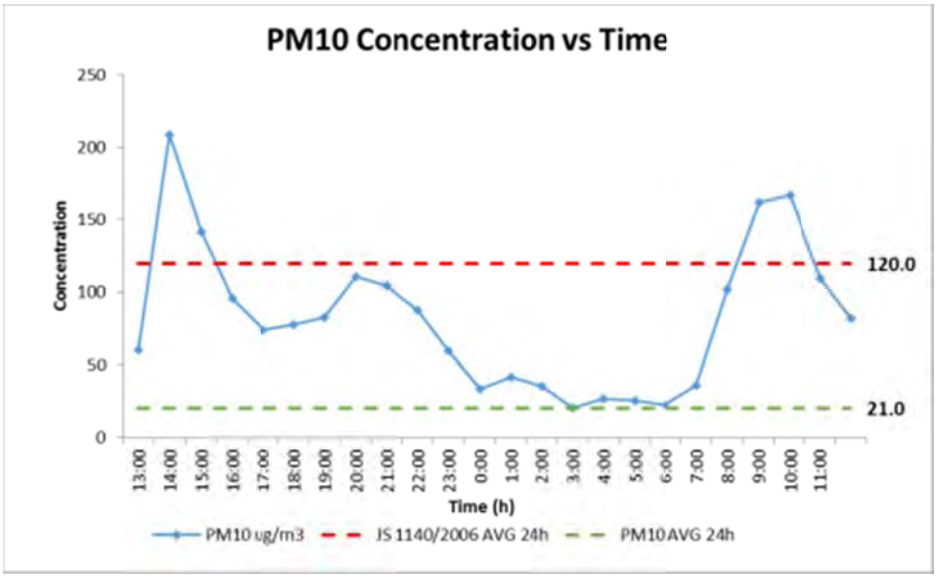


Figure 4-20: PM10 Concentration vs Time – TAB

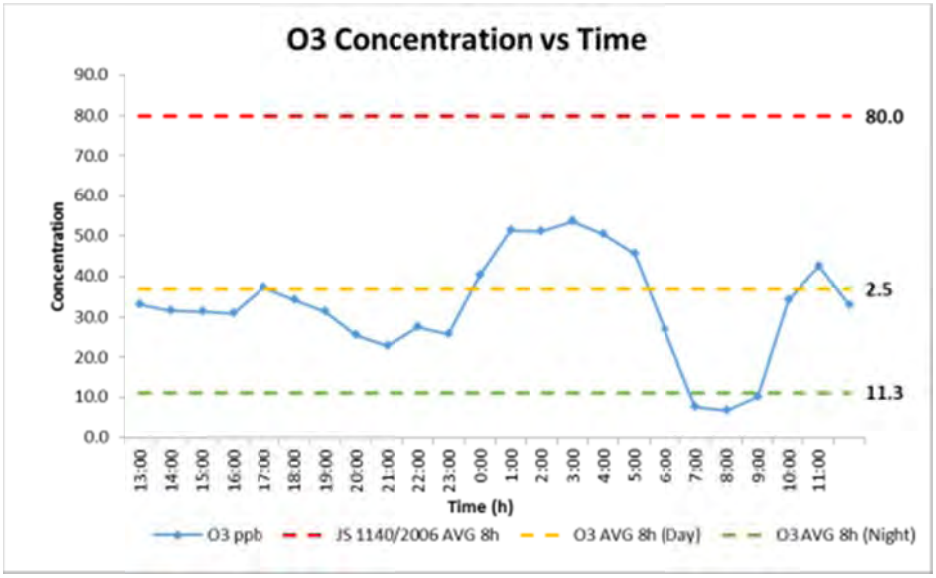


Figure 4-21: CO Concentration vs Time – TAB

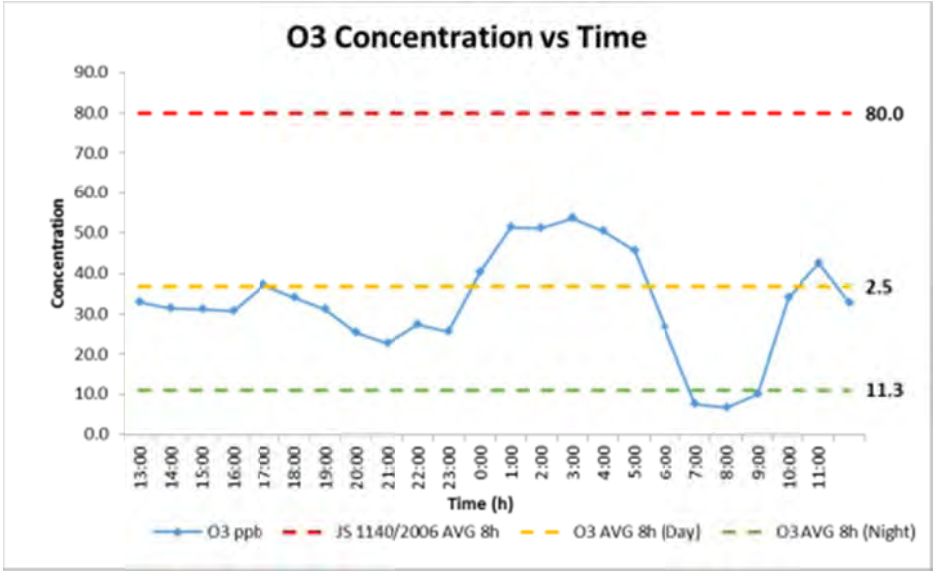


Figure 4-22: O3 Concentration vs Time – TAB

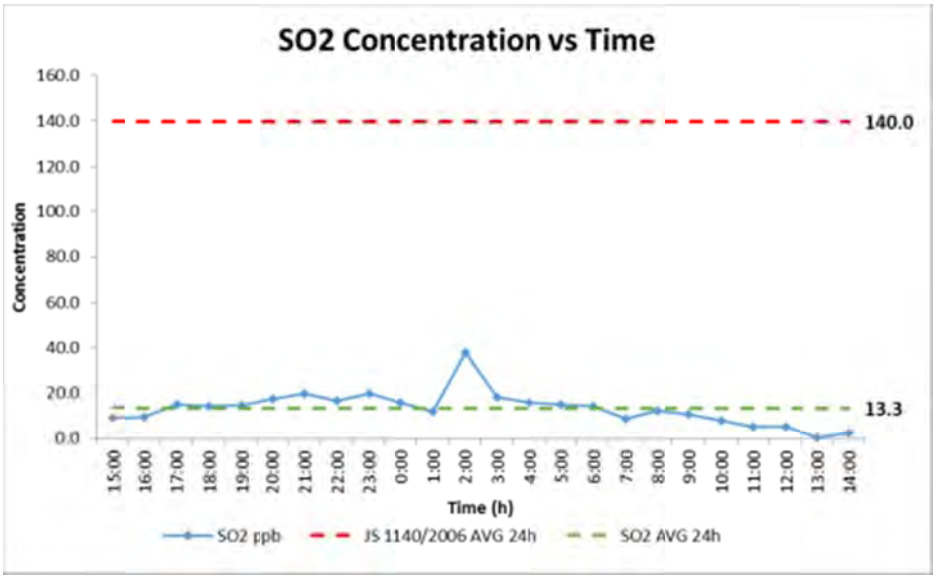


Figure 4-23: SO2 Concentration vs Time – HAJ

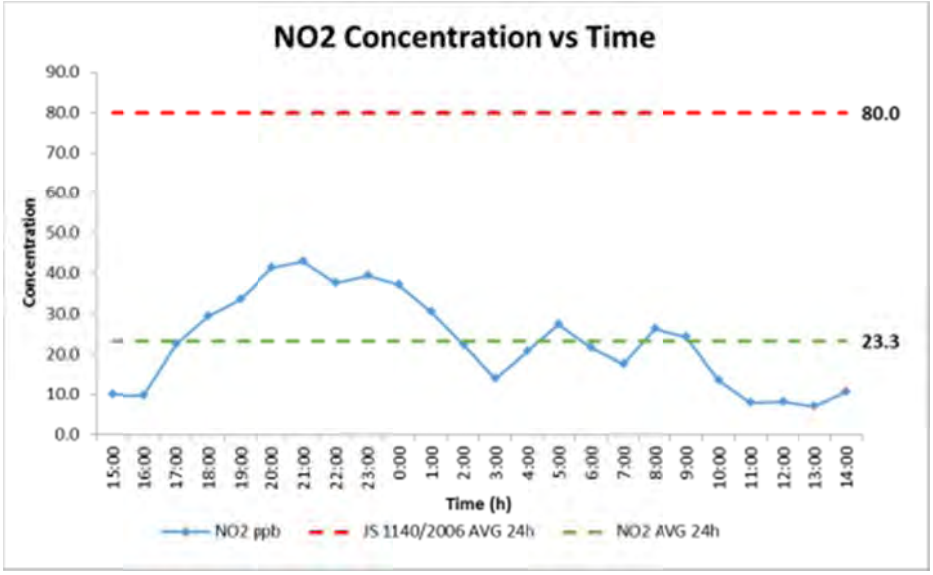


Figure 4-24: NO2 Concentration vs Time – HAJ

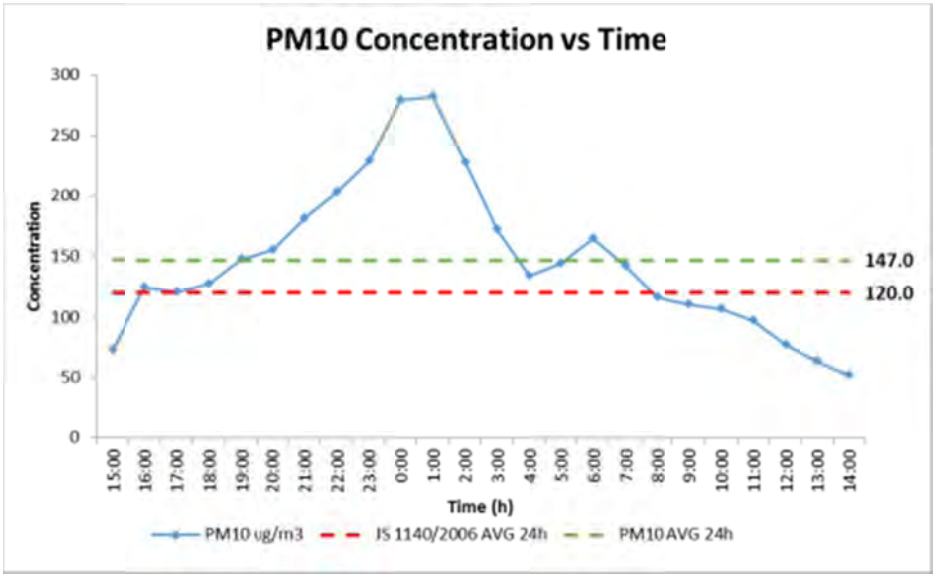


Figure 4-25: PM10 Concentration vs Time – HAJ

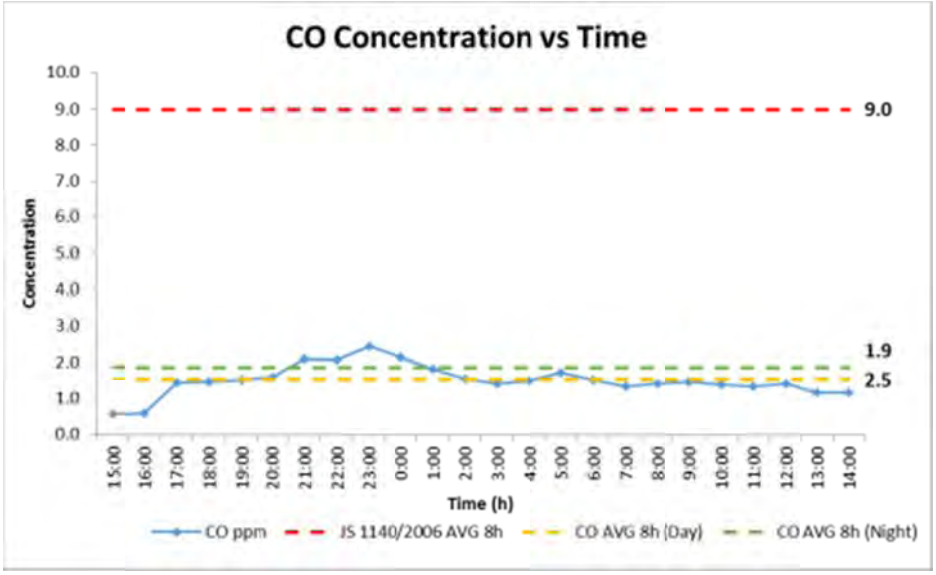


Figure 4-26: CO Concentration vs Time – HAJ

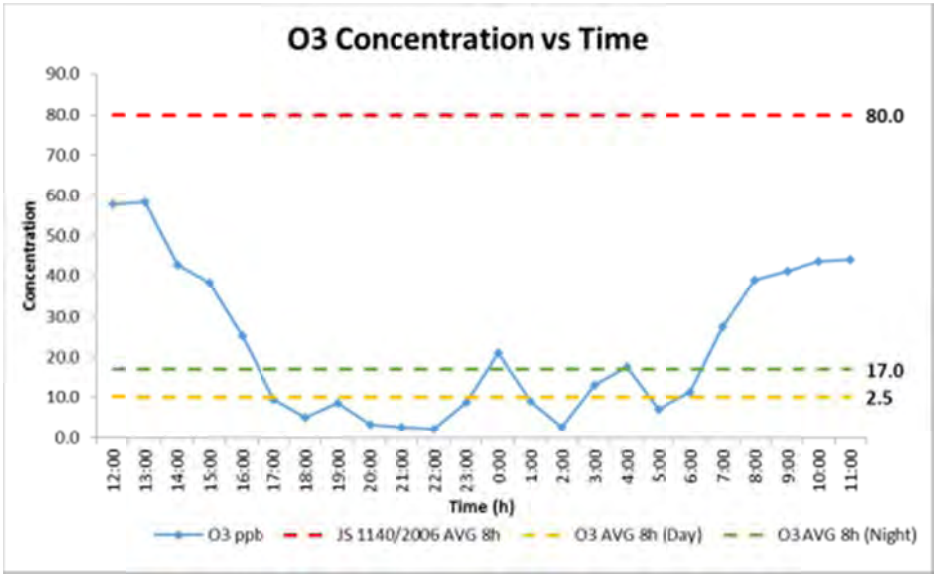


Figure 4-27: O3 Concentration vs Time – HAJ

4.5 NOISE LEVELS

Spot noise monitoring was carried out at GAM, TAB and HAJ locations in order to determine the ambient baseline sound level profile, measurements were undertaken using hand held Sound Level Meter.

The noise meter was hand-held and positioned such that the microphone, equipped with a windshield, was pointing opposite to wind direction. At each location noise measurement (day and night) was conducted for a period of 15 minutes 4 times. The noise meter was set to automatically record a range of noise related parameters as follows:

- LAeq: The A-weighted equivalent continuous sound pressure level. A representation of a continuous sound level containing the same amount of sound energy as the measured varying noise over the measurement period.
- LAmax: The highest A-weighted noise level recorded during a noise measurement period.
- LAE: The noise level that would be generated if all the energy from a discreet noise was compressed into 1second. This measurement is used to compare the noise energy contained in discreet events that may last different lengths of time.
- LA90: The A-weighted sound pressure level that is exceeded for 90% of the measurement period, this is commonly used as the Background Noise Level for assessing the effects of industrial noise.
- LA10: The A-weighted sound pressure level that is exceeded for 10% of the measurement period.
- LCpeak: Peak sound pressure, maximum value of the C-frequency weighted instantaneous noise pressure.

Table 4-13 below present the average noise level at the three stations, full results of noise level monitoring are presented in Appendix B.

Table 4-13: Comparison of Measured Noise Levels verses Jordanian Noise Standards

Location	Day-Time Noise L Aeq dB(A)	Night -Time Noise L Aeq dB(A)	Jordanian Standard
GAM	76.1	58.7	65 dB(A) Day-Time 55 dB(A) Night- Time
TAB	72.2	68.5	
HAJ	58.0	42.1	

The project area is generally experience very high noise levels exceeding the Jordanian Standards especially at GAM and TAB monitoring locations with an average day-time noise level of 76.1 dB(A) at GAM and 72.2 dB(A) at TAB monitoring location. Also night-time noise levels was found to exceed the Jordanian Standards with 58.7 dB(A) at GAM and 68.5 dB(A) at TAB. On the other hand, day and night-time noise levels at HAJ were within the Jordanian Standards with an average noise day-time noise level of 58.0 dB(A) and 42.1 dB(A) average night-time noise level.

Figure 4-28 and **Figure 4-29** are graphical presentation of the obtained noise level-monitoring results for GAM, TAB, and HAJ monitoring stations during the period from15 October 2017 to 18 October 2017.

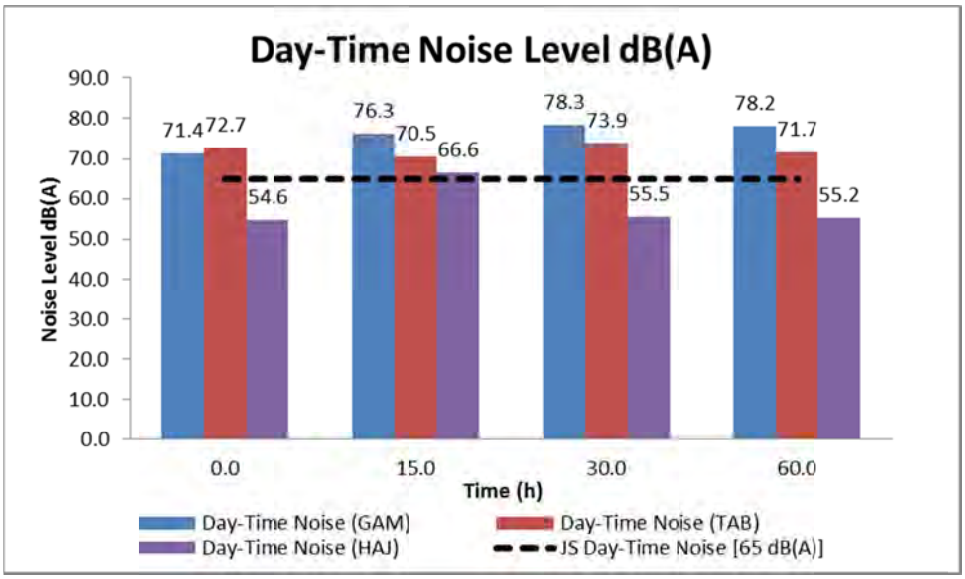


Figure 4-28: Day-Time Noise Level, GAM, TAB, and HAJ

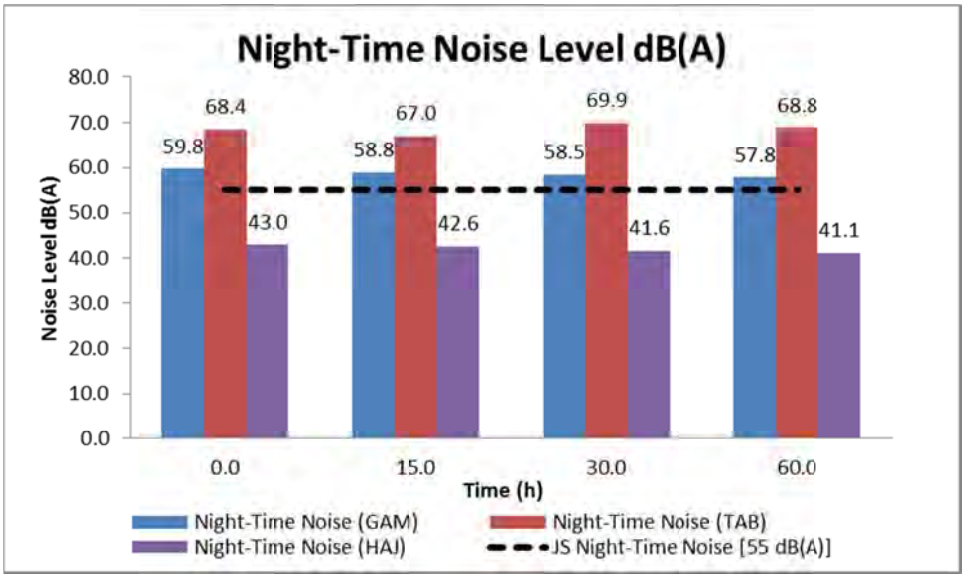


Figure 4-29: Night-Time Noise Level, GAM, TAB, and HAJ

4.6 CULTURAL RESOURCES

The BRT project alignments do not pass through any known archeological sites, conversely the BRT project area has many known archaeological sites of importance. It is also likely that unexcavated sites exist throughout the area. Investigation has identified a number of archaeological sites in the project area. This section describes the cultural resources in the study area and provides relevant information about these resources in order to enable an understanding of the potential impacts from the proposed project.

Archaeological heritage is protected by the Jordanian legislation under the Antiquities Law number 21 for the year 1988 and its amendments. Archaeological sites in Jordan, including the project area, are listed on JADIS (Jordanian Antiquities Data Information System)

The information provided on the archaeological sites in the study area is based on the official registers and excavation reports available at the Department of Antiquities (DoA) and by conducting site visits to archaeological sites along the BRT routes [2,3]. Unofficial consultations were also undertaken with Jordanian archaeological experts to confirm unpublished information or to cross-check data.

Providing baseline information on the cultural heritage and identifying the sensitive assets or sites that are in need of protection are one of the important components of this study. The below sections describe the key cultural heritage features in the study area and the identified issues of concern related to archaeological heritage and proposing measures to protect threatened sites or sites that may be adversely affected by the proposed project.

The Jordanian Law of Antiquity No. 21 for the year 1988 and its amendments defines the cultural resource as prior to the year 1750 with the Department of Antiquity of Jordan as the entity responsible for its protection. Architectural and urban heritage is defined by the Law as post 1750, no list or register has been published in the official newspaper.

The present cultural resources in the BRT project's influence area generally suffer from pressures from various sources. They have been affected by direct and indirect impacts such as the following:

a. Debris accompanying rain that flows through these sites and covers or erodes cultural layers.

b. Exposing cultural remains by human activities (e.g. excavation).

c. Agricultural activities exposing much of the surface features including the ancient remains.

d. Urban expansion.

e. Land surveys and infrastructure planning.

f. Limited pre-definition of the sites by earlier archaeologists.

g. Isolation of the urban archaeological sites from the current urban scene such as in isolating protected areas within rigid boundaries.

4.6.1 Cultural Resources along BRT Line 1

This BRT line extends from Al Mahattah terminal to Swuayleh via Sports City and the University of Jordan (Queen Rania Street). It is approximately 15.5 km long and has the following alignment: Mahattah Terminal– Istiqlal Street –Prince Hamzah Bin Al Hussein Street- Habes Al-Majali - Aqsa Street-Shaheed Street-Queen Rania Street-Swuayleh Roundabout, **Figure 4-30** represents cultural resources along BRT Line 1

Site No. 1 - Bronze Age Caves

Although the site is located along Istiqlal Street, it is very close to the intersection with Rashid Al Hassan Street along Al Mirbat wadi. East of this site is Al-Hashemi Ashamali starting from the natural sloping edge while Al-Hashemi Ajjanubi is located to the west of it along the cut that was associated with the construction of Istiqlal Street. Burial caves were bulldozed at ca.1980s during the construction works for the Istiqlal Street project. Alongside these caves are concrete buildings dating from the 1970s.

The rocky valley here has natural shelters too, inhabited from the same period. Many cave traces are still visible in this section. Most of the types of chambers date back to the early Bronze Age, Phase IV (ca.2300 BC). The remains of the group of caves do not reflect any significant site (e.g. a large cemetery) since it has been largely destroyed. The site is considered a very low risk site with limited potential impact from the project.

Site No. 2 - Juranin

The Juranin site is located along the western edge of Aqsa Street south of the intersection of Aqsa Street with Habis Al Majali Street. It does not fall directly along the route of Line 1 BRT. Relatively new housing quarters, Daheyt el-Amir Hassan and Al Rewqa are located next to this site. The remains still have Bronze Age caves, traces of walls form Roman/Byzantine- Early Islamic and Ayyubid/ Mamluk settlement (1250 AD). Pottery sherds collected from this site were referred to these periods. The condition of the site can be described as heavily damaged with some patches of ruins and segments of exposed parts scattered among the new apartment buildings. The site sits on private land and has already experienced strong human impacts largely due to nearby urban development. Although this is considered a fragile archaeological site, the BRT project is not expected to adversely affect it.

Site No. 3 - Al Baidar

Al Baidar is located approximately 700m north of the Islamic University along Prince Al Hussein Ben Abdallah Street. It is an important site with remains of structures dating back to the Iron Age (Ammonite culture). The site sits on private land and has not been excavated by DOA so far.

Site No. 4 - Roman Milestone

This site is located where Al Shaheed Street crosses Al Urdon Street over the bridge. This Roman milestone was unearthed in 2002 during construction and the stone was placed in Amman theatre forum since then. The archaeological survey examined the accumulation of pieces of dressed boulders related to a Roman watch tower, but no traces to the site itself were found.

Site No. 5 - Roman Tombs/Sports City

This site is located along Queen Rania Street on the northwestern corner of Sports City square. The site hosted a number of Roman tombs which were discovered in 1980. Salvage excavations by DOA revealed numerous pottery objects, metal bracelets, earrings and glass bottles. According to JADIS, this site is called Qatnah el-Janubi (now built up as Al-Faisal Apartments) and was the edge of a plateau that was covered with a small mound called Rujm with suspected ruins. This group of tombs extends more than 300m alongside Queen Rania Street. Evidence strongly suggests that this was a Roman cemetery that was mostly destroyed by several urban development projects. All of these tombs were discovered by accident, the Roman carved their rock cut tombs 2m from the surface of the ground by drilling a shaft. Salvage excavations that were conducted aimed at cleaning this section. The site now sits on privately-owned land.

Site No. 6 - Tel Seiran

Tel Seiran is located at the University of Jordan Campus and is not expected to be affected by the BRT project. This site was heavily damaged in 1972. However, the Tel still has a section of approximately one meter that contains cultural remains with a water cistern underneath. A rare and unique inscribed bronze bottle, dating back to the Ammonite culture (ca. 700 BC) found at this site is considered one of the best evidence and record of the late Ammonite period. Later, the Faculty of Engineering and Technology was built around this site. No direct or indirect impacts from the BRT project are anticipated on this site.

Site No. 7 - Khirbet Salameh

The site is located up on a hill overlooking Queen Rania Street and is adjacent to the American School of Oriental Research (ACOR). Khirbet Salameh is a Byzantine agriculture center (family house) and was reused in the early Islamic period. It was built from rough cut stones in a rectangular shape and consisted of several rooms and their facilities with one entrance. The farmstead was founded in the Roman and Byzantine period, in order to collect the industrial-agricultural production. They discovered some storage jars and kind of local presses. The site is generally well-preserved and sits on land that is owned by the Department of Antiquities.

Site No. 8 - Abed Er-Rahman Bin 'Awf

Near Swaileh Square off the road from the Queen Rania Street intersection with Yajouz Street, a memorial Islamic shrine called As-Sahabi Abed Er-Rahman Bin 'Awf is located approximately 900m from the BRT Line. The site is owned by the Ministry of Awqaf and Islamic Affairs and has a considerable open land around it. It is surrounded by houses, villas and apartment buildings. No direct impact from the BRT project is expected on this site.

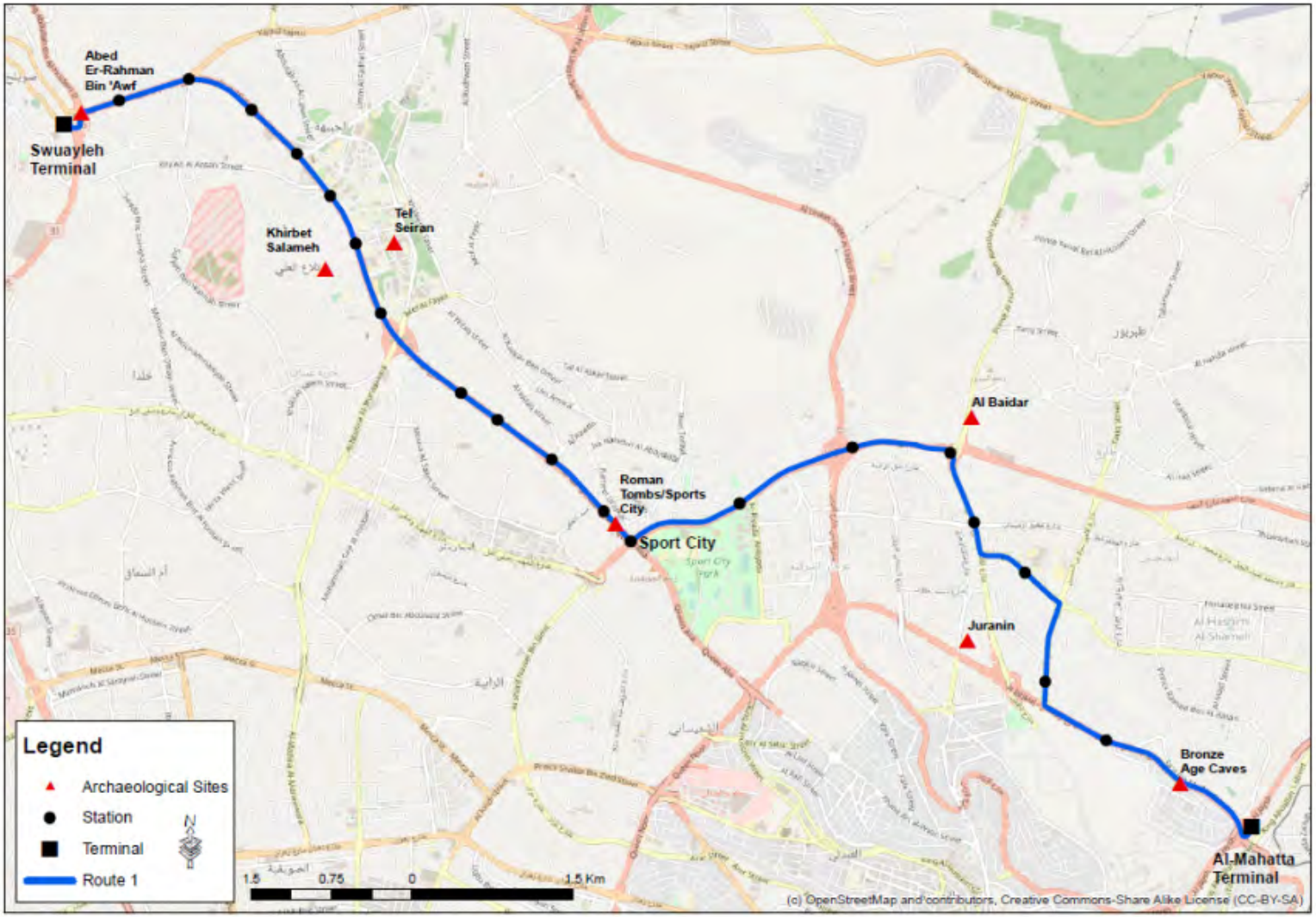


Figure 4-30: Key Cultural Resources along BRT Line 1

4.6.2 Cultural Resources along BRT Line 2

Figure 4-31 on the following page represents cultural resources along BRT Line 2. The sites are described in detail in this section.

Site No. 1 - Abdoun Rural area

Along Princess Basma Street and next to the Sanaya Amman development site as one enters Wadi Abdoun, is an area that contains disturbed remains of a fragile archaeological site that had been partially removed during the construction of adjacent streets which took place in the 1980s. Rescue excavations were carried out in 2007 and 2008 and the remains of a site (apparently a storage house) were discovered on site with partial walls that date back to the late part of Iron Age period (ca. 450BC). The same foundations of this building were later reused in the Roman /Byzantine period. The Department of Antiquities documented the excavated part of this site. The site sits on a private land. Figure 4.37 shows this site as seen from the intersection of Princess Basma Street with Wadi Abdoun Street. It is expected that the BRT Line 2 will pose no direct risk to this site.

Site No. 2 - Caves at Khirfan Area

These caves occupy the hills that overlook the Ras al Ein from the North. The hills form the southern part of Jabal Amman and contain more than one natural cave that are still visible and had been inhabited, reused and disturbed over the years. These caves could be prehistoric as they are situated at the edges of mountains and hills situated around the main source of water in the area (Ras el-Ain). No direct impact from the BRT project is expected on this site.

Site No. 3 - Menhir Structure

The only Prehistoric Menhir structure still surviving in Amman and dating back to ca. 3400BC is located in a vacant plot of land situated opposite the Sports City main entrance. This site is on a private land approximately 600m to the south of Queen Alia Street. It is constructed from a single monolithic stone. No direct impact from the BRT project is expected on this site.

Site No. 4 - Qatana el-Janubi

Qatana El-Janubi archaeological consists of a Roman settlement that had been built opposite the Roman cemetery (Site No. 5 above, situated adjacent to Al-Faisal Hotel Apartments). The site sits on a private land on southern side of Queen Rania Street. The site is approximately 280m from the Sports City interchange (on a straight line). Nothing from the site is still visible at the surface as it was completely removed in the 1980s. In 2005, a contractor bulldozed the remaining Iron Age water cistern and a team from the Department of Antiquities discovered in the rubble Iron Age and Roman pottery sherds. This accumulation provides evidence of a heavy occupation during the Roman period. No direct impact from the BRT project is expected on this site.

Figure 4-31: Key Cultural Resources along BRT Line 2

4.6.3 Cultural Resources along BRT Line 3

Cultural resources along BRT Line 3 are presented on **Figure 4-32** . Two sites were identified along the BRT route which are:

Site No. 1 - Qasr Shabib

Located in the centre of Zarqa City, it is a square building (13.75 × 13.75) with a double entrance is located in the centre of the northern side. It was built of trimmed limestone and consists of square hole, roofed by vault and has three divorces arrows of more than two meters high. In the northeast corner staircase ascends to the roof of the first floor.)

Site No.2 - Khirbet Russeifa

Khirbet Russeifa is located (15Km) north west of Amman. On the main Yajuz road and it lies on the left bank of the river. Studies and analysis of this excavation results proved that Khirbet Russeifa is a wide riche site of ruins passed through different historical periods, monuments and findings that represent each period, starting from the Chalcolithic , Bronze and iron ages, and continues up to the age of the Roman Empire, to the Byzantine and ending with Islamic ages.

In addition to the two sites mentioned above, a few other locations exist but are not in proximity to the BRT route which are:

Site No. 3 - Khirbat Masarah

Located in the west of Zarqa, it is dated to the Roman-Byzantine periods. Remains of church walls still appear on the surface in addition to many walls and buildings foundations.

Site No. 4 - Qaser al- Hallabat

Locate about 65 kilometers east of Amman, it is one of the most extensive and elaborate of the Umayyad desert complexes in Jordan. The main building is a 44-metre square, with four large rectangular corner towers.

Site No. 5 - Hammam as-Sarah

Locate about 2 kilometers south east Qasr Al-Halabat. The bathhouse was decorated in fine marble, mosaics and painted plaster. It is a small version of the baths of Qasr Amra.

Site No. 6 - Qaser Azraq

Qaser Azraq was probably first built in the late Roman period, around 292- 306 AD. The 80 x 72 meter fort was one of a string of Roman defensive installations which

protected this area. An inscription confirms the fort was rebuilt in 1237 under the Ayyubids, and it must have been used by the Byzantine, and the Umayyad, Abbasid and succeeding Arab/Islamic inhabitants of the land.

Site No. 7 - Quseir Amra

Quseir Amra is an Islamic castle in Jordan, about 50 miles east of Amman. It was said to have been built by the Umayyad Caliph al-Walid between 712-715 AD, for use as a vacation residence or rest stop. Quseir Amra is best known for its amazing mosaics and murals which decorate the central hall and connected rooms.

Site No. 8 - Tall Al-Sukhneh

Located near to Al-Sukhneh village. It is dated to the Middle Bronze ages.

Site No. 9 - Tall al-Birah

Located north of Zarqa, it has archaeological remains and artifacts dated to the Early Bronze age, Iron, Byzantine and Islamic periods.

Site No. 10 - Hashmiyah Mill stones

Located in Al-Hashmiyah town, it is an important site dated to the Roman period. It was built near to the old Roman road and contains number of Roman mile stones.

Site No. 11- Gharesa

Located on the top of a hill west of Khirbet As-Samra. It was dated to many periods started from prehistoric till to Islamic periods.

Site No. 12 - Khirbet As-Samra

A major site located between Zarqa and Mafraq Cities .The site represent a village of several occupational phases especially the Byzantine periods.

Site No. 13 - Batrawi

It is Middle Bronze age site, located north-east of Al-Hashmiyah town. It has many fortification walls and considered as one of the major sites of Zarqa City.

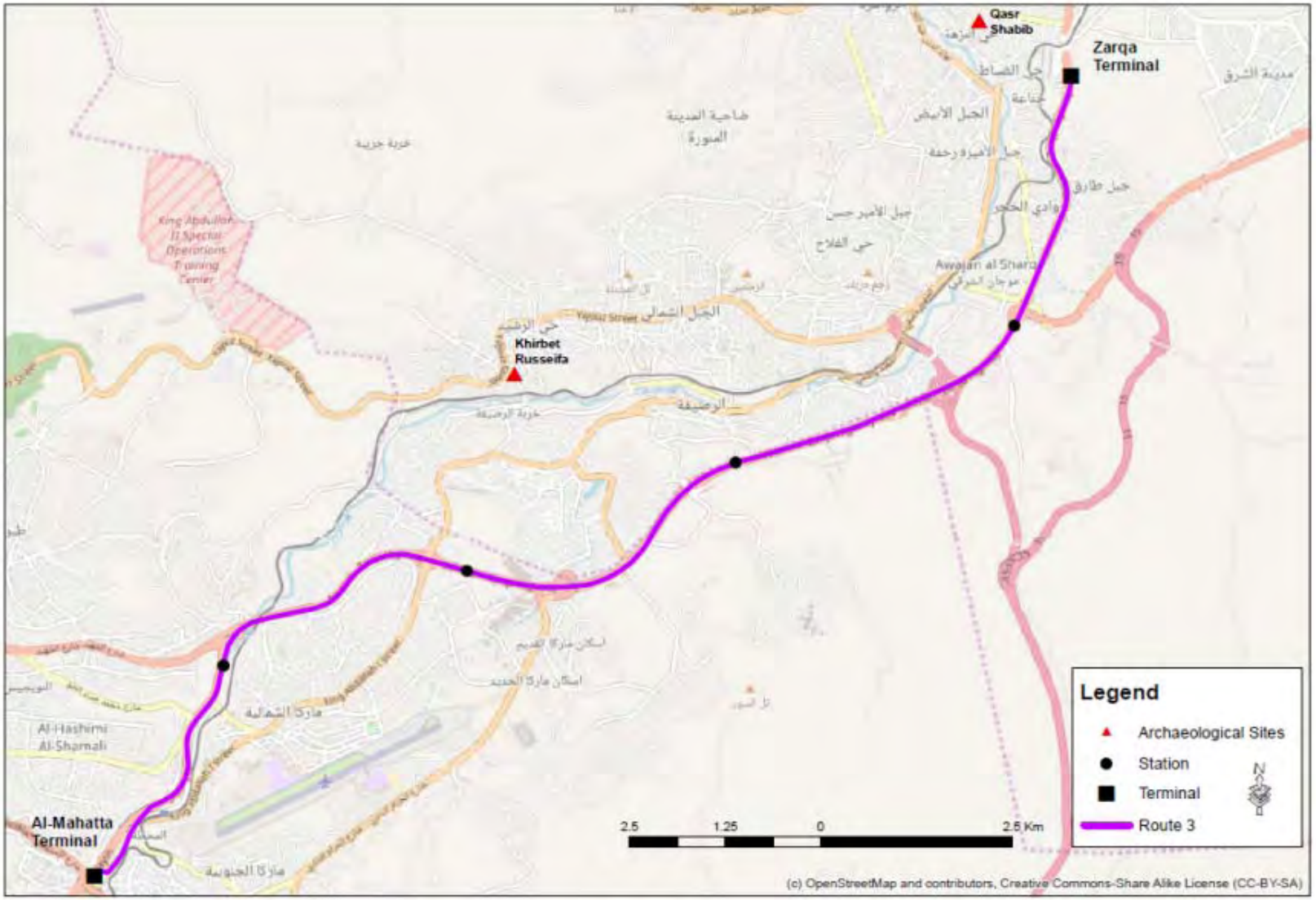


Figure 4-32: Key Cultural Resources along BRT Line 3

4.7 SOCIO-ECONOMIC PROFILE

4.7.1 Socioeconomic Profile of the Study Area

According to the latest population census conducted in 2015, the overall population of Jordan is 9,531,712, with an expected population growth of 2%. This represents a sharp increase over the past five years due to the influx of refugees from Syria (DOS, 2016). About 42% of the total population lives Amman making it the most populated governorate of the country with Zarqa constituting about 14.32%. This means that more than half of the population of Jordan resides in those two governorates alone. In addition, there are currently 654,877 Syrian refugees registered with the UNHCR in Jordan with 181,257 located in Amman Governorate and 107,696 in Zarqa Governorate (UNHCR, 2017). There are also a high number of non-registered refugees that reside in the country. **Table 4-14** presents the population breakdown for each of Amman Governorate and Zarqa Governorate.

Table 4-14: Population Statistics for Districts in Amman and Zarqa Governorate, 2015

Location	Population
Amman Governorate	4,007,526
Zarqa Governorate	1,364,000

Source: DOS. 2016

Amman's population has more than doubled since 2007 reaching over four million inhabitants in 2015. Similar growth patterns were also present in Zarqa as the population almost doubled in the same timeframe. Supply-side efforts to expand the road network and add more road infrastructure have ultimately been outpaced by the increasing number of private automobiles on the roads. Due to its major significance in the Jordanian economy, Amman provides many jobs and opportunities that are accessed by people who live outside of the city, often coming in from cities like Zarqa, Salt, and others. **Figure 4-33** and **Figure 4-34** show the population growth of Amman and Zarqa, respectively.

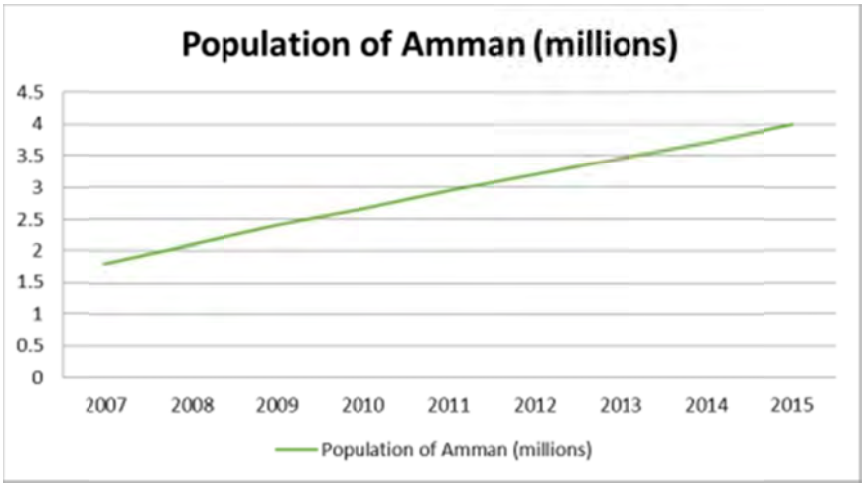


Figure 4-33: Population Growth of Amman

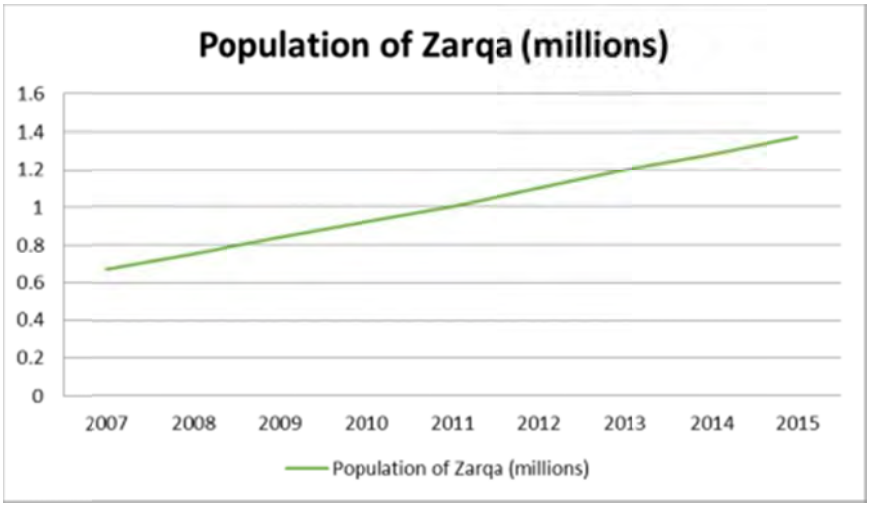


Figure 4-34: Figure Population Growth of Zarqa

The Routes selected for the BRT project are major commercial areas and include a variety of businesses. As shown in **Table 4-15** below 27 % of businesses along the BRT lines are trading cars and car rental agencies while restaurants and shopping comprise 22% of the businesses along the BRT lines, pharmacies and health centers comprise 11% of the total businesses while the remaining percentage are disrupted along the remaining business types. These businesses are all within immediate walking distance from the BRT (one hundred meters or less).

Table 4-15: Business Types along The BRT Lines

Business Type	BRT 1	BRT 2	BRT 3
Academy	1	-	-
Airlines	1	-	-
Amusement Park	-	1	-
Auto Services Center	1	-	4
Bank	12	3	-
Book Shop	5	-	-
Bowling Center	1	-	-
Bus Station	2	-	1
Capital Indicator	-	1	-
Cemetery	-	-	1
City Hall	-	1	-
Civil Defense	1	1	1
Coffee Shop	20	-	1
College	1	-	1
Community Center	6	2	1
Company	17	13	-
Consular	1	-	-
Court Houses	3	-	1
Cultural Center	1	5	-
Embassy	-	1	-
Gasoline Station	9	6	-
Governmental	8	6	12
Grocery Store	-	1	16
Health Center	23	4	1
Historical	-	1	-
Hospital	4	2	3
Hotel	20	7	-
Industry	-	-	2
Library	1	-	-
Mosque	9	3	9
Nightlife	1	2	-
Others	1	1	-
Park	2	2	1
Political Party	-	-	2
Pharmacy	22	13	6
Police Station	1	2	-
Rental Car Agency	11	49	2
Restaurant	43	9	18
School	11	1	3
Shopping	63	4	1
Souvenir	-	2	-
Sport Center	3	1	-
Trading Car	64	30	9
University	1	-	1

4.7.2 Mobility in the Study Area

Zarqa and Amman are separated by a 20 km corridor. The close proximity of the two cities and the presence of better opportunities in Amman generates 343,000 daily trips, only 64,000 of which are carried out using public transport. Peak demand occurs from Zarqa to Amman in the morning and from Amman to Zarqa in the evening, although there are also significant flows in the opposing directions. Low public transportation ridership reflects the inadequacy of the current level of service. In the case of the Amman - Zarqa route, 86% of public transport users make a transfer prior to or after traveling from Zarqa to Amman and vice versa

The public transportation fleets of Amman and Zarqa are shown in **Table 4-16**. There are three types of vehicles that run on set routes and perform public transport services: Large buses that carry 34-45 passengers; Coasters (medium-sized buses) that carry 23 passengers, and service taxis (white taxis) which are passenger cars that can carry up to four passengers. The current populations of both cities require a larger fleet in order to be properly serviced, and amendments to the current network need to be made to account for the large number of transfers that occur in order to reach one's destination.

It should be noted that the Amman figures in **Table 4-16** represent the number of licensed vehicles. In effect, the number of vehicles that are actually in operation is much smaller. For example, GAM officials1 estimate that about 50% of the 475 licensed buses in Amman actually operate regularly.

Table 4-16: Public Transportation Fleet in Amman and Zarqa

Public Transportation Fleets				
City	Bus	Coaster	Service Taxi	Inter-city Routes
Amman	475	200	3000	11
Zarqa	23	560	92	

Reference: GAM and LTRC

A growing population, urban expansion, and a public transport system that has failed to adapt to this growth have made owning a car a necessity. **Figure 4-35** and **Figure 4-36** illustrate this trend towards increased automobile ownership and use as more roads are surpassing their volume capacity throughout Amman. The rise of single occupancy vehicles has also been linked to significant economic losses as a result of increased traffic congestion. The lack of a convenient alternative to the personal automobile exacerbates this problem and also prevents many people who do not have access to cars from accessing job and educational opportunities. The

[1] Meeting with GAM's Executive Director for Public Transportation, November 4, 2017.

need for developing a viable public transportation system is becoming more critical every day as a result of these conditions.

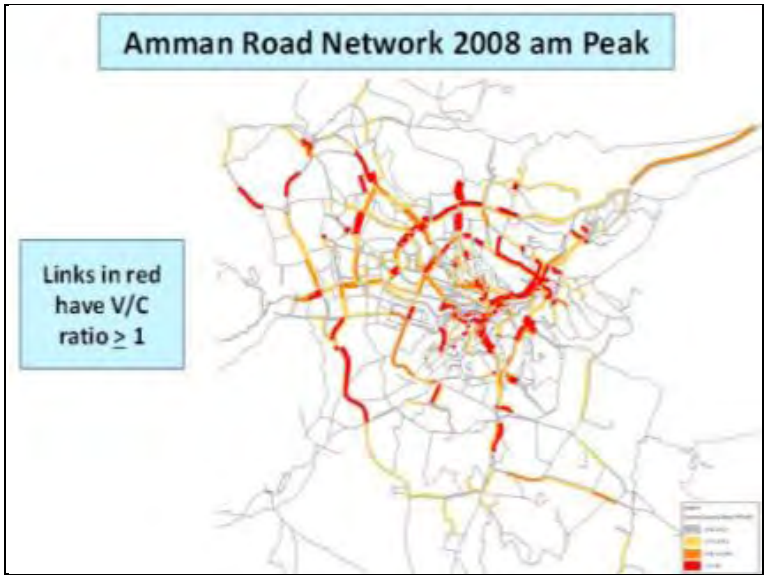


Figure 4-35: Volume/capacity ratio of Amman's streets in 2008.

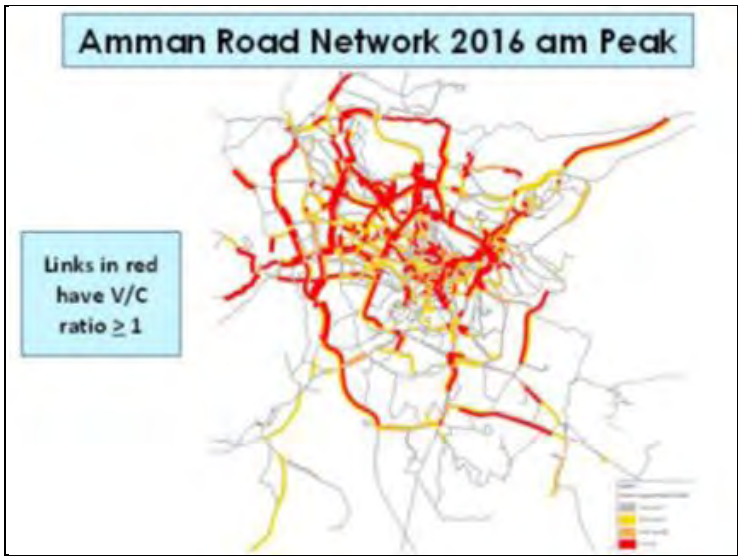


Figure 4-36: Volume/capacity ratio of Amman's streets in 2016. Photo credit: GAM

Figure 4-37 also illustrates this trends and highlights the use of public transportation in Amman holding 13% mode share, according to the most recent household survey conducted in 2008.

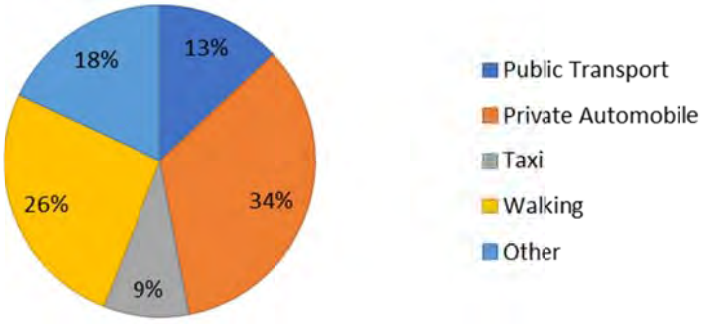


Figure 4-37: Transportation Mode Share % in Amman

Sensitive Receptors

Sensitive receptors include, but are not limited to, hospitals, schools, daycare facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides, and other pollutants. Extra care must be taken when dealing with contaminants and pollutants in close proximity to areas recognized as sensitive receptors. Regarding the Jordanian Standards and Regulations, the sensitive receptors in Jordan include Hospitals, Worship Houses and Educational Institutes.

The following figures (**Figure 4-38, Figure 4-39 and Figure 4-40**) represent the identified receptors on the three BRT routes.

Figure 4-38: Identified sensitive receptors on BRT route 1 (H: Hospital, W: Worship House, and E: Educational institute)

Figure 4-39: Identified sensitive receptors on BRT route 2 (H: Hospital, W: Worship House, and E: Educational institute)

Figure 4-40: Identified sensitive receptors on BRT route 3 (H: Hospital, W: Worship House, and E: Educational institute)

5. IDENTIFICATION AND ASSESSMENT OF IMPACTS AND PROPOSED MITIGATION MEASURES

This section provides an overview of the potential impacts that are expected to arise during the design, construction, and operation of the BRT project. Impacts are comprehensively identified and assessed in this section and specific, practical mitigation measures are proposed and discussed under each impact heading. Mitigation measures are designed to ensure that positive impacts are enhanced and potential negative impacts are minimized. These measures are incorporated in the Environmental Management and Monitoring Plan presented in **Section 6**.

5.1 IDENTIFIED IMPACTS AND PROPOSED MITIGATION MEASURES DURING PROJECT DESIGN

The BRT design is very challenging due to the restrictions of the existing roads, infrastructure, and buildings as the BRT is planned to be developed within existing heavily used major roads in Amman and Amman and Zarqa.

The main identified impacts and mitigation measures during the design phase include:

5.1.1 Demolition of Road Median and Removal of Trees

The design of the BRT utilizes the middle of the roads for developing the BRT corridor which means all the trees that have been planted in the median must be removed. The designer in most of the routes has no other choice and therefore cannot save these trees.

Mitigation Measure

The designer to incorporate the planting of new trees and transplant existing trees into the new median designed to serve the BRT project and surrounding roads. More detailed discussion about this issue in the impact during construction.

5.1.2 Exclusion of Socially Vulnerable Groups

Several socially vulnerable groups currently are excluded from access to public transportation including the handicapped, blind and visually impaired, and to a less extend the elderly. The current bus systems in Jordan do not cater for those groups.

Mitigation measures

The BRT design should include special provisions for accessibility of these groups including:

- Stations and buses that have wheel chair accessibility
- Sound announcements of stations when in bus to alert the blind and visually impaired
- Braille language signs at stations
- Reserved seating for elderly

5.1.3 Not Including Sustainability in Project Design

Several opportunities exist within the design to select sustainable options related to:

- Selection of construction material for project elements including station and terminals.
- Waste management infrastructure within the bus stations and terminals.
- Water usage
- Energy usage. Within the BRT project several elements can consume large amount of energy such as lighting, heating, and cooling of the project stations and terminals.
- Indoor air quality within the buses and any buildings in the terminals

Mitigation Measures

The BRT design shall take into consideration sustainable development and engineering principles and adopt when possible the following:

- Use of recycled material or material that can be recycled in the construction
- Use of locally available material
- Design for waste recycling and reuse
- Design water efficient outlets and allow for water reuse if possible
- Energy efficiency and renewable energy sources
- Maintain fresh and ventilated indoor air quality

5.2 IDENTIFIED IMPACTS AND PROPOSED MITIGATION MEASURES DURING CONSTRUCTION

A number of potential impacts are expected during the construction of the BRT project. The main Project construction elements that are anticipated to have an impact on the environment and social existing situation include the following main elements:

- Demolition of the existing road medians including cutting of trees
- Construction of new medians to separate the new BRT corridors
- Expansion of the existing road widths when possible to allow for additional road capacity to compensate for the space taken by the BRT corridor

- Construction of BRT intersections which include bridges and tunnels
  - The Sahafa Tunnel
  - Sports city intersection
- Construction of BRT stations along BRT routes
  - A station every 500 m along the Amman routes
  - 4 station along the Amman to Zarqa route
- Construction of BRT terminals

During the construction activities several inconveniences to the public are road users are anticipated including closure of congested roads to allow for safe construction of BRT intersections and terminals, production of dust and noise, production of demolition waste, movement of construction equipment and vehicles. Identified impacts and mitigation measures represented in the following sub-sections. It is recommended to provide this section as part of the tender documents for construction of the main project elements.

5.2.1 Air Quality Impacts

Identified Impacts

During construction activities, dust and combustion exhaust emissions are anticipated from activities including earthworks, equipment movement, exposed storage piles, truck dumping, hauling, vehicle movement on unpaved roads, combustion of fuel in equipment and vehicles, land excavation, and concrete mixing. There are various sources of fugitive emissions during construction activities:

- Earth excavation and moving
- Disturbed surface areas
- Unpaved roads
- Open storage piles
- Paving and application of asphalt
- Machinery and vehicles

Workers at construction sites will be in direct contact with fugitive emissions such as dust, air pollutants (SOx, NOx, CO and VOCs) from the operation of different machinery and the vehicles passing nearby, especially during the construction activities on the trunk-line. In addition, there are direct emissions resulting from equipment such as the diesel generators and heavy-weight vehicles operating at the construction sites. Exposure to air emissions has both acute (respiratory problems) and chronic impacts (cancer), therefore mitigation measures are necessary to eliminate or reduce the propagation of fugitive and direct emissions.

Mitigation Measures

A wide variety of options exist to control emissions from construction sites. The most effective means of reducing the dust emission is wet suppression. Watering exposed surfaces and soil with adequate frequency to keep soil moist at all times can reduce the total dust emission from the project.

In case surplus water is not available to suppress dust at certain locations, it is recommended that if works are within 10 meters of any sensitive receptors, the contractor shall install site hoarding between the works and the road edge to provide a barrier to protect the sensitive receptors and passing traffic.

The hoarding should be easily erectable 2.5 meter high hoarding /fiber boards and/or steel sheets to make protection fences around the construction site (at each station location during the construction) within which all construction works can take place. They can be moved from site to site along the BRT route as the work proceeds.

The need for large soil stockpiles shall be minimized by careful planning of the supply of materials from controlled sources. Stockpiles should not be located within 50 m of schools, hospitals or other public amenities and shall be covered with tarpaulins when not in use and at the end of the working day to enclose dust. If large stockpiles (>25m3) of crushed materials are necessary they should be enclosed with side barriers and also covered when not in use.

Construction materials that are susceptible to dust formation shall be transported only in securely covered trucks to prevent dust emission during transportation.

Measures for emissions control from vehicles include periodical checking and maintenance of the construction machinery and haul vehicles also the contractors shall ensure regular change of engine oil and use new engines/machinery/equipment having good efficiency and fuel burning characteristics.

All generators being used on site shall be fitted with catalytic converters and all generators stacks are recommended to be placed at least 3 meters above the ground to reduce direct exposure to exhaust.

5.2.2 Noise Levels

Identified Impacts

The BRT area's noise environment is dominated by typical urban activities. During construction, additional noise sources will be introduced to the active construction sites, this includes the equipment and machines that will be used to remove the median areas and to make room for the bus ways in addition to excavation and removal of cut material.

Noise levels at any one location will vary as different combinations of construction machinery are used throughout the construction of the BRT lines. The major expected sources of noise during the construction include excavators, dumpers, trucks, loaders and cranes at different stages of construction. These sources are expected to generate different noise levels. Indicative sound levels for the types of construction equipment that may be used on site are shown on **Table 5-1** below.

Table 5-1: Indicative noise outputs for typical items of construction plant

Type of plant	Activity equivalent continuous sound pressure level (LAeq) at 10m distance
Pneumatic breaker (demolition)	80 – 90
Bulldozer	77 – 90
Tracked loader	76 – 86
Tracked excavator (backhoe)	78 – 86
Dump truck	75 – 85
Vibratory roller	74 – 86
Tracked crane	66 – 86
Concrete batching plant	65 – 80
Truck mixer	72 – 88
Concrete pump	78 – 81
Compressor (silenced)	75 – 85
Generator set	67 – 83
Water pump	65 – 85

Source: Reproduced from BS 5228, Part 1 1997.

Overall, noise generated during the construction phase is not expected to be significant due to the relatively short span of work for the BRT routes. However longer periods of construction are expected during work on intersections and terminals especially Sahafeh tunnel and Sport city intersections.

If transportation is required at night in order to avoid traffic congestion, then night-time routes should avoid residential areas to minimize nuisance from noise.

Ground vibration may be caused by some construction activities such as excavation, concrete and asphalt breaking, and compaction. Such effects may cause vibration to nearby buildings or other structures that can either lead to damage or annoyance. This is expected to be the case where construction sites are close to buildings and residences. However, it is not expected that construction vibration will have a significant adverse impact.

Mitigation Measures

The following are mitigation measures recommended to be followed and applied at construction sites throughout the BRT lines to reduce the impacts from noise and vibration:

- All mechanical and engine powered equipment should be maintained properly and regularly to minimize noise generation.
- Exhaust mufflers should be employed on engine-powered construction plant and vehicles.
- Mobile plant and other vehicles will be driven responsibly and below 30 km/h within the construction site and surrounding areas.
- Traffic of Construction vehicles and equipment not be permitted inside Amman without authorization.
- Transportation of materials will be optimized during construction as much as possible to reduce number of trucks and consequently the potential for traffic noise.
- Any necessary night time construction activities should be restricted to relatively quiet activities.
- All major compressors should be of sound-abated models or enclosed to reduce noise impacts.
- Noise mitigation measures should be followed such as providing acoustic enclosures around emergency generators and using low noise specification for motors, pumps, etc.

5.2.3 Traffic and Transport

Identified Impacts

Road closures are anticipated to cause severe congestions particularly during construction of intersections where closures may be anticipated for long durations possibly 6 months to a year. The BRT project corridors and stations may also include temporary closure of roads but for relatively shorter periods at a time.

In addition to road closure, heavy equipment, trucks, construction martial, demolition waste will be using the already congested roads. Overweight and oversized loads could cause temporary disruptions and could require some modifications to roads.

Mitigation Measures

Mitigation measures can be applied to reduce transportation impacts of the BRT project depending upon site conditions. Transportation impacts are related to the amount and types of vehicular traffic associated with the construction activities. As mentioned earlier, these impacts are expected to be exacerbated by the fact that the BRT lines will be built on heavily trafficked main roads and highways in Amman. Many such impacts, however, can be reduced or avoided when accounted for during the design phase. The efficient management of traffic once the construction activity commences will be critical in order to minimize the risk of possible road accidents and construction related hazards.

The following considerations are recommended in order to mitigate these impacts:

- Any detours required for road closure to be clearly marked and prepared for this purpose
- Traffic signs and warning instructions shall be displayed at the sites and along the proposed routes being used by the construction traffic for the information of other road traffic as well.
- Public awareness campaigns through radio and newspaper advertisements shall be conducted to educate the public and sensitize them to cooperate with the construction staff and project focal staff in order to try and avoid the areas under construction as far as possible, particularly during the peak times when traffic volumes is the highest.
- The potential risks of accidents to pedestrians and commuters while in the immediate vicinity of construction sites shall be conveyed to them in order to educate them and gain their cooperation and minimize the risk of accidents.
- Employ flag persons to control traffic at the work sites for safety reasons when construction equipment is entering or leaving the work area.
- Lanes shall be created through the work site using rope or flagging to minimize risks and injuries from falling objects.
- As much as possible, lifting and placing of the pre-cast sections will be done at night to minimize traffic congestion.
- Post traffic advisory signs (to minimize traffic build-up) in coordination with local authorities.
- Use traffic cones to direct traffic to move to the open lane.
- Provide sufficient lighting at night within and in the vicinity of construction sites.
- Regularly monitor traffic conditions along access roads to ensure that project vehicles are not causing congestion.
- Define and observe schedules for different types of construction traffic trips (e.g., transport of pre-cast sections, haulage of spoils, delivery of construction materials, etc.).
- As much as possible, schedule delivery of construction materials and equipment as well as transport of spoils during non-peak hours.
- Implement suitable safety measures to minimize risk of adverse interactions between construction works and traffic flows through provision of temporary signals or flag controls, adequate lighting, fencing, signage and road diversions.
- Ensure relocation of any affected public transport infrastructure (bus stops, shelters etc.) prior to commencement of works.
- Provide advance notification to the community regarding changes to public transport facilities or routes.
- Schedule construction works to minimize extent of activity along linear construction site at any one time.
- Comply with traffic regulations and avoid, where possible, roads with the highest traffic volumes, high density of sensitive receivers or capacity constraints are not used as access to and from the construction areas and spoil disposal sites.
- Install temporary accesses to properties affected by disruption to their permanent accesses.

- Reinstate good quality permanent accesses following completion of construction.

5.2.4 Water Resources

Identified Impacts

Water would be required during the project construction for the everyday use of the laborers for drinking and washing. Water will also be used at the sites along the project corridor for sprinkling to suppress dust emissions. In addition, water shall also be used during the construction activity itself for mixing of gravel in the batching plant etc.

Water is normally provided by tankers to construction sites along the entire project corridor. Water is not expected to be a limiting factor to construction but could be used excessively if not monitored carefully.

Mitigation Measures

Even though water availability for the project construction should not be very large issue, it is recommended to implement some precautionary measures for water efficiency including:

- Monitoring of water usage to ensure it is not wasted
- Use recycled water sources when possible and suitable
- Keep records of water use per activity and aim to reduce the amount used with time
- Consider recycling water within the project location when possible

5.2.5 Health and Safety

Occupational Health and Safety

Identified Impacts

Different types of work incidents might occur for project workers during the construction operations that could result in injuries including:

- Sunstrokes. This issue is very critical during the summer season where the temperature might exceed 40 C under the direct sun
- Electrical shocks
- Wrong usage of electro-mechanical equipment
- Traffic accidents. Which could occur with passenger vehicles or construction equipment.
- Incidents related to the low hygiene level such as food poisoning.
- Use dangerous equipment and tools by untrained workers.

- Fire incidents at the project facilities.
- The possibility for any of the working team to be subjected to “Run over” accidents by the project machinery or private vehicles while working at the construction site or moving from one place to another within the project’s “working Zones”.

Mitigation Measures

In such big project, any of the above listed hazards are likely to occur (without the implementation of the appropriate occupational health and safety plan and procedures). Furthermore, it is considered that the intensity/severity of such hazards to be high due to the fact that, many of these hazards can cause human fatality, while the extent is considered local and the duration temporary, thus, such issue is considered to be of high significance.

Monitoring the significant risk posed by the construction work to the surrounding commuters and pedestrians, it shall be ensured that the Contractor provides his staff with a provided detailed orientation on the safety protocols to be followed at all times during the construction work to minimize the risk of accidents, some examples are:

- Appoint an environment, health and safety manager to look after implementation of required environmental mitigation measures, and to ensure that health and safety precautions are strictly implemented for the protection of workers and the general public in the vicinity of construction areas.
- Conduct orientation for construction workers regarding health and safety measures, emergency response in case of accidents, fire, etc., and prevention .
- Provide first aid facilities that are readily accessible by workers.
- Provide fire-fighting equipment at the work areas, as appropriate, and at construction camps.
- Provide adequate drainage in workers camps to prevent water logging/accumulation of stagnant water and formation of breeding sites for mosquitoes.
- Provide adequate housing for all workers at the construction camps.
- Provide reliable supply of potable water.
- Provide separate hygienic sanitation facilities/toilets and bathing areas with sufficient water supply for male and female workers.
- Ensure that all wastewater emanating from worker camps, construction camps and other project-related activities and facilities are treated consistent with national regulations.
- Establish clean canteen/rest area.
- Provide appropriate personnel safety equipment such as safety boots, helmets, gloves, protective clothes, breathing mask, goggles, and ear protection

Public Health and Safety

Identified Impacts

The project construction activity will be conducted in a heavily populated areas with high volumes of pedestrians and vehicular traffic which exposes the public using the roads and living near the construction sites to the construction hazards.

Without implementing the appropriate safety measures regarding the people whom are: (i) living or using the households located close to the planned work areas and/or (ii) might be passing within or close to the work zones; there is a major possibility for Impacting the safety of the people whom are passing through the work areas as a result of :

- The possible collisions between their personal vehicles and the project vehicles or other private vehicles as a result of the expected traffic congestions. This potential impact may occur also during the movement of the project machinery from one working site to another without implementing an appropriate traffic management plan.
- Accidental collision between the private vehicles and the project barriers due to the absence of reflective diversions or caution signs.
- Pedestrians “Run over” accidents by the project machinery. Special attention should be given to the presence of small children close to the construction sites, and also the fact that many of the existing pedestrian crossing bridges will be removed and reconstructed by the Project.
- Pedestrians “Run over” accidents by road using vehicles along the BRT route and the detours and traffic diversion areas. Particular attention is needed for students and young children especially during the time of going to school and returning from school. Coordination and collaboration with schools administrations, Sheikhs of mosques, and most importantly with the traffic police is needed to control and limit such impacts and risks, and to implement schools-focused awareness and communication programme for safety on roads.
- Road lightening is a major issue of concern during the construction phase, as lacking sufficient and well distributed lightning will increase the risks of accidents and put people lives and safety at higher risk. This impact will be of higher magnitude at current road hazard points (curves, near bridges, major economic activities, etc.) and also at all parts and sections of the road were construction works will be taking place.

Mitigation Measures

Implement an appropriate safety measures regarding the people whom are living or using the households located close to the planned work areas, and/or might be passing within or close to the work zones. The following mitigation measures to ensure public safety shall be implemented by the contractor:

- Implement precautions to ensure that objects (e.g., equipment, tool, debris, precast sections, etc.) do not fall onto or hit people, vehicles and properties in adjoining areas.

- Fencing of construction sites and regular patrols to restrict public access.
- Prior to excavation work, provide fencing on all sides of areas to be excavated.
- Provide warning signs at the periphery of the construction site.
- Strictly impose speed limits along residential areas and where other sensitive receptors are located.
- Educate drivers on safe driving practices to minimize accidents and to prevent spill of hazardous substances and other construction materials during transport.

5.2.6 Construction and Demolition Waste / Wastewater from Camps

Identified Impacts

Existing medians within the BRT corridor are identified for demolition including cutting and removal of the trees and concrete. In addition to the demolition waste (excavated material and demolished debris), construction activities may also produce construction waste resulting from defective materials, packaging waste, and used oils and lubricants. This impact can potentially be significant if the waste is not managed properly or left on construction sites poorly stored where the wind can blow the waste into nearby neighborhoods. Storing piles of construction waste in areas that are visible to the public will constitute nuisance for the local residents.

Furthermore, the staff and labor camps for the construction of the proposed BRT will be a source of wastewater generated from the toilets, washrooms and the kitchen.

Mitigation Measures

The contractor shall develop a waste management plan prior to the start of construction. This plan shall provide procedures for managing hazardous and non-hazardous waste materials from the source of generation to its temporary site storage location and up to its final disposal locations.

This plan should include:

- Site specific information of the types of waste with estimated quantities that shall be produced
- Location, number, and type of waste containers that shall be used
- Procedures, tools, and equipotent planned to be used to mange and transport of the waste to its final disposal destination
- Approved disposal sites and routes for all types of wastes anticipated after coordination with GAM, Ministry of Environment, Ministry of public works, and the Public Security's Traffic Department

- Procedures for monitoring of the proper disposal of all wastes from construction to ensure it is all disposed of in approved locations only
- Procedures and methods to ensure all waste hauling equipment are well secured to eliminate any waste from falling from the loaded trucks.
- Excavated materials that are approved for reuse at site should be stored separately from other construction wastes in order to be able to use them on site for fill.
- The contractor shall ensure that domestic wastewater and municipal solid waste from the camps is not mixed with other construction waste and not released to the environment and all generated quantities of wastewater and MSW are transferred to the nearest wastewater treatment plant or disposal location for treatment and disposal.

Periodic on-site audits of waste management shall be undertaken along with auditing of waste disposal contractors and disposal facilities on regular basis to check that procedures are being followed.

Licensed waste contractors shall be engaged to dispose-off all non-hazardous waste material that cannot be recycled or reused, and training shall be provided to personnel for identification, segregation and management of waste.

5.2.7 Soil Erosion and Change in Local Hydrology

Identified Impacts

Soil exposed by construction activities is especially vulnerable to erosion. Even during a short period of time, construction sites can contribute considerable sediments to the existing storm water collection networks across the BRT project area.

The storm water run-off from the construction site could carry oil and grease if the soil is contaminated or the potentially contaminated areas (oil and grease storage areas, maintenance areas and workshops) are in hydrological contact with the surrounding areas.

Excavations, especially for the construction of BRT facilities located outside the paved roads and highways, will alter the topography of these sites. This is not expected to cause significant changes to the downstream hydrology, as the site presents a relatively small sub-catchment in relation to the catchments in Amman.

Mitigation Measures

An erosion and sedimentation plan should be developed, implemented and monitored by the contractor with focus on eliminating discharge of sediment and other pollutants flowing out of the site with rainwater. More specifically the plan should address the following:

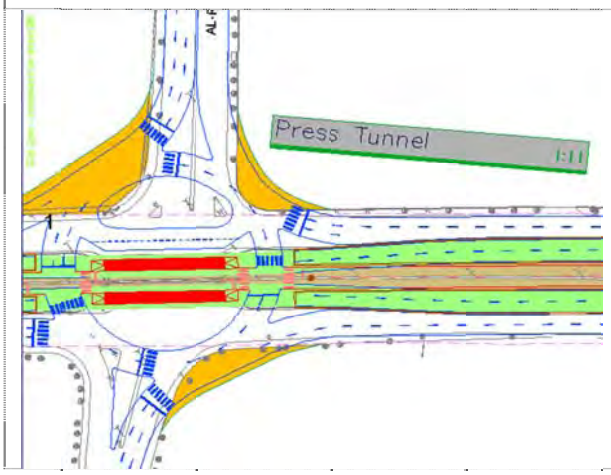
- Storm water control diversion structures to prevent rainwater from flow onto the construction site in addition to sediments control measures such as silt fences to prevent sediments from flowing outside the construction site.
- Minimizing the size of stockpiled materials and soil that can cause sedimentation and select the stock pile location to be away from water run off and to cover all such piles during wet periods
- Ensure protection of nearby culverts and storm water structures and Wadis from sedimentation and blockage

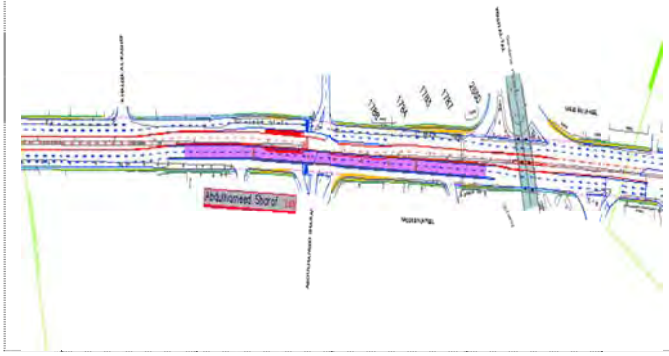
5.2.8 Land Acquisition and Resettlement

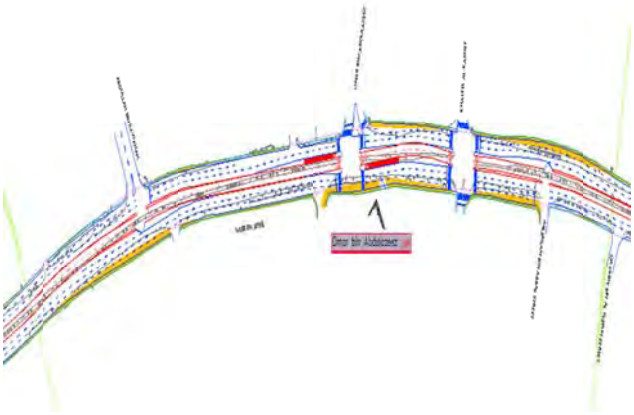
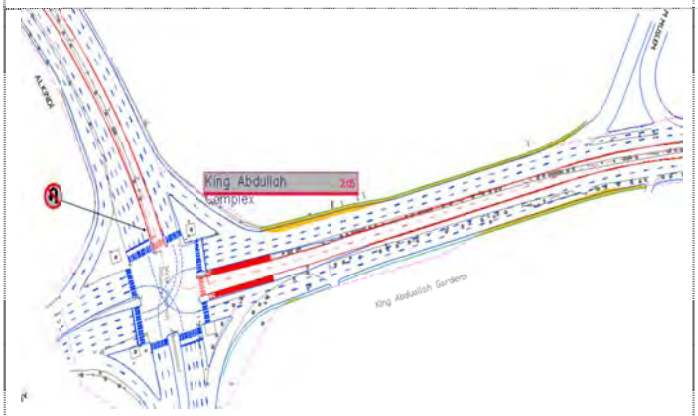
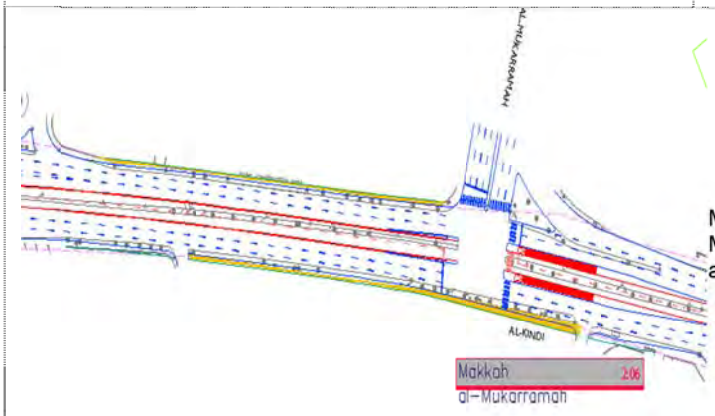
Identified Impacts

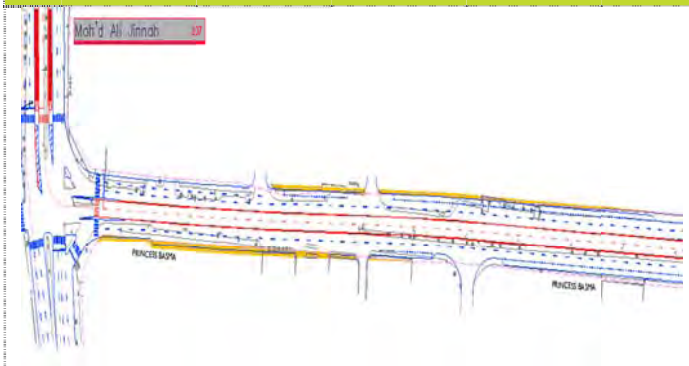
As mentioned earlier in this report, there are several instances of land acquisitions necessary to expand the roads or at intersections. These include the following in **Table 5-2:** Some of these lands may already be owned by the government but others may required acquisition.

Table 5-2: Lands Acquisition along the BRT Lines

Land Acquisition Location (in Yellow)	Location	BRT Line	Area (m^2)
	Swuayleh Terminal	BRT Line 1	743
	Press Tunnel	BRT Line 1	Left Upward : 748 Right Upward : 253 Right Downward: 314 Sum: 1314

Land Acquisition Location (in Yellow)	Location	BRT Line	Area (m^2)
	Sport City	BRT Line 1	Left Upward : 1509 Right Downward: 323 Left Downward: 187 Sum: 2019
	Al-Aqsa	BRT Line 1	2616
	Abdulhameed Sharaf	BRT Line 2	Upward : 761 Downward: 688 Sum: 1449

Land Acquisition Location (in Yellow)	Location	BRT Line	Area (m^2)
	Omar Bin Abdulazeez	BRT Line 2	Upward : 1078 Downward: 1972 Sum: 3050
	King Abdullah Complex	BRT Line 2	Upward : 431 Downward: 214 Sum: 645
	Makkah Al-Mukarramah	BRT Line 2	Upward : 138 Downward: 204 Sum: 342

Land Acquisition Location (in Yellow)	Location	BRT Line	Area (m^2)
	Moh'd Ali Jinnah	BRT Line 2	Upward : 375 Downward: 510 Sum: 885
11 thin areas along the BRT corridor	From Swuayleh Terminal to Sport City	BRT Line 1	Ranging from 7- 292

Mitigation Measures

Land acquisition is deemed necessary for project development and appears to be essential to the project. Therefore the only mitigation measure is as guaranteed by the Jordanian laws related to Land acquisition where fair market prices are estimated by specialized court estimators and paid to land owners. No resettlement or displacement is anticipated.

5.2.9 Cultural Resources

Identified Impacts

The main cultural resources sites in the BRT influence area have been extensively examined and mapped during the cultural resources review conducted under the previous ESIAs. The findings with full site description were presented in **Section 4.6** of this report.

It is clear from the cultural resources review that no significant direct impacts are foreseen to affect known archaeological sites within the study area. A direct impact is defined in terms of close proximity, visual connectivity or if it can affect negatively any future development of the area for heritage tourism.

5.2.10 Ecology

Identified Impacts

The main direct effect from the BRT project on ecological resources will be the removal of the trees and plantations in the median areas of the roads and highways to make room for the BRT corridor. The ecological survey conducted for the BRT

lines and affected areas revealed that the median sections contain both exotic (Casuarinas, Eucalyptus and Washingtonia) and native trees (Karup, Oleander, Arabian palms and others). The surveys estimated that approximately 1400 trees will need to be removed along BRT Line 1, while 870 and 1182 trees will have to be removed from Line 2 and 3, respectively.

The areas surrounding the BRT lines contain habitat that is already degraded as a result of decades of human intervention and intensive urban development. The ecological characteristics as well as biodiversity in general will be marginally affected by the construction activities. The project area is not located in close proximity to any nature reserves, protected areas, or important habitat.

The impacts on the natural ecosystem components could arise from the following:

- Changes in the land topography around the BRT routes due to construction activities.
- Damage to micro-habitats affecting existing species, mainly in terms of floral composition.

Loss of natural habitat is expected on a very limited scale and will be confined to the areas along the BRT routes where active construction is taking place. However, increased accessibility, vehicle movement into relatively inaccessible areas in the vicinity of the BRT routes, and human activities may contribute to the pressures on natural habitats there. Trees would be at a risk of exploiting their woods for heating by the construction workers.

Fragmentation of habitats is not expected to occur from the construction of the BRT lines as the roads and highways designated for BRT use have existed for a relatively long time. Removal of the natural vegetation cover along the sides of the BRT lines due to clearing and construction is expected but on a very limited scale and will not reduce the density of floral species in any noticeable manner.

Minimal impacts would affect the mammalian and reptilian species within the study area during construction. Most mammals roaming the BRT sites are rodents that are considered undesirable pests.

Construction along segments of Al Aqsa Street, Queen Rania Street and Al Shaheed Street may result in affecting nearby open habitat used by birds like domestic sparrows (Passer domesticus), Palestine sunbird (Nectarina osea), Black Bird (Turdus merula). However, this is expected to be very limited as the area is considered already disturbed by the existing roads and adjacent urban development.

Mitigation Measures

It is recommended to attempt trans-locating the native tree species that will be removed from the median areas or other parts of the roads and highways to make room for the BRT corridor. Younger trees (up to 7 years old) will have a better

chance of surviving the trans-location and are recommended to be given priority over older trees for trans-location.

Exotic tree species are not recommended to be trans-located for two reasons: first because they are exotic and had been introduced to the region from other climates; and second due to the fact that their age will reduce the chances for surviving the translocation. It is recommended that landscaping plans should tend to use natural trees and vegetation for the rehabilitation of sites where construction activities have resulted in the removal of existing trees and vegetation. **Table 5-3** below shows the number of trees that will be affected from the BRT construction and the number of trees that can be trans-located.

Table 5-3: Trees Affected by the BRT Project

BRT Line	Number of trees that need to be removed	Number of trees that can be trans-located	Number of trees that will be lost
Line 1	1,400	800	600
Line 2	870	370	500
Line 3	1,180	500	680
Total	3,450	1,670	1,780

It can be seen that a great loss of trees will occur along BRT Lines. However, the design of the BRT lanes allowed for new trees to be planted to replace the removed trees. Along the segment of Line on Queen Rania Street extending from Sports City Roundabout to Suwaileh Roundabout a tree will be planted at 6m interval on each side. This amounts to approximately 1,800 new trees on this segment alone. Hence it is considered that new trees planted as part of the BRT system will more than compensate for the trees lost

Except for the removal of the trees and plantations to construct the bus lanes, construction activities for the BRT project are not generally expected to cause significant impacts on other flora, the area's fauna or their habitat. The construction contractors should ensure that their staff and workers refrain from any practices that may affect the local ecology and harm the environment such as collection of firewood around the construction sites. Awareness and proper site practices should be sufficient to eliminate this impact. Finally for each tree that is cut at least two trees should be planted.

5.2.11 Damage or Disruption of Utility Lines and Existing Services

Identified Impacts

The BRT lines include areas of urban Amman and Amman to Zarqa road that have been intensely used for decades. During construction there is a potential to disrupt and/or damage existing utility lines (e.g. water mains, sewerage collection lines, storm water drainage, telephone, electricity, street lighting, etc.).

Construction activities have the potential to cut or damage any of the existing utility lines leading to stoppage or disruption of the services they provide. Damage to wastewater mains in or near inhabited areas will have the potential to cause health impacts and raise serious community concern. Interruption of communication lines and electricity will disrupt businesses in the area and have an impact on the livelihood of the affected communities.

Mitigation Measures

Full and detailed information on existing utilities at the BRT construction sites should be compiled by the construction contractors before any construction commences. The contractors in coordination with GAM are expected to contact the relevant authorities to obtain such information. These include Jordan Telecommunications Company, Jordan Electric Power Company, Water Authority of Jordan and the relevant sections at GAM in charge of services such as domestic waste collection.

Plans for the re-routing or protection of existing utility lines must be developed by the contractors and presented as part of their method statements and construction bids. These plans must be reviewed, evaluated and approved by GAM infrastructure specialists and by Ministry of public works specialists (each within their areas). Proper construction methods will ensure that utility lines are not damaged causing services to be interrupted. Plans for relocating the utility lines and street lighting that occupy the median areas should be an essential part of the contractors' construction bids.

It is expected that experienced construction contractors will be engaged on the BRT project who will follow the terms, conditions and procedures outlined in the Jordanian codes of practice and GAM's instructions and Ministry of public works instructions. Furthermore, considering the thorough documentation of the existing utility and service lines in Amman, it is expected that impacts from unplanned interruption of services resulting from interference or damage to utility lines during the construction phase will be limited.

5.3 IDENTIFIED IMPACTS AND PROPOSED MITIGATION MEASURES DURING OPERATION

During project BRT operations, positive impacts are anticipated for the public transportation sector in Amman. People using this system should have a much more efficient system that is safe, reliable and timely. The proposed BRT system however is expected to have some adverse environmental and social impacts during the operational phase if not managed properly. These impacts include:

5.3.1 Improved Public Transportation

This is the most important positive impact of the project and the main objective of the BRT. The BRT system will offer Amman commuters an efficient and reliable service that will address their need to commute in a comfortable, timely fashion at affordable cost. The BRT aims to solve some of the major challenges faced by commuters on the road in their daily journeys include traffic jams, bad driving behavior, and speeding. At bus stations, commuters are bothered by crowded stations, unethical behavior by some people, and sometimes the long distance that the bus stops from the station. Challenges that current bus passengers face include smoking, crowded buses and not enough seats, too many stops along the route, loud music, lack of adherence to schedule, delays, and lack of safety measures.

5.3.2 Air Pollution and CO2 Calculations

Air pollution impact

The BRT is anticipated to be utilized at higher mileage compared to current public transport busses as the BRT will go more frequently and produce better service. This additional mileage can be offseted by the reduction in idle and waiting time in buses if no BRT is implemented as the BRT routes are dedicated for BRT with no other traffic so the bus will keep moving with minimal stops due to traffic. It is also anticipated that some modal shift will occur switching some personal vehicle users to the BRT which will reduce emissions.

CO_2 Calculations

According the 3rd National communications report for Jordan, Transportation is by far the largest energy consumer in the Kingdom. CO_2 reduction from transportation usually requires complex and difficult solutions which should focus on reducing all emissions from transport sector (i.e. CO_2, CO, PMx , NOx) in addition to reducing fuel consumption (in tons per day) but at the same time provide good services to the public.

CO_2 calculations for this project were based on the results of the PVT VISUM traffic model results. The number of cars, trucks, school buses, and other buses passing through each segment of the three BRT corridors were obtained from the model for the baseline situation of no BRT and for the BRT situation. This data included the Annual Average Daily Traffic (AADT) for each vehicle category passing through each portion of the route with known length which give the total km per year.

The total yearly km are converted to fuel which is Diesel for buses and trucks and Gasoline for cars and taxis through average miles per gallon data obtained from US Department of Transportation (DOT). Buses were assumed to be at 7 miles per gallon of diesel and cars at 24 miles per gallon of gasoline.

The L of diesel and gasoline were finally converted to CO2 equivalent using conversion factors obtained from UK's Department for Environment, Food and Rural Affairs (DEFRA). Each L of diesel produces 2.67193 kg CO2e and each L of gasoline produces 2.30075 kg CO2e. The results of these calculations are summarized in the **Table 5-4** below.

Table 5-4: CO2 Emission Calculation Results for BRT Routes

Route	Baseline CO2 Ton/yr (Base flow only No BRT)	Project CO2 Ton/yr(base flow plus BRT)	% Reduction
1	223,582	179,930	20
2	68,457	63,736	7
3	269,395	245,271	9

CO_2 reduction is a positive aspect of the BRT and it is magnified by the tremendous improvement in service. In other words the BRT is a lower emissions method of transporting people with higher efficiency and better service level. CO_2 reduction also indicates redauction of the other air pollutants associated with traffic (i.e. CO_2, CO, PMx , NOx)

Mitigation measure

Traditional diesel buses can produce harmful exhaust emissions especially using low grade diesel as in some of the existing buses currently running in Amman. Advanced technologies can be utilized to reduce or eliminate harmful exhaust emissions. These technologies are shown in **Table 5-5**below.

Table 5-5: Technologies to Reduce Harmful Emissions

Bus Technology	Advantages
Euro 5	Improved exhaust quality in relation to CO, Hydrocarbons, NOx, and PM
Euro 6	This is the most recent European standard for Improved exhaust quality in relation to CO, Hydrocarbons, NOx, and PM
Hybrid (Diesel / Electric)	Reduced exhaust quality, reduced CO2 emissions and fuel consumption, and reduced noise
Electric	If charged from renewable energy source this is the least emissions and lowest noise option

5.3.3 Disposal of Wastes Generated from BRT Operation

Identified Impacts

There will be two types of solid wastes generated from the operation of the BRT system. These are:

- Solid waste in the form of garbage and refuse generated by BRT users and drivers during normal operation.

- Solid wastes generated from bus maintenance operations conducted at designated depot. (The BRT depot is outside the scope of this report)

Mitigation Measures

Solid wastes generated from the BRT operation should be collected, stored, handled and disposed of in a proper manner that allows for waste recycling and without causing environmental hazards or aesthetic nuisance. Wastes generated by BRT users would have been generated regardless of the mode of public transport used and thus are not expected to cause any unforeseen load on GAM's local capacity for collecting and disposing refuse in the City. However, it is important that the BRT vehicles are properly equipped with waste containers of an appropriate shape and size to handle the expected waste generated on the bus. These would need to be regularly emptied to prevent overflows. BRT stations should also have similar waste collection facilities.

Solid wastes generated from maintenance operations would include used parts, tires, consumables, packaging and similar items. These would need to be disposed of in accordance with the Ministry of Environment regulations and GAM's procedures for similar facilities in Amman (Noting that the BRT depot is outside the scope of this report).

5.3.4 Impacts on Existing Public Transport Operators

Introduction & Context

Any new transport system is bound to have an impact on existing systems. The level of impact can vary in its scale and nature depending on several factors. Some of the factors that are relevant to Jordan include the level of overlap between the old and new systems, the planned degree of integration after the new system comes in place, the presence and strength of support systems (good fare integration systems, for example, can allow for minimizing the negative impact), and socio-political factors pertaining to the existing operations. Laws and regulations can also play a role in facilitating certain mitigation measures.

The existing public transport system in Jordan—or specifically in Amman and Zarqa—was described earlier in this report. Perhaps the most prominent characteristic of the existing system is fragmentation. Over 85% of the fleet is owned and operated by individuals, with the remainder run by companies. Many of the individuals had obtained their operating licenses decades ago through what was known as the ‘traffic subcommittees’ that fell under the Ministry of Interior—the ministry that manages much of the country’s security apparatus, namely the Public Security Directorate and, within that, the Traffic Police.

Many of these individual operators see the rights to operate on their routes as entitlements that could be passed on to their next of kin. A change to the status quo

is, therefore, often viewed by operators as a threat to their livelihoods and a key source of income.

From the official side, this fragmentation—commonly known as the issue of "individual ownership" or *Al Mulkiyya Al Fardiyya* in Arabic—is viewed as a hindrance to growing and transforming the Kingdom's public transport system. To that end, the new Passenger Transport Regulation Law (No. 19/2017) which came into effect in May 2017 attempts to put an end to individual ownership. The law requires all individual owners to adjust their status within a five-year period. Adjusting the status requires either merging into a company, joining an existing operating company, or creating a shared management company that would serve as an umbrella entity for a group of operators. If they fail to do so, their routes would be bought out by the government in exchange for compensation.

This section will assess the impact the BRT will have on existing operators in light of the above. Mitigation measures will be proposed, taking into account the abovementioned law, best practice, and plans already in place at the different regulatory authorities.

Methodology

To assess the impact of the BRT on existing operators, data on public transport routes within Amman and between Amman and Zarqa were obtained from GAM and LTRC, respectively. The impact has been measured based on the level of overlap of the existing route with the proposed BRT. It is still understood, however, that network effects may cause an impact that goes beyond routes that overlap with the BRT. The proposed mitigation measures will also be applicable to such routes.

The data-set used for routes within Amman was obtained from the Greater Amman Municipality and included a total of 340 routes that include the different public transport vehicles operating within greater Amman and are illustrated in **Figure 5-1**

For Zarqa, only inter-urban routes between Zarqa and Amman will be shown without an in-depth look into the internal routes that operate in Zarqa. The Amman-Zarqa BRT does not provide significant coverage within Zarqa and will therefore have minimal impact on the majority of the routes that run internally as it provides direct service between the major arterial running between Zarqa and Amman. The data-set that was used in this case was obtained from LTRC and only included inter-city routes which comprise eleven bus routes.

In order to find out how these different routes will be affected by the introduction of the BRT, the following was done:

1. Current public transport routes were differentiated by vehicle type.

2. Each route was analyzed on ArcGIS to see how much of it overlaps with one or more of the BRT routes.

3. Routes that intersect with the BRT at any point were then categorized into low-impact, medium-impact, or high-impact based on how the BRT will affect them. An example of a low, medium, and high impact route is shown in **Figure 5-2**. The criteria for selection used percentage of overlap between the existing transport routes and the BRT to determine which category they would fall under. Routes that had more than 60% overlap were categorized as highly impacted routes (red), Routes that had between 25 and 60% overlap were considered medium impacted routes (blue), and routes with less than 25% overlap were minimally or low impacted routes (green).

4. Depending on which category the route is under, recommendations were made to mitigate the effects.

Figure 5-1: Current Public Transport Routes in Amman

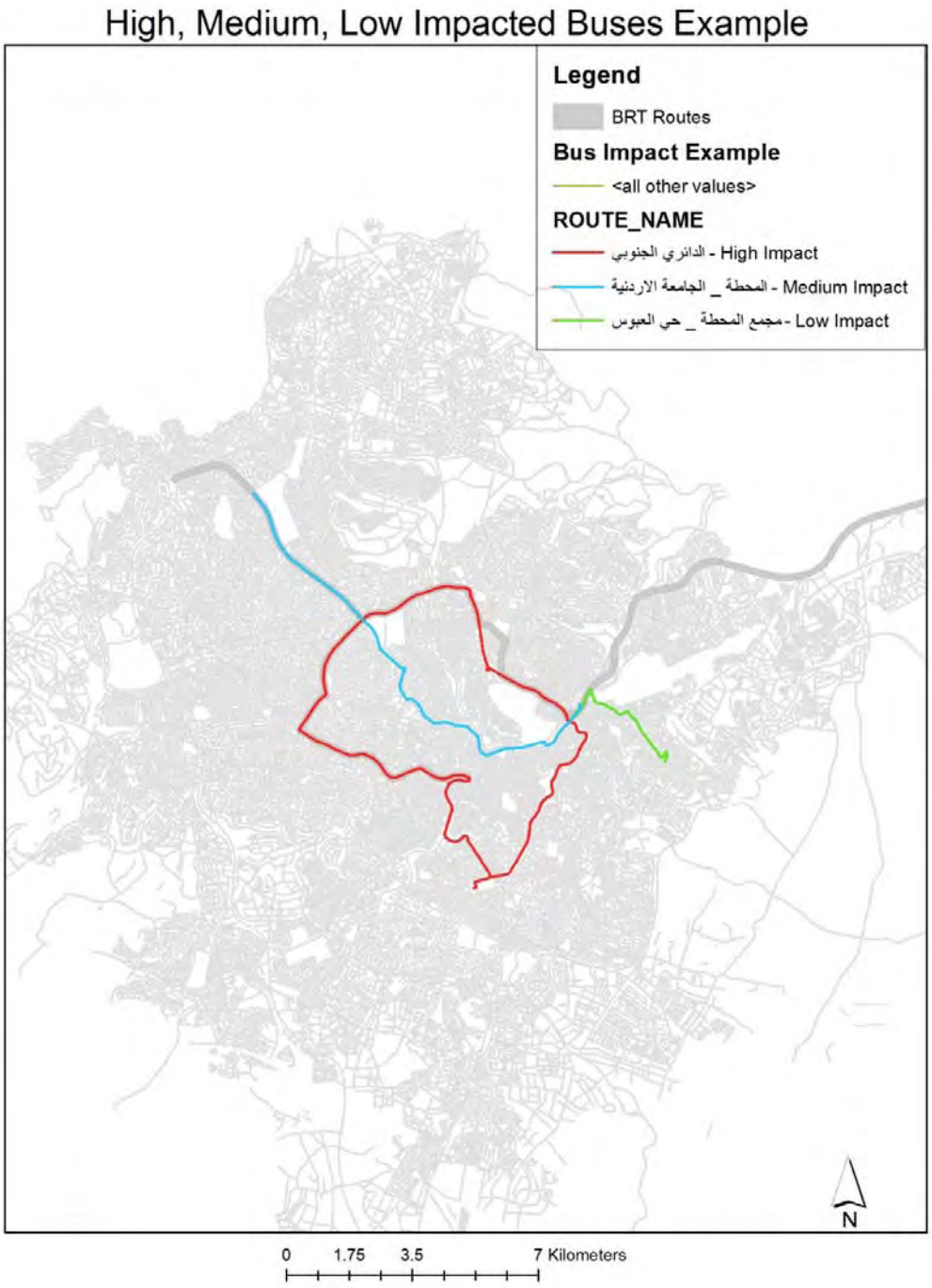


Figure 5-2: Example of High, Medium, and Low Impact Buses

The addition of the BRT may also have positive effects on the public transportation system because it provides much needed support to an otherwise deteriorating system (these are part of the network effects mentioned above). These positive effects will be highlighted where possible.

In **Figure 5-2** a clear difference can be noticed between each of the three routes overlaying the BRT route. The green low impact bus serves a nearby neighborhood and may provide much needed feeder service to the BRT route in dark gray. On the other hand, the medium impacted bus route in blue overlaps the BRT on a major corridor but continues on through the city servicing areas that the BRT does not. Finally, the high impacted route in red can be seen to overlap with the BRT for the majority of its path.

The routes that intersect with the BRT were categorized by vehicle type and impact level. These results can be found in **Appendix A**. Summary of the results can be shown below in **Table 5-6**

Table 5-6: Summary of Impact Levels by Vehicle Type

Vehicle Type	Number of non-intersecting vehicles (No impact)	Intersecting Routes		
		Number of low impacted routes	Number of medium impacted routes	Number of highly impacted routes
Bus	6	63	15	6
Coaster	38	35	13	13
Service Taxi	60	79	11	2
Zarqa Buses	3	4	0	4

There are a total of 90 bus (large) routes running in Greater Amman, 84 of which intersect with the BRT system and have therefore been included in **Appendix A**. Going by our criteria, 6 routes won't be impacted by the BRT since they do not intersect with it and service different areas. There are 63 routes that will be low impacted, 15 that will receive medium impacts, and 6 that will be highly impacted. (See **Figure 5-3**)

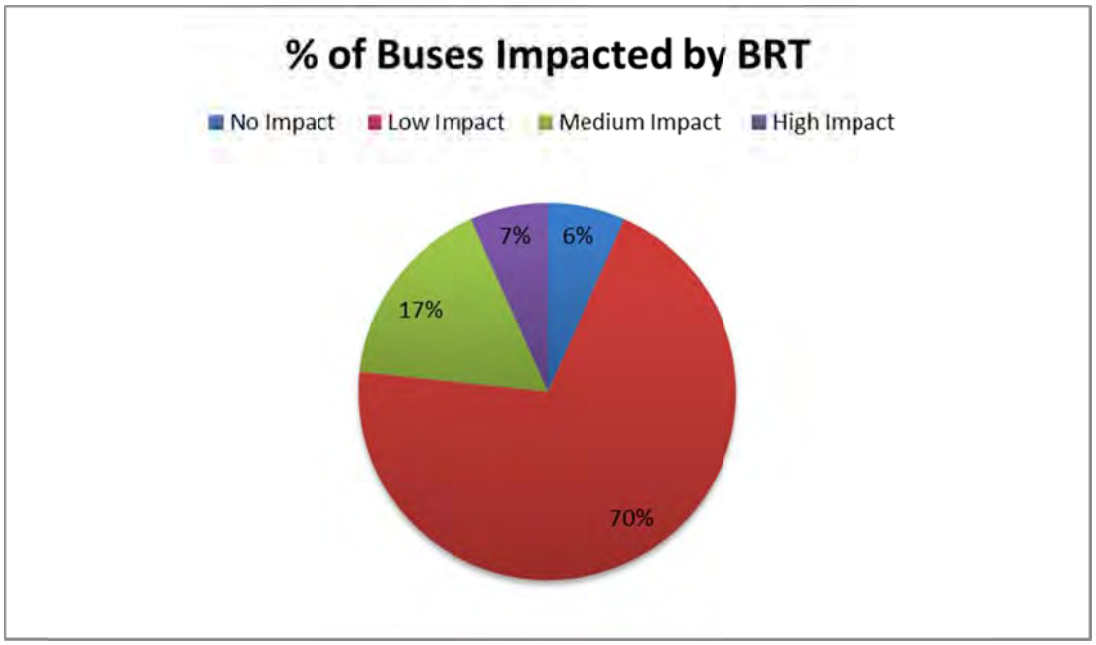


Figure 5-3: Percentage of Low, Medium, and Highly Impacted Buses

There are a total of 99 coaster routes running in Greater Amman, 61 of which intersect with the BRT system and have therefore been included in **Appendix A**. Going by our criteria, 38 routes won't be impacted by the BRT since they do not intersect with it and service different areas. There are 35 routes that will be low impacted, 13 that will face medium impacts, and 13 routes that will be highly impacted (See **Figure 5-4**)

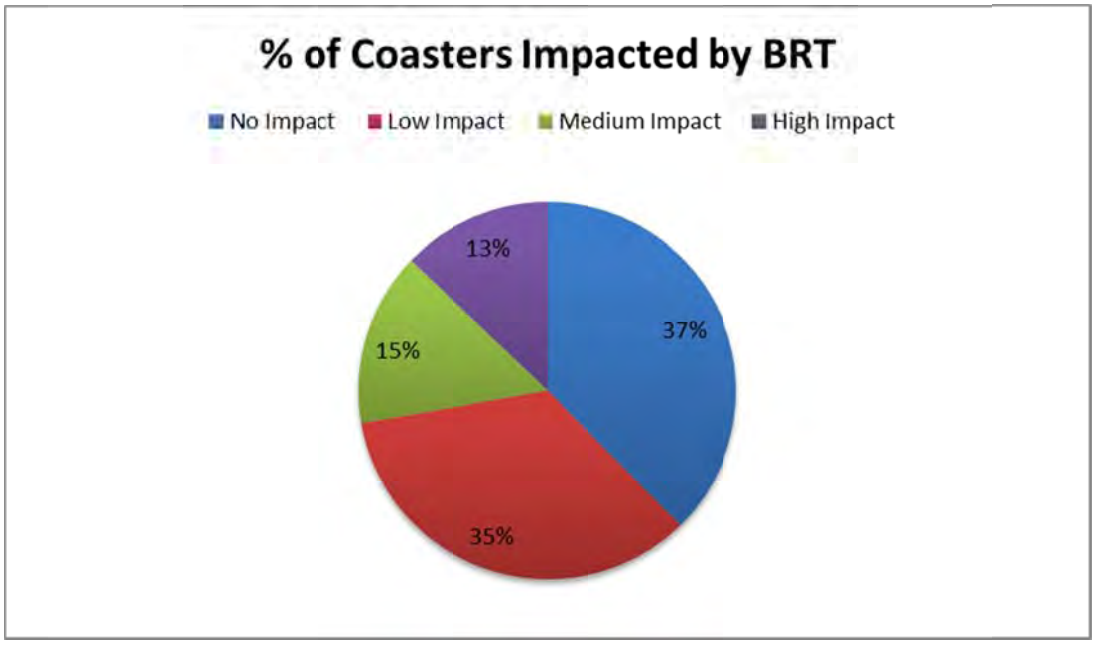


Figure 5-4: Percentage of Low, Medium, and Highly Impacted Coasters

There are a total of 152 service taxi routes running in Greater Amman, 92 of which intersect with the BRT system and have therefore been included in **Appendix A**. Going by our criteria, 60 routes won't be impacted by the BRT since they do not intersect with it and service different areas. There are 79 service taxi routes that will be low impacted, 11 that will receive medium impacts, and 2 that will be highly impacted. (See **Figure 5-5**)

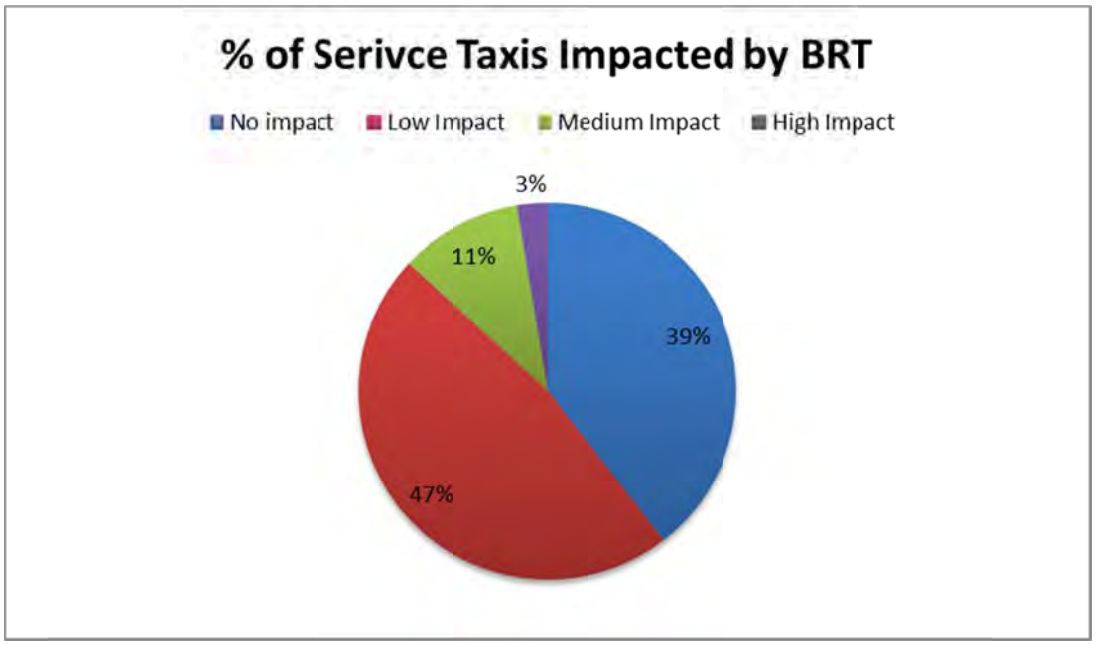


Figure 5-5: Percentage of Low, Medium, and Highly Impacted Service Taxis

There are a total of 11 inter-city routes that run between Zarqa and other neighboring cities, 8 of which run through Amman and intersect the BRT route. These routes have been included in **Appendix A**. Going by the criteria used in this study, 3 routes will not be impacted since they do not pass through Amman, or intersect the BRT at any point. There are 4 routes that will be low impacted and 4 that will be highly impacted. (See **Figure 5-6**)

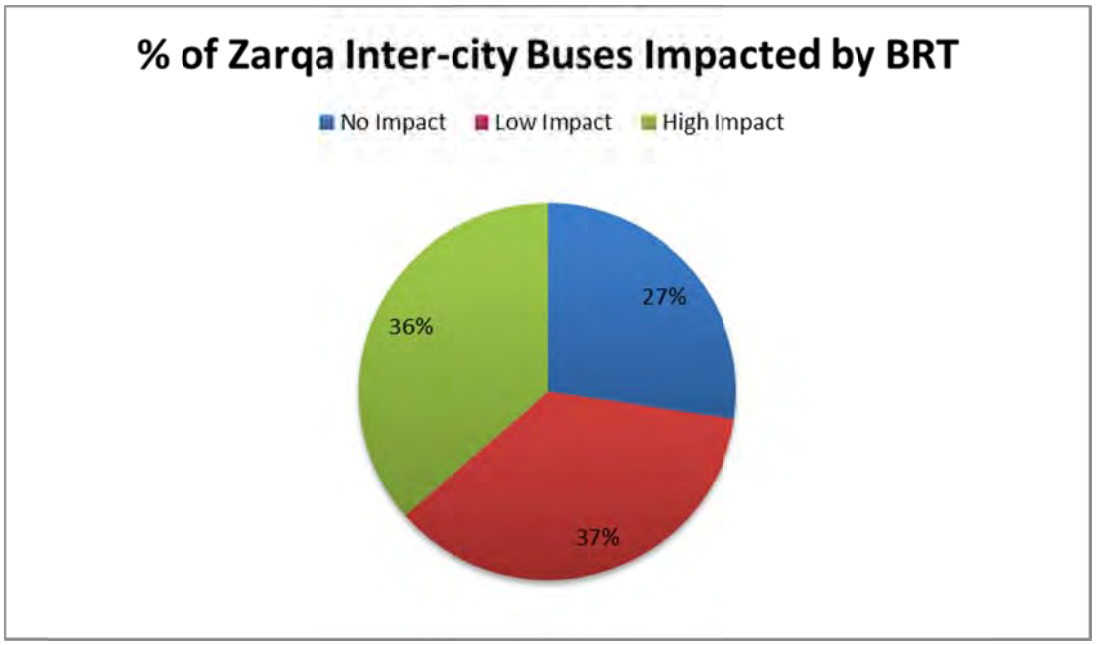


Figure 5-6: Percentage of Low, Medium, and Highly Impacted Inter-city Buses between Zarqa and Amman

Table 5-7 shows where the majority of the overlap occurs. Underlined vehicle IDs overlap on more than one BRT route, and can be matched with the route name on the index shown in Appendix A. What can quickly be noticed is the Sweileh - Mahatta route receives the most overlap. This is partly expected because the two arterials that are along the Sweileh - Mahatta route are some of the busiest in Amman.

Table 5-7: Location of Overlap by Vehicle Type and Impact Level

Vehicle Type	Buses	Coasters	Service Taxi
Medium Impact / Sweileh - Mahatta	8, 88, 199, 203, 249, 250, 327, 329	86, 99, 202, 204, 220, 238, 241, 248, 253, 265, 298	87, 90, 100, 101, 269
Medium Impact / Sports City - Ras al Ain	46, 268, 272, 305, 329	302	135, 223, 225
Medium Impact / Mahatta - Zarqa	194, 236	-	0, 27, 120
High Impact / Sweileh - Mahatta	229, 287, 311	186, 188, 189, 192, 196, 197, 256, 288, 317, 318, 330, 332	19
High Impact / Sports City - Ras al Ain	311	-	-
High Impact / Mahatta - Zarqa	193, 263	186, 188, 189	24

Maps of the different categories overlaying the BRT are shown in the appendix and are separated by vehicle type for reference. The individual routes are more accurately represented in the **Appendix A**, which show the bus ID for each of the

routes. In order to identify the ID, an index table with the corresponding route name is shown in **Appendix A**

In the above analysis, impact was measured based on the level of physical overlap with the BRT. It was noted, however, that this is only one measure, and there are network effects that can produce wider impacts—both positive and negative.

Before addressing mitigation measures for the loss of income to public transport operators, it may be useful to consider the issue of existing operations from a transport planning perspective and also from a passenger-trip perspective (rather than a route perspective).

The BRT will serve a limited number of corridors. For many passengers, using the BRT will constitute one of two or more segments within a longer trip from an origin to a destination. Other segments may involve walking, taking a taxi (common in Jordan to get to a bus terminal), being dropped off by a private car, or taking another public transport route.

If the objective were to eliminate all overlap with the BRT, then all overlapping routes (identified in the above analysis) should be rerouted. Mitigations would then involve compensating the operators for the income they lose to the BRT.

In reality, the issue is more complex. Applying such a 'cookie-cutter' approach, in which any overlap with the BRT is removed can create problems not only for operators, but also for passengers. It may very well result in adding more segments to a passenger's trip. In other words, a passenger would be required to switch from a regular bus (or Coaster) to the BRT to get to their destination, whereas they had not been required to do so before BRT came into operation.

In transport planning and modeling, interchanging from one vehicle to another is viewed as an onerous, costly matter. It has a significant negative impact on the user experience on public transport. (There are, however, mitigation measures to improve the interchange experience, as discussed later.)

A clear example is shown in **Figure 5-7**. There is significant public transport traffic coming from towns to the north-west of Amman (Baqa'a, Ein Al-Basha, etc.) destined to the University of Jordan. Completely eliminating overlap with the BRT would require passengers coming from these towns to get off the bus at Sweileh, wait for the BRT, get on the BRT, and get off not too far from Sweileh at the University of Jordan. This would significantly reduce the trip quality for passengers and may very well increase their travel times.

In that context, it makes sense to allow for some overlap with the BRT on the section between Sweileh and the University of Jordan.

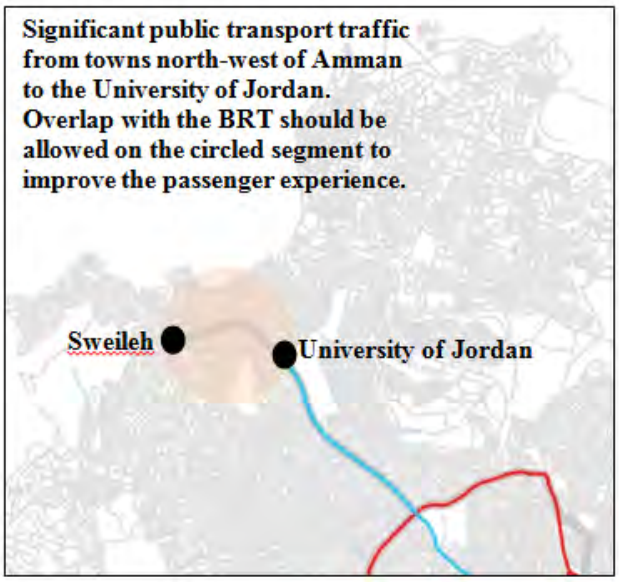


Figure 5-7: Example of a Section where Overlap with the BRT Should be Tolerated

Based on the above, the following approach is recommended to identify routes that should be amended:

- Routes that are highly impacted by the BRT should most likely be rerouted.
- Routes on which the BRT has a medium or low impact should be analyzed vis-à-vis passenger travel patterns. Rerouting should be done such that the passenger experience is not severely affected. For some routes, this may require completely eliminating the overlap; for others, it will require rerouting will maintaining some overlap with the BRT, and for a number of routes, it may require keeping everything as is.

Rerouting a public transport route to accommodate the BRT may result in the loss of income to the respective operator. In that case, mitigation measures should be implemented, as outlined in the next section.

Mitigation Measures

Based on the above, routes whose operators are deemed to be losing income from the BRT can be compensated in a number of ways. One or a combination of the below measures can be applied:

1. **Rerouting and monetary compensation**: The operator's license and permit can be transferred to another route. Due diligence should be carried out to determine the level of ridership (and profitability) on the new route. If the new route is deemed less profitable than the old route, a monetary compensation should be given by the relevant authority to the operator along with the rerouting.

2. **Buy-out by government**: If there are no rerouting options (or the operator does not wish to reroute their routes), the government can buy out the route or routes. This approach is essentially a variation of no. 1 above and would also require a valuation exercise to determine the amount to be paid.

3. **Incorporation into the BRT operation**: Impacted operators could also be "rerouted" to serve on the BRT—essentially becoming part of the BRT operating company. Whether or not this model should be pursued is dependent on the work of the Transaction Advisory, which will be soon appointed by GAM. The BRT operations contract may include, in addition to the BRT routes themselves, some feeder routes. Existing operators could also be rerouted to serve on those routes.

For routes operating wholly within Amman, the above mitigation measures are the responsibility of GAM. Otherwise, they fall under the mandate of LTRC.

Further measures to improve the public transport user experience are also recommended and could be considered mitigation measures in the context of this report. These involve improving the interchange experience—meaning the experience of switching from one public transport mode to another (one of which would be the BRT). Such measures include:

1. **Fares and ticketing integration**: Allowing a fare paid on one public transport vehicle to be valid on the next vehicle that a user rides within a given time period (time-based fares) could reduce what is known as the "interchange penalty" experienced by the user. In the currently modus operandi, such a fare integration is not possible, since each operator keeps their own farebox revenue. Implementing such integration requires something like a third-party clearing-house that collects all fare revenues and then distributes them to operators based on ridership.

2. **Timetable integration**: Minimizing the waiting time when switching between modes is also beneficial from a user experience standpoint. A user would be more willing to take a trip that involves an interchange if they knew that after getting off the bus at a station, the BRT would arrive within a few minutes (or would already be waiting at the station), for example.

Such integration measures have systemwide benefits, as they would contribute to increasing ridership on both the BRT and other public transport routes.

Finally, it should be noted that the new Passenger Transport Regulation Law (No. 19/2017) which came into effect in May 2017 can potentially facilitate the implementation of the proposed mitigation measures. The law—specifically Article 13—requires all individual owners to adjust their status within a five-year period. Adjusting the status requires either merging into a company, joining an existing operating company, or creating a shared management company that would serve as

an umbrella entity for a group of operators. If they fail to do so, their routes would be bought out by the government in exchange for compensation. If they follow through, on the other hand, they would benefit from incentives such as customs and sales tax waivers.

Although this article does not directly address the mitigation measures, it sets in motion a process of consolidation that could potentially facilitate the rerouting and/or buying out of existing routes from operators that would be negatively impacted by the BRT.

5.3.5 Noise Impacts and Modeling from Operation of BRT System

Noise is undesirable sound that interferes with daily activities of people. At some levels noise can become simply annoying to people going to school or getting treatment in a hospitals or doing any other activity. Under extreme conditions noise may cause harm to human hearing or even hearing loss. For new public mass transit projects, noise assessments are an important element of the environmental impact assessment as noise can be among the major concerns with regard to the effects of a transit project on the surrounding community. A transit system normally is placed near populated centers and often causes additional noise to the typical noise levels.

The most adopted unit of the amplitude of noise is the decibel (dBA). To be able to understand this unit of noise, typical dBA from some noise sources are presented in **Figure 5-8.**

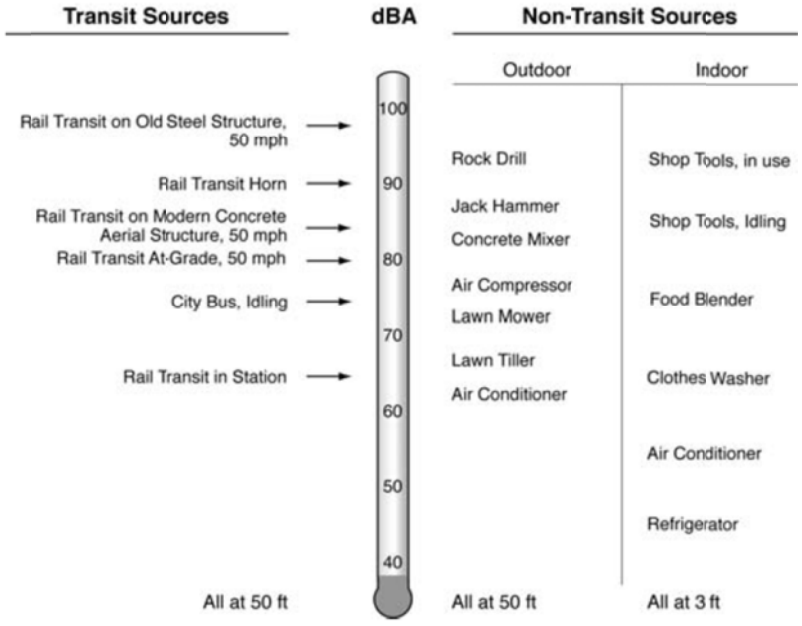


Figure 5-8: Typical dB(A) from Noise Sources.(Source: FTA, 2006)

The additional noise from a project to what already exists in the baseline conditions is not a simple summation of numbers but has a complicated logarithmic relation which is presented for simplification in **Figure 5-9.** For example and based on the figure, if the noise from one bus resulted in a sound pressure level of 70 dBA, the noise from two buses with 70 dBA each would be 73 dBA. Another example, if two sound levels of 64 dBA and 60 dBA are to be added, the difference in decibels between the two levels to be added is 4 dBA. The curve intersects the "4" where the increment to be added to the higher level is "1.5." Therefore the sum of the two levels is 65.5 dBA.

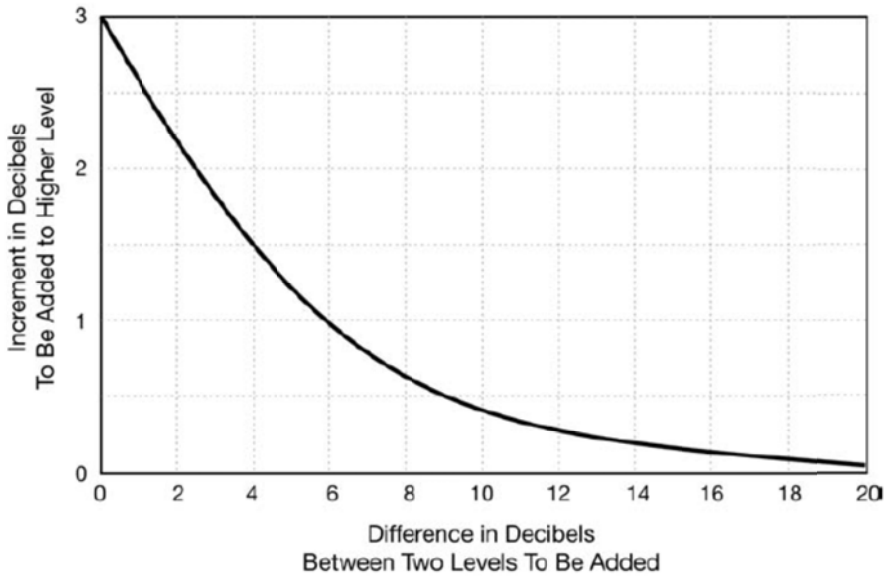


Figure 5-9: Approximate dB(A) Addition Graph (Source: FTA 2006)

Based on this concept of additional noise it can be concluded that if the noise of the project is less than the background noise then its contribution is minimum but if it is above then the final noise level will be very near to the project noise.

Noise will dissipate with distance and will dissipate with obstacles between the source of noise and the receptor. Therefore, impact of Noise for a project on a receptor is assessed by analysing the noise sources from the project, the background noise, the distance between the source and the receptor, and the rows of structures or obstacles (buildings) between the sources and the receptor.

Noise Modeling Methodology

The methodology adopted for noise modelling consists of the following steps.

1. Identification of sensitive receptors on the routes of the BRT. Sensitive receptors were defined as in the Jordanian noise regulation to be hospitals, places of

worship, and Education institutes. These types of places were identified on each of the three routes of the BRT using GIS landmarks maps for Jordan. Identified sensitive receptors are presented on **Figure 5-10** to **Figure 5-12**

2. Obtaining Peak hour traffic flow for baseline traffic of the existing situation projected to 2018 and the peak hour flow for base flow traffic and BRT traffic also projected to 2018. These data were obtained from PTV VISUM traffic modeling for the BRT routes.

3. Identify the distance and rows of buildings between the Road and each of the receptors

4. Apply FTA's noise impact assessment sheet for each of the receptors to determine the baseline noise exposure if the BRT project is not developed and the noise exposure with the BRT. This was conducted for both electric and Diesel BRT buses.

5. Compare the estimated noise exposure to the Jordanian regulations and to FTA's noise impact assessment guidelines.

Figure 5-10: Identified Sensitive Receptors on BRT Route 1 (H: Hospital, W: Worship House, and E: Educational institute)

Figure 5-11: Identified Sensitive Receptors on BRT Route 2 (H: Hospital, W: Worship House, and E: Educational institute)

Figure 5-12: Identified Sensitive Receptors on BRT Route 3 (H: Hospital, W: Worship House, and E: Educational institute)

Noise Impact Criteria

Two noise criteria shall be used in this noise assessment. The Jordan noise regulations and the FTA noise assessment criteria.

Jordanian Noise regulations Criteria

Noise regulations in Jordan are simple criteria that prohibit disturbances above pre-determined dBA levels based on land use categories and if it is day or night. A summary of the Jordanian regulations criteria are presented in **Table 5-8**.

Table 5-8: Jordanian Noise Regulation Limits

Location	Noise Level (dBA)	
	Day Time	Night Time
Residential zones inside cities	60	50
Residential zones inside suburbs	55	45
Residential zones inside villages	50	40
Residential zones where: there are workshops or commercial activities, or business and administrative zones, or downtown	65	55
Industrial areas (light industries)	75	65
Places of education, worship, medical centers, hospitals	45	35

Source: Ministry of Environment Regulation on Noise, 2003

FTA Noise Impact Criteria

According to FTA the noise impact on a receptor depends on the existing noise exposure at the receptor (background noise) and the project noise exposure at the same receptor. The higher the existing noise is the lower the allowable additional noise is. The criteria also depend on the land use category. FTA defines three categories of land use as presented in **Table 5-9**

Table 5-9: FTA Land Use Categories

Land use category	Description
1	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Residences and buildings where people normally sleep. This category includes homes, hospitals and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

To determine if a transit project has no impact, has a moderate impact, or has a severe impact. The existing noise exposure, the project noise exposure, and the land use category must be determined and **Figure 5-13** can be utilized to determine the impact significance.

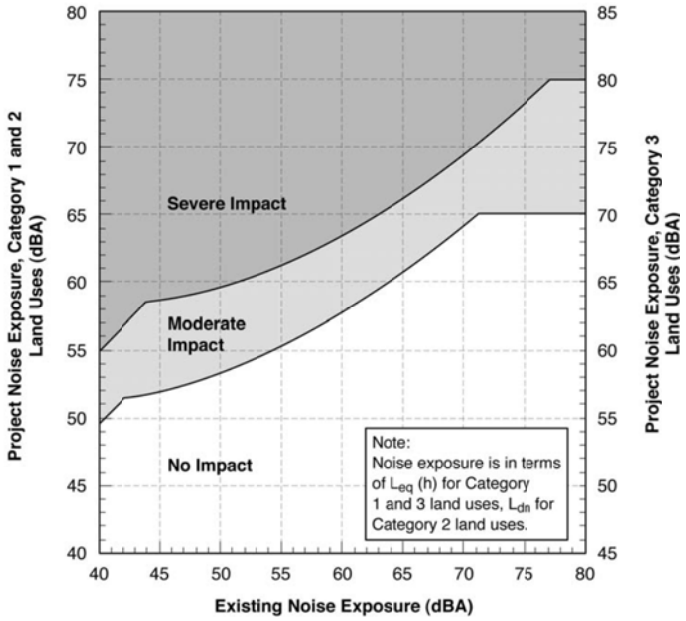


Figure 5-13: Noise impact criteria for transit projects (FTA, 2006)

5.4 NOISE MODELING RESULTS

5.4.1 Noise Exposure Assessment Compared to the Jordanian Standard

Total noise exposure for sensitive receptors as defined by the Jordanian regulation are summarized for each route in below. **Table 5-10** to **Table 5-12.**

Table 5-10: Noise Exposure Assessment based on Jordan Noise Regulations for BRT Route 1

Receiver Number	Distance (m)	Land use Category 1	Route	Existing Total Noise Exposure (dBA)	Jordanian regulation criteria2	Jordanian regulation criteria3	Total Noise Exposure with Diesel BRT (dBA)	Total Noise Exposure with Electric BRT (dBA)
1.1	26	E	Route1	62	45	65	64	62
1.2	52	W	Route1	57	45	65	59	58
1.3	45	E	Route1	58	45	65	60	59
1.4	30	H	Route1	59	45	65	61	59
1.5	23	W	Route1	61	45	65	63	61
1.6	24	H	Route1	61	45	65	63	61
1.7	22	E	Route1	65	45	65	65	64
1.8	32	E	Route1	63	45	65	63	62
1.9	16	E	Route1	68	45	65	68	68
1.10	42	E	Route1	56	45	65	59	58
1.11	39	W	Route1	56	45	65	60	58
1.12	35	H	Route1	53	45	65	60	58
1.13	29	W	Route1	55	45	65	61	59
1.14	70	E	Route1	55	45	65	57	56
1.15	63	W	Route1	51	45	65	52	52
1.16	27	W	Route1	61	45	65	63	62

[1]H: Hospital, W: Worship House, and E: Educational institute
[2]Jordan Criteria for sensitive receptors (Hospitals, Worship Houses, and Educational institutes)
[3]Jordan Criteria for urban areas with commercial activities

Table 5-11: Noise Exposure Assessment based on Jordan Noise Regulations for BRT Route 2

Receiver Number	Distance (m)	Land use Category 1	Route	Existing Total Noise Exposure (dBA)	Jordanian regulation criteria2	Jordanian regulation criteria3	Total Noise Exposure with Diesel BRT (dBA)	Total Noise Exposure with Electric BRT (dBA)
2.1	47	H	Route2	54	45	65	59	57
2.2	21	W	Route2	58	45	65	63	61
2.3	18	W	Route2	60	45	65	65	63
2.4	29	W	Route2	58	45	65	61	60

[1] H: Hospital, W: Worship House, and E: Educational institute
[2] Jordan Criteria for sensitive receptors (Hospitals, Worship Houses, and Educational institutes)
[3] Jordan Criteria for urban areas with commercial activities

Table 5-12: Noise Exposure Assessment based on Jordan Noise Regulations for BRT Route 3

Receiver Number	Distance (m)	Land use Category 1	Route	Existing Total Noise Exposure (dBA)	Jordanian regulation criteria2	Jordanian regulation criteria3	Total Noise Exposure with Diesel BRT (dBA)	Total Noise Exposure with Electric BRT (dBA)
3.1	45	W	Route3	67	45	65	68	68
3.2	26	W	Route3	72	45	65	72	72
3.3	60	W	Route3	67	45	65	66	66
3.4	70	E	Route3	66	45	65	65	65
3.5	38	H	Route3	70	45	65	70	69
3.6	37	H	Route3	70	45	65	70	69
3.7	37	W	Route3	70	45	65	70	69
3.8	71	E	Route3	66	45	65	65	65
3.9	52	H	Route3	68	45	65	67	67
3.10	59	E	Route3	67	45	65	66	66

[1] H: Hospital, W: Worship House, and E: Educational institute
[2] Jordan Criteria for sensitive receptors (Hospitals, Worship Houses, and Educational institutes)
[3] Jordan Criteria for urban areas with commercial activities

5.4.2 Noise exposure assessment compared to FTA guidelines

Total noise exposure for sensitive receptors are summarized for each route in **Table 5-13** to **Table 5-15** below.

Table 5-13: Noise Exposure Assessment based on FTA Noise Guidelines for BRT Route 1

Receiver Number	Distance (m)	Route	Land use Category	Existing Total Noise Exposure (dBA)	FTA criteria Moderate / severe (dBA)	Total Noise Exposure with Diesel BRT (dBA)	Noise impact assessment for Diesel BRT	Total Noise Exposure with Electric BRT (dBA)	Noise impact assessment for electric BRT
1.1	26	Route1	3	62	64-69 / >69	64	Moderate impact	62	No impact
1.2	52	Route1	3	57	62-67 / >67	59	No impact	58	No impact
1.3	45	Route1	3	58	62-68 / >68	60	No impact	59	No impact
1.4	30	Route1	2	59	57-63 / >63	61	No impact	59	No impact
1.5	23	Route1	3	61	63-69 / >69	63	Moderate impact	61	No impact
1.6	24	Route1	2	61	58-64 / >64	63	Moderate impact	61	Moderate impact
1.7	22	Route1	3	65	66-70 / > 70	65	No impact	64	No impact
1.8	32	Route1	3	63	64-69 / > 69	63	No impact	62	No impact
1.9	16	Route1	3	68	69-74 / > 74	68	No impact	68	No impact
1.10	42	Route1	3	56	61-67 / > 67	59	No impact	58	No impact
1.11	39	Route1	3	56	61-68 / > 68	60	No impact	58	No impact
1.12	35	Route1	2	53	55-61 / > 61	60	Moderate impact	58	Moderate impact
1.13	29	Route1	3	55	60-66 / > 66	61	Moderate impact	59	No impact
1.14	70	Route1	2	55	55-61 / > 61	57	Moderate impact	56	Moderate impact
1.15	63	Route1	3	51	59-65 / > 65	52	No impact	52	No impact
1.16	27	Route1	3	61	63-69 / > 69	63	Moderate impact	62	No impact

Table 5-14: Noise Exposure Assessment based on FTA Noise Guidelines for BRT Route 2

Receiver Number	Distance (m)	Route	Land use Category	Existing Total Noise Exposure (dBA)	FTA criteria Moderate / severe (dBA)	Total Noise Exposure with Diesel BRT (dBA)	Noise impact assessment for Diesel BRT	Total Noise Exposure with Electric BRT (dBA)	Noise impact assessment for electric BRT
2.1	47	Route2	2	54	55-62 / > 62	59	Moderate impact	57	Moderate impact
2.2	21	Route2	3	58	62-68 / > 68	63	Moderate impact	61	Moderate impact
2.3	18	Route2	3	60	63-69 / > 69	65	Moderate impact	63	Moderate impact
2.4	29	Route2	3	58	62-68 / > 68	61	No impact	60	No impact

Table 5-15: Noise Exposure Assessment based on FTA Noise Guidelines for BRT Route 3

Receiver Number	Distance (m)	Route	Land use Category	Existing Total Noise Exposure (dBA)	FTA criteria Moderate / severe (dBA)	Total Noise Exposure with Diesel BRT (dBA)	Noise impact assessment for Diesel BRT	Total Noise Exposure with Electric BRT (dBA)	Noise impact assessment for electric BRT
3.1	45	Route3	3	67	67-72 / > 72	68	Moderate impact	68	Moderate impact
3.2	26	Route3	3	72	72-80 / > 80	72	No impact	72	No impact
3.3	60	Route3	3	67	67-72 / > 72	66	No impact	66	No impact
3.4	70	Route3	3	66	66-71 / > 71	65	No impact	65	No impact
3.5	38	Route3	2	70	71-80 / > 80	70	No impact	69	No impact
3.6	37	Route3	2	70	71-80 / > 80	70	No impact	69	No impact
3.7	37	Route3	3	70	71-80 / > 80	70	No impact	69	No impact
3.8	71	Route3	3	66	66-71 / > 71	65	No impact	65	No impact
3.9	52	Route3	2	68	68-73 / > 73	67	No impact	67	No impact
3.10	59	Route3	3	67	67-73 / > 73	66	No impact	66	No impact

5.4.3 Noise Modelling Results Discussion

The Jordanian Criteria

The first criterion used was from the Jordanian regulations for sensitive receptors which is that hospitals, educations institutes, and worship places should not be exposed to more than 45 dBA. When comparing the traffic noise from flow baseline without the BRT to the 45dBA criteria, it was concluded that all of the sensitive receptors were exposed to noise levels above this standard which indicted that these roads are too noisy for such places but it is an existing situation outside the control of the project.

The second applicable criteria also from the Jordanian regulations is 65 dBA which is the Jordan Criterion for urban areas with commercial activities. For route one, the baseline conditions noise exposure were below this limit with exception of one receptor which was originally above the limit. The BRT will not raise any of the noise exposure levels above this criterion. The points which were below the limit stayed below the limit and the point which was above stayed above. The BRT is estimated to raise noise on this route from 0 to 7 dBA.

For route 2 all the baseline exposures were below the limit of 65 dBA but the BRT raised the exposure at one of the points to above the limit only for that one point. However if an electric bus is used the noise exposure would go back below the limit. The BRT is estimated to raise the noise on this route from 3 to 5 dBA.

Route 3 is the noisiest route and is in the baseline conditions always above the 65 dBA limit. The BRT does not significantly add any noise in fact it reduces the noise in some situations the BRT contribution ranges from -1 dBA to 1dBA for this route.

FTA Guidelines

FTA introduces three levels of noise impact which are No impact, moderate impact, and severe impact. Moderate impact areas means that the change in the noise is noticeable to most people but it might not be sufficient to cause strong or adverse reactions from the community. However Severe impacted areas means most people in these areas will be highly annoyed by the noise and if the noise exceeds 80 dBA then it becomes an unacceptable living environment.

Noise assessment of the BRT routs demonstrated that there are some areas that will be moderately impacted but no areas are severely impacted.

Additional dBA

Additional dBA at all sensitive receptors from baseline conditions for a diesel BRT and an electric BRT are summarized in **Table 5-16** below.

Table 5-16: Additional Noise exposure (dBA)

Receiver Number	Existing Total Noise Exposure (dBA)	Total Noise Exposure with Diesel BRT (dBA)	Additional Noise (dBA) for Diesel BRT	Total Noise Exposure with Electric BRT (dBA)	Additional Noise (dBA) for Electric BRT
1.1	62	64	2	62	0
1.2	57	59	2	58	1
1.3	58	60	2	59	1
1.4	59	61	2	59	0
1.5	61	63	2	61	0
1.6	61	63	0	61	0
1.7	65	65	0	64	-1
1.8	63	63	0	62	-1
1.9	68	68	0	68	0
1.10	56	59	3	58	2
1.11	56	60	4	58	2
1.12	53	60	7	58	5
1.13	55	61	6	59	4
1.14	55	57	2	56	1
1.15	51	52	1	52	1
1.16	61	63	2	62	1
2.1	54	59	5	57	3
2.2	58	63	5	61	3
2.3	60	65	5	63	3
2.4	58	61	3	60	2
3.1	67	68	1	68	1
3.2	72	72	0	72	0
3.3	67	66	-1	66	-1
3.4	66	65	-1	65	-1
3.5	70	70	0	69	-1
3.6	70	70	0	69	-1
3.7	70	70	0	69	-1
3.8	66	65	-1	65	-1
3.9	68	67	-1	67	-1
3.10	67	66	-1	66	-1

The additional noise (dBA) in Route 1 rose as a result of the project in the range of (0 to 7) along the route if diesel BRT is used and (1 to 5) if electric buses are used. In route 2 the change in dBA was (3 to5) for Diesel and (2 to 3) for electric. In Route 3 the change in dBA was in the range of (-1 to 1) and remained at the same range for the electric buses.

Mitigation Measures

- **Noise barriers**

Since the noise impact ranged between "no impact" to "moderate impact" with no areas of severe impacts, it does not seem there is an immediate need for noise barriers as a result of the BRT. Moderate impact means that people will feel the additional noise but not to an extent where they become really annoyed by it. If electric BRT buses are use this will lower the noise impact even further.

As the city becomes more developed and if some areas are truly affected and noise barrier are deemed necessary, several options are available to be used as noise barriers.

- **Earth mounts**

These are simple earth mounts on the side of the corridor which could be used for greening the side of the road with a design height and width to block the noise. The advantage of this type of barrier is that it is organic and can blend in especially if it is used to plant trees and shrubs but the disadvantage is that is requires relatively large road width to build and requires maintenance for the trees.

- **Vertical constructed walls**

These are simply walls with specific height and width designed to block the noise. These are great for narrow roads as they don't require wide foot print to install and require very low maintenance.

- **Use of electric buses.**

Electric buses have been demonstrated to lower the total noise level exposures of a transit system. In this modeling exercise the electric BRT lowered the total noise exposure for up to 2 dBA from of diesel buses. Use of electric buses can be a requirement from the operators of the BRT.

- **Proper fleet maintenance**

Proper and continuous maintenance of the BRT buses can ensure smooth operating buses.

5.4.4 Reduced Capacity of the Existing Roads

The BRT corridors as discussed earlier are built on existing roads with heavy traffic. The corridors are expected to reduce the width available for regular traffic on the roads but in most places the same amount of lanes shall remain the same. The number of lanes before and after the BRT are summarized in **Table 5-17** and **Table 5-18** below.

Table 5-17: No of Lanes for the Baseline and BRT Project for Route 1

BRT Stations	No of Lanes (Baseline)	No of Lanes (BRT)
Swuayleh Terminal-Yajouz	3	3
Yajouz-University Street	3	3
University Street-Jordan University Hospital	3	3
Jordan University Hospital-Mahmoud al-Kiswani	3	3
Mahmoud al-Kiswani-Press Tunnel	3	3
Mahmoud al-Kiswani-Press Tunnel	3	3
Press Tunnel-Sports City	3	3
Sports City-Al-Riyadhah	3	3
Al-Riyadhah-North Terminal	3	3
North Terminal-Al-Aqsa	3	3
Al-Aqsa-Tarek Interchange	3	3
Tarek Interchange-Prince Hamzah Hospital	2	2
Prince Hamzah Hospital-Al-Istiqlal	2	3
Al-Istiqlal-Al-Mahatta Terminal	3	3

Table 5-18: No of lanes for the baseline and BRT project for route 2

BRT Stations	No of Lanes (Baseline)	No of Lanes (BRT)
Sports City-Abdulhameed Sharaf	3	2
Abdulhameed Sharaf-Omar bin Abdulazeez	2	2
Omar bin Abdulazeez-Al-Imam Muslem	2	3
Al-Imam Muslem-Makkah al-Mukarramah	2	2
Makkah al-Mukarramah-Moh'd Ali Jinnah	2	3
Moh'd Ali Jinnah-Fawzi al-Qawuqji	2	2
Fawzi al-Qawuqji-Moh'd Ali Bdair	2	2
Moh'd Ali Bdair-Barada	2	2
Barada-Prince Ali bin Al-Hussein	2	3
Prince Ali bin Al-Hussein-King Hussein Cultural Centre	3	3
King Hussein Cultural Centre-City Hall	3	3
City Hall-Al-Muhajareen Terminal	3	3

The only section that shall see lane reduction is from the Sport city towards Wadi Saqra. (from 3 lanes to 2). The actual width of lanes however maybe reduced to accommodate the BRT corridor which is a minimum of 7.5 m wide. Therefore the actual capacity of the roads may be affected even if the actual number of lanes is not changed in most cases.

Mitigation Measures

To mitigate this situation it is important that GAM implements traffic solutions to keep the traffic going and increase the flow so that the reduced road capacity can be compensated. These solutions include:

- Intersection solutions especially for the road that will be reduced which is from sport city towards King Abdalla Park. These solutions could be bridges or tunnels.
- Parking solution to eliminate car parking on the side of the roads. This is important as current road users especially in Route 2 use the side of the roads to park which significantly reduces road capacity.
- Traffic control tools such as control cameras and clear road signage to ensure proper driving to facilitate traffic flow.

6. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Table 6-1: Environmental and Social Management Plan

Area of Impact	Mitigation Measures	Monitoring		Monitoring Location	Monitoring Frequency	Responsibilities (incl Review & reporting)
		Indicators	Targets			
Design						
Exclusion of socially vulnerable groups						
Current bus systems do not cater for vulnerable groups (i.e. handicapped, blind, visually impaired, elderly)	The stations and terminals design as well as the buses selection shall allow for wheelchair accessibility and reserved seats for elderly. All project buses shall have sound announcements of stations when to alert the blind and visually impaired in addition Braille language signs shall be used at all stations	Compliance with the proposed mitigation measures	Full compliance	Detailed Design Documents and TOR for hiring BRT operator	Once, at the completed detailed design stage / and once in the TOR for hiring the BRT operator	GAM and MoPW each in their portion of the roads
Not Including Sustainability in Project Design						
The project is expected to utilize significant quantities of construction material, solid waste is also expected to be generated from all project activities, the project will require a significant amount of water and energy	The project design shall utilize sustainable/ recycled/ local construction material for all project components, waste management infrastructure shall be also incorporated into the project design The design of all stations and terminals shall incorporate all means for reducing water consumption (i.e. water saving nozzle) as well as measures to cut the project energy demand (i.e. energy efficiency buildings, renewable energy sources)	Compliance with the proposed mitigation measures	Full compliance	Detailed Design Documents	Once, at the completed detailed design stage / prior to works commencement	GAM and MoPW each in their portion of the roads
Adverse Impacts and Mitigation during Construction						
Air Quality						
Dust emission from earthworks, equipment movement, exposed storage piles, truck dumping, hauling, vehicle movement on unpaved roads and concrete mixing	Implementing dust suppression measures Ensuring works are within 10 meters of any sensitive receptors Installing fiber boards or steel sheets hoarding with a height of 25 m around the stations locations Keeping stockpiles 50 m away from any sensitive receptor and cover all stockpiles with tarpaulins Installing side barriers for stockpiles larger than >25m3	Number community complains related to dust emission	0	Construction sites along BRT alignment Stations, Terminals and Intersections Locations	Daily	Contractor for abiding with mitigation measures GAM and MoPW for monitoring implementation of mitigation measures

Area of Impact	Mitigation Measures	Monitoring		Monitoring Location	Monitoring Frequency	Responsibilities (incl Review & reporting)
		Indicators	Targets			
Air emission from combustion of fuel in equipment and vehicles	Periodically check and maintenance of the construction machinery and haul vehicles Regular change of engine oil and use new engines/machinery/equipment having good efficiency and fuel burning characteristics Installation of catalytic converters for generators and maintain all generators stacks at least 3 meters above the ground	Number of community complains related to air emission	0			
Noise Levels						
Elevated in noise levels due to construction vehicles and equipment (i.e. excavators, dumpers, trucks, loaders and cranes)	Periodically check and maintenance of the construction machinery and haul vehicles Installation of exhaust mufflers on engine-powered construction plant and vehicles Limiting vehicle speed to 30 km/h within the construction site and surrounding areas Construction traffic shall not be permitted inside Amman without authorization Optimizing materials transportation to reduce number of trucks and the associated traffic noise Night time construction activities shall be restricted to relatively low noise activities All major compressors should be of sound-abated models or enclosed to reduce noise impacts Provision of acoustic enclosures around emergency generators Adopting low noise specification for motors, pumps, etc.	Number of complaints related to noise	0	Construction sites along BRT alignment Stations, Terminals and Intersections Locations	Daily	Contractor for abiding with mitigation measures GAM and MoPWfor monitoring implementation of mitigation measures

Area of Impact	Mitigation Measures	Monitoring		Monitoring Location	Monitoring Frequency	Responsibilities (incl Review & reporting)
		Indicators	Targets			
Traffic and Transport						
Road closures and traffic congestions particularly during constructions of intersections Temporary traffic disruptions due to heavy equipment and trucks movement along congested roads	Provision of traffic signs, warning instructions, traffic cones and flag persons to direct traffic Limiting major lifting activities to night shits to minimize traffic congestion Provision of sufficient lighting at night within and in the vicinity of construction sites Schedule equipment and material transport during non-peak hours Relocation of any affected public transport infrastructure prior to commencement of works Provision of Radio and newspaper advertisements to notify the community regarding changes to public transport facilities or routes Install temporary accesses to properties affected by disruption to their permanent accesses Reinstate permanent accesses after completion of construction	Traffic flow	Reduce traffic congestion	Construction sites along BRT alignment Main intersections along BRT alignment	Daily	Contractor for abiding with mitigation measures GAM and CTD for monitoring implementation of mitigation measures
Water Resources						
Increasing water demand for construction activities and construction camp this include water required for dust suppression	Means to minimized wastage of water shall be adapted in the project specially ensuring minimal water usage for dust suppression	Water demand	Reduce water demand	Construction sites along BRT alignment Stations Locations	Monthly	Contractor for abiding with mitigation measures GAM and MoPW for monitoring implementation of mitigation measures
Occupational Health and Safety						
Exposure of construction workers, pedestrians, vehicular traffic to the construction hazards	Provision of monthly safety induction to construction workers Monitoring construction workers and taking strict action against any non-compliance with safety of pedestrians and vehicular traffic	Number of accidents related to occupational health and safety	Zero accidents	Construction sites along BRT alignment Stations Locations	Daily	Contractor for abiding with mitigation measures GAM for monitoring implementation of mitigation measures

Area of Impact	Mitigation Measures	Monitoring		Monitoring Location	Monitoring Frequency	Responsibilities (incl Review & reporting)
		Indicators	Targets			
Construction and Demolition Waste / Wastewater from Camps						
Demolition of existing medians including removal of trees and concrete Construction waste resulting from defective materials and packaging waste Wastewater generated from the toilets, washrooms and the kitchens in construction camps	Excavated materials that are approved for reuse at site should be stored separately from other construction wastes in order to be able to use them on site for fill Ensuring that untreated wastewater effluent from labors in camps is not released to the environment and all wastewater quantities are transferred to a wastewater treatment plant for treatment A waste management plan shall be prepared to provide procedures for managing hazardous and non-hazardous materials prior to disposal Periodic on-site audits of waste management shall be undertaken along with auditing of waste disposal contractors and disposal facilities on regular basis to check that procedures are being followed Licensed waste contractors shall be engaged to dispose-off all non-hazardous waste material	General waste management as a function of visual inspections General housekeeping as a function of visual inspections Number of community complains related to waste management	Full compliance Full compliance <3 per month	Construction sites along BRT alignment Stations Locations	Weekly	Contractor for abiding with mitigation measures GAM and MoPWfor monitoring implementation of mitigation measures
Soil Erosion and Change in Local Hydrology						
Soil erosion and sediments transport to the existing storm water collection networks across the project area Contamination of storm water run-off from potentially contaminated areas (oil and grease storage areas, maintenance areas and workshops)	Develop and implement sediment and erosion control plans and apply good housekeeping practices on site to reduce the discharge of sediment and other pollutants from construction sites Minimize size of stockpiles and keep stockpiles areas away from potential runoff areas (road edges) Cover all stockpiles that are susceptible to erosion, or a suitable erosion control measure such as silt fences should be included	Blockage of near by storm water networks due to sediments transport	Zero Incident	Construction sites along BRT alignment Stations Locations	Monthly / Winter Season	Contractor for abiding with mitigation measures GAM and MoPW for monitoring implementation of mitigation measures
Ecology						
Removal of the trees and plantations in the median areas along the project alignment	Trans-locating the native tree species that will be removed from the median areas or other parts of the roads / Planting new trees to be planted to replace the removed ones with a ratio of two new trees for each removed tree	Amount of trees cut/ newly planted	Plant 2 trees per each tree removed	Construction sites along BRT alignment Stations Locations	Quarterly	Contractor for abiding with mitigation measures GAM for monitoring implementation of

Area of Impact	Mitigation Measures	Monitoring		Monitoring Location	Monitoring Frequency	Responsibilities (incl Review & reporting)
		Indicators	Targets			
						mitigation measures
Damage or Disruption of Utility Lines and Existing Services						
Disturbance and/or damage existing utility lines (i.e. water mains, sewerage collection lines, storm water drainage, telephone, electricity, street lighting, etc.)	Compilation of full and detailed information on existing utilities in the project sites should before any construction commences, Development of plans and methods of statements for re-routing or protection of existing utility lines	Disrupt and/or damage existing utility line	Zero accidents	Construction sites along BRT alignment Stations Locations	Monthly	Contractor for abiding with mitigation measures GAM and MoPW for monitoring implementation of mitigation measures
Adverse Impacts and Mitigation during Operation						
Air Quality						
The BRT buses will travel more mileage compared to current public transport busses as the BRT will go more frequently	Encourage modal shift from the personal vehicle users to the BRT which will reduce emission, Use advanced technologies instead of traditional diesel such as electric buses to reduce or eliminate harmful exhaust emissions	CO2 foot print	Reduce CO2 foot print	Along BRT alignment	Yearly	Operator for abiding with mitigation measures
Disposal of Wastes Generated from BRT Operation						
Solid waste in the form of garbage and refuse generated by BRT users and drivers during normal operation, as well as the soild waste generated from bus maintenance activities conducted at designated buses depot	Solid wastes generated from the BRT operation should be collected, stored, handled and disposed-off in a proper manner that allows for waste recycling and without causing environmental hazards or aesthetic nuisance	Waste is regularly and properly collected.	Clean sites,	Stations Locations	Daily	Operator for abiding with mitigation measures GAM and MoEnv for monitoring implementation of mitigation measures
Impacts on Existing Public Transport Operators						
Reduction in buses and coasters ridership along routes overlapping the BRT alignment	Partial reroutes for medium impacted buses and coasters Complete reroutes for medium impacted buses and coasters	Loss of income for each bus and coaster	Minimal loss	Along BRT alignment	Quarterly	GAM and LTRC for monitoring implementation of mitigation measures
Noise Impacts Generated from Operation of BRT System						

Area of Impact	Mitigation Measures	Monitoring		Monitoring Location	Monitoring Frequency	Responsibilities (incl Review & reporting)
		Indicators	Targets			
Noise exposure to increase slightly due to BRT in some locations	Use of Electric bus Use of noise barriers if needed Proper maintenance	Noise levels	Noise complains	Along BRT alignment	Quarterly	GAM and MoPW for monitoring implementation of mitigation measures
Reduced Capacity of the Existing Roads						
Some roads will experience reduced capacity because of the BRT	Traffic solutions to reduce effect of capacity reduction	Site	Driver complains	Along BRT alignment	Quarterly	GAM and MoPW for monitoring implementation of mitigation measures

7. BUS DEPOT SITE SELECTION CRITERIA

For the purposes of this criterion, a bus depot means land used primarily for parking, servicing or repairing of BRT buses.

Large number of buses for the BRT project operation will require a bus depot facility to enable operational efficiency in the BRT system. Such depots have indirect effects of improving passenger convenience and increasing the overall performance of the BRT. In order to serve the system well, bus depots should have at least the following facilities:

- A large area for parking buses
- Good pavement quality
- Sufficient space for bus marking and manoeuvring area
- Re-fuelling facility, cleaning and washing system
- Maintenance and repair area (workshop)
- Administrative office for operators, and employee facilities

The size of a bus depot is usually stated in terms of the number of buses that it can accommodate, which may vary from fewer than 10 buses to several hundred. The area required for any given number of buses will vary according to the shape and layout of the site.

For the site selection criteria of the bus depot, the following considerations shall be fulfilled (See **Table 7-1**):

Table 7-1: Main Considerations for Bus Depot Site Section Criteria

Parameter	Considerations
Available area and potential for site expandability	Total available area and total number of buses to use the depot
	Required area for each bus as per the type of busses used by the operators
Current site uses and conditions / Suitability nearby land uses	Land use surrounding the site to be of a similar or suitable use
	Presence of sensitive land uses near by
Environmental considerations	Waste impact
	Sites with sensitive ecology
	Water, biologic, or historic resource impacts
	Air and noise impacts
Depot proximity to BRT alignment	Nearest BRT stations

Environmental Impacts of Bus Depots

The activities of a bus depot and workshop can have a significant impact on the environment. If adequate measures are not taken they can cause serious damage, due to this an EIA report is required for the bus depot section.

The main potential problems associated with bus depot are traffic congestion caused by buses entering and leaving the depot, pollution from exhaust fumes and excessive noise from the buses and from other workshop activities.

Less visible, but often more serious, is environmental damage caused by waste oil or spilled fuel entering the drainage system or polluting nearby wadis. A vehicle workshop generates a considerable quantity of waste oil and if this is not disposed of properly it can cause serious pollution.

These environmental problems can be minimized with good design of the facilities, proper maintenance, and good discipline and housekeeping; the following sections provide an overview of the expected environmental impacts of bus depots.

Traffic Impacts

One of the most significant impacts of a bus depot is the impact on traffic from buses coming in and out of the deport as this will affect the neighborhood surrounding this depot.

Air Quality

A transport depot has the potential for emission of dust and fumes, which from the operation of diesel trucks or other mobile equipment.

Noise

Noise nuisance from bus depot includes noise generated from the movement of numerous buses and forklifts and reversing alarms on buses.

Waste Management

Waste generated is likely to include empty storage containers and packaging, general litter, by-products of any vehicle maintenance (including used oil, petroleum products, coolants, degreasing agents, sediment, rubber particles, detergents) and other hazardous materials.

Water Quality

Pollutants associated with road transport depots may include suspended solids, grease, lubricants, solvents, nutrients and oils. Such pollutants must be prevented from entering water bodies (including groundwater) through direct discharge, seepage or through contamination of storm water.

Fuel storage facilities (including overhead fuel tanks and hand pumps), or chemical and hazardous material storage facilities need to be bunded and preferably rain-proofed to minimize the risk of surface or groundwater contamination.

Leakage from underground petroleum storage systems is a significant issue that can have impacts on soils and groundwater and cause site contamination, as well as safety implications.

8. REFERENCES

[1] An Action Plan for Transport in Amman, 2007

[2] Feasibility Study and Detailed Design of the Amman – Zarqa Bus Rapid Transit – Jordan, 2016

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[4] Jamrah, Ahmad, and Rana Imam. "Energy consumption and environmental impacts of Bus Rapid Transit (BRT) systems." Jordan Journal of Civil Engineering 6.3 (2012): 328-339.

Appendix References:

- Public Transportation in Jordan: Obstacles, Opportunities, Strategies, and Projects. Greater Amman Municipality, 2015. <http://www.ammanbrt.jo/en/images/Amman2015.pdf>
- Amman- Zarqa Bus Rapid Transit ESIA Report. Dar al-Omran, SYSTSA, AEC, 2016.
- Yearly Report. Land Transport Regulatory Commission, 2016.

APPENDICES

APPENDIX A: BUSES, COASTERS AND SERFEESES AFFECTED BY BRT

1. PUBLIC TRANSPORT VEHICLES INTERSECTING BRT

Buses Intersecting BRT Sorted by Impact Level

Low Impact	Medium Impact	High Impact
7	8	193
12	46	229
13	88	263
14	194	287
21	199	311
47	203	312
48	236	
49	249	
51	250	
52	268	
82	272	
119	305	
121	327	
123	329	
137	338	
141		
143		
180		
181		
183		
184		
185		
190		
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201		
205		
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212		
213		
214		
218		
219		
221		
228		
231		
232		
233		
235		

Low Impact	Medium Impact	High Impact
245		
254		
258		
259		
264		
266		
267		
271		
273		
275		
276		
277		
278		
300		
301		
303		
313		
314		
315		
321		
328		
339		
340		

Coasters Intersecting BRT Sorted by Impact Level

Low Impact	Medium Impact	High Impact
6	86	186
50	99	188
57	202	189
58	204	192
74	220	196
89	238	197
130	241	256
133	248	288
144	253	317
145	265	318
146	298	330
170	302	332
176	331	333
187		
211		
222		
226		
234		
240		
242		
244		
251		
252		
260		
261		
262		
279		
280		
285		
296		
299		
304		
307		
326		
334		

Serfeeses Intersecting BRT Sorted by Impact Level

Low Impact	Medium Impact	High Impact
1	0	19
2	27	24
3	87	
4	90	
5	100	
9	101	
10	120	
11	135	
15	223	
16	225	
17	269	
18		
20		
22		
23		
25		
26		
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59		
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75		
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81		
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84		
85		
91		
102		
103		

Low Impact	Medium Impact	High Impact
104		
105		
106		
107		
108		
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110		
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117		
118		
134		
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224		
227		
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316		
319		
335		
336		
337		

Zarqa Buses Intersecting BRT Sorted by Impact Level

Low Impact	Medium Impact	High Impact
2610		4290
2854		806
2666		78
4106		1655

2. INDEX OF VEHICLE IDS AND CORRESPONDING ROUTES

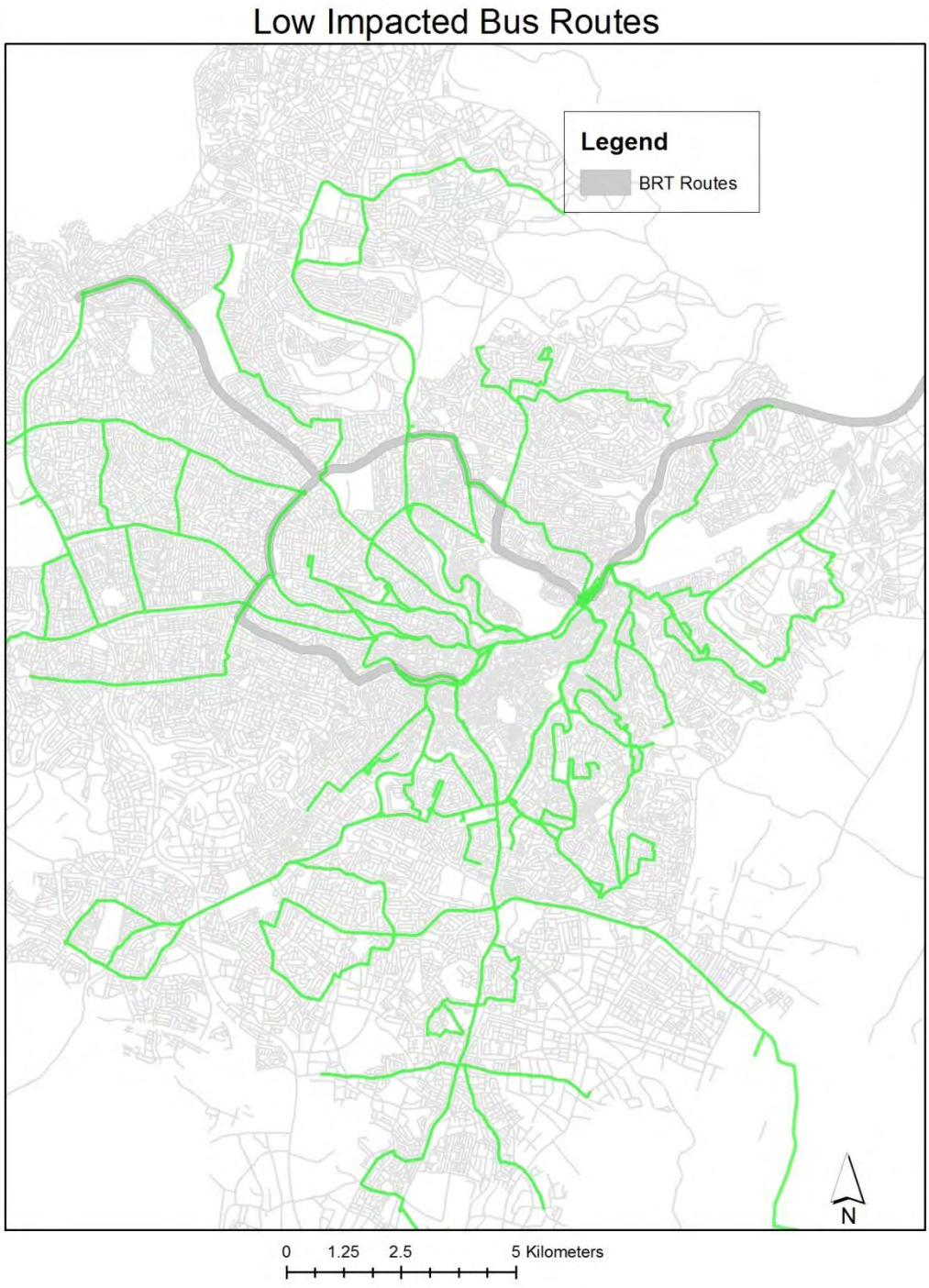
ID	Route Name	ID	Route Name
0	الهاشيم _ نيفالهشـ _ ها _ يملحاووز	47	المحطـ _ هي القيسيالذر _ هاع الغربي
1	جبـ لـ ارصنلـ _ حي الامير حسن 18	48	المهاجرين _ ساحة النوافال _ ريمقابلياس _ نكان المالية والزراعه
2	مجمع المحطوا _ ه ديـ النصر _ مجمع الجنوب	49	سقف السيحـ _ لـي بدر
3	حي الامير حسن - حي عالية 18 أ مؤقت	50	ساحة النوافير - المقابلين - ام قصير
4	جلى التاج - الحاووز 22	51	مجمع الجنوب _ مجمع الشمال
5	المحطه - الجوفه - المستشفيات 30 -السفلية 22	52	المهاجرين _ ساحة النوافريـ _ حي العواملة _ حي اليلير
6	مجمع رغدان - اسكان الجمعية	53	جلى التنظيف 31
7	مجمع المحطـ _ ةي العبوس	54	القويسمة - حي المعادي 50 أ
8	مجمع المحطة _ صويلح	55	عمان - الوحدات - سحاب - مدينة التجمعات الصناعية
9	الهاشمي الجنوبي - الرقابة الغذائية 16	56	القويسمة - الحرفية 50 ب
10	الهاشمي الشمالي - حي الزهراء	57	قرى بدر (سويسه - زبده) - مجمع المهاجرين
11	جبل المناره 18 ب	58	مجمع المهاجرين - المدينة الطبية - وادي السير
12	مجمع المحطالقو _ هيسما _ هلمعادي	59	ماركا الشماليال _ هبطاريات 17 أ
13	مجمع المحطالقو _ هيسمه _ حي النهاريه	60	ماركا الجنوبية - النصر - حي الامير حسن الغربي 17 ه
14	مجمع المحطاسـ _ ةكان الكهرباء	61	ماركا الجنوبيحي ا _ هلامير حسن _ حي العبوس _ حي الربوه
15	الهاشمي الشمالي - حي الاتراك	62	جلى القصمـ _ رويدان النزهة 13
16	الهاشمي الشمالي - حي نايفه 14	63	ماركا الشماليحي ا _ هلمزارع 17 و
17	وادي الحدادة - السوق الشعبي 12	64	الجوفة - المخيم 24
18	التاج - شارع الزهور 21	65	الجوفة - حي ام تينة 23
19	الملكه علياء 54	66	مدينة الحسين للشباب 8 أ
20	العبدلي الدائري 8 ب	67	مخيم الحسين - اخر ش.عين جالوت 10
21	مجمع المحطا _ ةلما _ قرانم نوارة	68	ماركا الجنوبية - نادي السباق - حي الامير حسن الشرقي
22	جلى التنزهه - دوار الضاحيه 11	69	الدوار الثالث _ ثاخليه 6ب
23	الهاشمي الشمالز _ يلماغاتيت 14 أ	70	يادر وادي السير - عراق الامير
24	ماركا الشماليالاسـ _ هكالـ _ نتطوير الحضري 17 ز	71	بيادر وادي السير - الرباحية - سويسة - زبدة
25	ماركا الشماليحي ا _ هلضباط1 17	72	وادي السير - بدر 1
26	المحطـ _ هي المعلنيحي ا _ هلعبدلات	73	وادي السير - القصير - الصياحين - المرافقين-صويلح
27	المحطة - حي الضباط 17ب	74	الجامعه الاردنية - مجمع وادي السير
28	الوحدات - المستشفيات - التاج 20	75	ماركا الشماليحي ا _ هلمزارع 17 و
29	جلى الحسين - مستشفى الامل - دوار الداخلية	76	ماركا الجنوبية - نادي السباق - حي الامير حسن الشرقي
30	جلى الحسوزاره ا _ نيلاوقاف _ جبل الحسين - الفرير	77	ماركا الجنوبيحي ا _ هلامير حسن _ حي العبوس _ حي الربوه
31	جلى الحسين - وزارة الاوقاف 9	78	ماركا الجنوبية - النصر - حي الامير حسن الغربي
32	رغدامجمـ _ نع النقابات 6 ا	79	جبـ لـ ارصنلـ _ حي الامير حسن 18
33	العبدلمد _ يبري ه الدفاع المدني 7	80	حي الامير حسن - حي عالية 18 أ مؤقت
34	جلى الحويبدة 4+5	81	جبل المناره 18 ب
35	العبدلـ مـ _ بيدان جمال عبد الناصر	82	مجمع المحطا _ ةلما _ قرانم نوارة
36	رغدان - مجمع الشمال 6	83	مجمع المحطوا _ هدي النصر _ مجمع الجنوب
37	ضاحية الحسين - مجمع جبر التجاري	84	جلى التاج - الحاووز 22
38	جبل عمان - الدوار الرابع 3	85	مدينة الحسين للشباب 8 أ
39	جبل عمان - الجوازات - الثالث 1	86	مجمع الشمال - ياجوز - مرورا بصويلح
40	جبل عمان 2	87	وصفي التل - دابوق 56 أ
41	الوحدات - جلى الحديد 27 أ	88	مجمع المحطة _ صويلح

ID	Route Name	ID	Route Name
42	الوحدات - سكة الحديد - ضاحية الحاج الحسن	89	الجامعه الاردنية - مجمع وادي السير
43	الوحدات - مجمع الجنوب 27	90	وصفي التل - خلدا
44	جبل المريخ 32	91	ضاحية الحسين - مجمع جبر التجاري
45	الاشرفية 25 +66	92	رغدامجم _ نع النقابات 6 ا
46	جنوب عمان _ الدائري الغربي	93	وادي السير - القصير- الصياحين- المرافقين-صويلح
94	مجمع صويلح - المدينة الطبية - مجمع وادي السير	154	حي نزال - ريفكو 29 أ
95	صويلح - مدينة الفردوس - وادي السير	155	راس العين - قرية الطيبات 28
96	يادر وادي السير - عراق الامير	156	الوحدات - مجمع الجنوب
97	مجمع صويلح - المدينة الطبية - مجمع وادي السير	157	سقف السيل - جبل المريخ
98	صويلح - مدينة الفردوس - وادي السير	158	الاشرفية 25 +66
99	مجمع الشمال - ياجوز - مرورا بصويلح	159	جبل عمان 2
100	وصفي التل - دابوق 56 أ	160	العبدلمد _ يريه الدفاع المدني 7
101	وصفي التل - خلدا	161	جبل عمان - الدوار الرابع 3
102	وادي الحدادة - السوق الشعبي 12	162	جلى الحسوزاره ا _ نيلاوقاف _ جلى الحسين _ الفرير
103	الهاشمي الشمالي - حي الاتراك	163	مجمع المحطه - مجمع المهاجرين 61
104	المحطه - الجوفه - المستشفيات السفلية	164	حي نزال - الجامع الكبير 29
105	الهاشمي الشمالي - حي نايفه 14	165	جلى النظيف 31
106	الهاشمي الشمالز _ يلاغاتيت 14 أ	166	جلى الويبدة 4+5
107	الهاشيم _ نالهاش _ هفيا _ يملحاووز	167	جبل عمان - الجوازات - الثالث 1
108	الهاشمي الشحي ا _ يلاملزهراء 15	168	المهاجرين - مستشفى عاقله 55
109	الهاشمي الجنوبي - الرقابة الغذائية 16	169	مجمع الجنوب _ مجمع الشمال _ الوحدا _ تلعبدلي المباشر
110	جلى القصم _ رويدان النزهة 13	170	مجمع الجنوب - مجمع الشمال
111	الملكه علياء 54	171	مجمع الجنوب _ مجمع الشمال 27 ج
112	جلى النزهه - دوار الضاحيه 11	172	الدوار الثالث _ ثاخاليه 6ب
113	مخيم الحسين - اخر ش.عين جالوت 10	173	جلى الحسين - وزارة الاوقاف 9
114	جلى الحسين - مستشفى الامل - دوار الداخلية	174	العبدل م _ ييدان جمال عبد الناصر
115	ماركا الشماليالاس _ هكاال _ نتطوير الحضري	175	رغدان - مجمع الشمال 6
116	ماركا الشماليحي ا _ هلضباط 17	176	مجمع رغدان _ قرية البيضاء
117	ماركا الشماليال _ هبطاريات 17 أ	177	الوحدات - خريبة السوق - جاوا 52
118	المحطه _ هي المعلنيحي ا _ هلعبدلات	178	المدينة الصناعية - الجويدة
119	مجمع المحطه _ ةي العبوس	179	الجويدة - المدينة الصناعية
120	المحطة - حي الضباط 17ب	180	المحطا _ هلمدينه الصناعيه
121	المحطه _ نزهه سحاب	181	المحطاس _ هكان سحاب
122	عمان (الوحدات) - الجويدة - قرية نافع -قرية سالم	182	المقابلين - المدينة الطبية
123	المهاجرين _ ساحة النوافري _ اسكان الصيادلاس _ ةكان الرحمانيه	183	مجمع المحطمخ _ ةيم الامير حسن _ حي الخلايلة
124	عمان _ الطنيب (الوحدات _) _ الطن ناديا _ بيلسباق اليادوده	184	مجمع المحطال _ ةحرشا _ هلمرقب
125	_ عماس _ نكان الصيادله (الوحدات) - اليادوده	185	المحطالصا _ هلحيال _ همغيرات
126	عمان (الوحدات) - اليادودة - ضاحية الملكة علياء	186	صويلح _ ماركا (التطوير الحضري)
127	ضاحية الملكة علياء - اليادودة - وسط البلد	177	مديرية ترخيص الشحنات - صويلح
128	عمان (الوحدات) - العلكومية - خريبة السوق - جاوا - حي النور الشرقي	188	الترخيص العمومي - الحزام الدائري- صويلح
129	عمان _ الحي _ اواجد الشا _ يقرلعلكوميال _ هوحدات _ خريبه السوق _ اواجد _ الدوريات الخارجيه	189	صويلترخ _ جيص الشاحنات
130	قرى بدر (سويسه - زبده) - مجمع المهاجرين	190	مجمع المحم _ ةطاركا
131	يادر وادي السير - الرباحية - سويسة - زبدة	191	مجمع المحابو _ ةط عليا
132	وادي السير - بدر 1	192	منطقة القرطوعية - الجامعة الاردنية
133	مجمع المهاجرين - المدينة الطبية - وادي السير	193	مجمع المحطال _ ةتطوير الحضري
134	المهاجرين - مرج الحمام 30	194	مجمع المحطا _ ةلاتحاد الرياضي

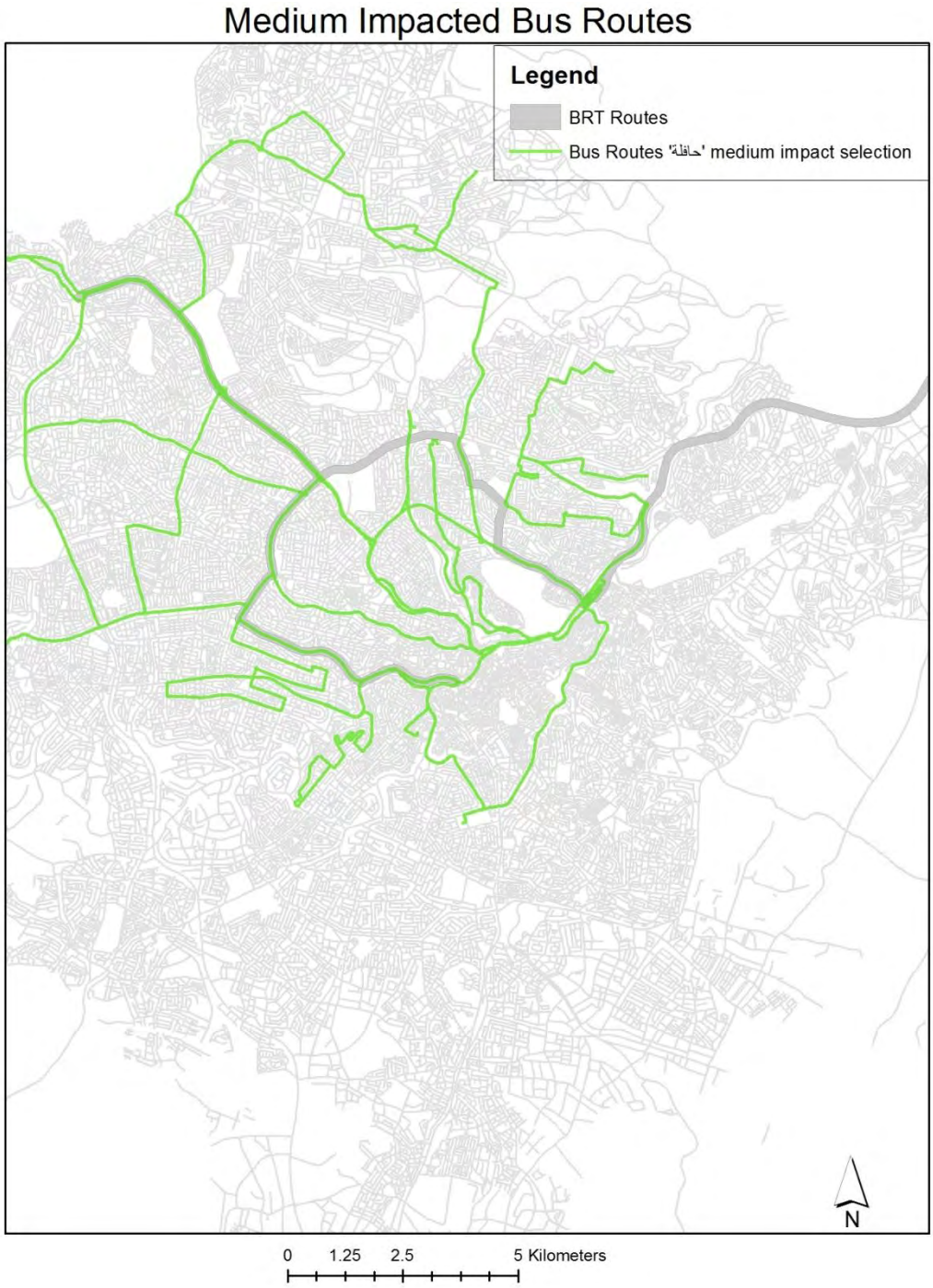
ID	Route Name	ID	Route Name
135	المهاجرين - حي القيسية 55 أ	195	داخل منطقة طبربور
136	عمان - الوحدات - سحاب - مدينة التجمعات الصناعية	196	الجامعة الاردنية - ابو عليا
137	مجمع المحطاس _ ةكان الكهرباء	197	طارق - الجامعة الاردنية
138	العبدلي الدائري 8 ب	198	مجمع المحطض _ ةاحية الامير هاشم
139	القويسمة - الحرفية 50 ب	199	مجمع المحطشفا _ ةبدران _ طاب كراع
140	القويسمة - حي المعادي 50 أ	200	مركز انطلاق المحطا _ ةلجامعة التطبيقيشفا _ ةبدران _ كلية العوم المصرفيه
141	مجمع المحطالقو _ ةيسمه _ حي النهاريه	201	مركز انطلاق المحطا _ ةلجامعة التطبيقيشفا _ ةبدران _ كلية العوم المصرفيه
142	الوحدات - جلي الحديد 27 أ	202	مجمع الشمال - ياجوز - الكوم
143	مجمع المحطالقو _ ةيسما _ ةلمعاد ي	203	مجمع الشماشفا _ ل بدران _ طاب كراع
144	مجمع رغدان - اسكان الجمعية	204	مرج الفرس - مجمع الشمال
145	عمان - المنتزه	205	مجمع الجنوب _ مستشفى الامير حمزة - _ مجمع الشمال
146	عمان - ام قصير	206	اسكان التطوير الحضري - عمان
147	الوحدات - ضاحية الحاج حسن 27	207	جنوب عمان _ الدائري الشرقي
148	جبل الزهور 37	208	ابو علندا - الوحدات 33
149	التاج - شارع الزهور 21	209	ابو علندا - اسكان الكهرباء 33
150	الجوفة - حي ام تينة 23	210	مجمع المحابو _ ةط علندا
151	الوحدات - المستشفيات - التاج 20	211	رغداسكا _ نان الجمعيه \ المحطه _ البنياس _ تكان الجمعيه
152	حي نزال _ حديقة الشورى 29 ب	212	سقف السيل _ ل هور الشرقي
153	الجوفة - المخيم 24	213	سقف السيل - نزال - اسكان التلفزيون
214	المهاجرين _ ساحة النوافا _ ريلسوق المركزي	277	مجمع المحطة _ عغو الله دبشة
215	الوحدات - حي النهارية	278	المحطا _ ةلمدينه الطبيه
216	عمان - المعادي	279	مجمع المهاجرين _ وادي السير
217	التطوير الحضري - ام نوارة - الشرق الاوسط	280	وا _ ادلخدي السير (دائري)
218	مجمع المحطالمس _ ةتنده	281	وادي السير - بدر - دوار السوط
219	مجمع المحطض _ ةاحية الحاج حسن	282	المعسر (الحاميه) _ وادي السير
220	الجمرك - الاستقلال - صويلح	283	الالمانيالرجا _ ةحو _ ةادي السير
221	مجمع المحطة _ كلية حطين	284	وادي السير _ الظهير
222	عمان - المنتزه	285	رغدان - مرج الحمام
223	المهاجرين - حي القيسية 55 أ	286	داخل منطقة مرج الحمام
224	راس العين - قرية الطيبات 28	287	مجمالشد عمال _ صويلا _ حلمنطقة الصناعية
225	55 المهاجرين - مستشفى عاقله	288	صويلح - الجامعة -داخل صويلح -حي التلفزيون - اسكان المهندسين
226	مجمع الجنوب - مجمع الشمال	289	البحاث - وادي السير
227	جبل الزهور 37	290	وادي السير - الالمانية
228	الدائري الغربي	291	البردايو _ عراق الأمير
229	مجمع الشما ا _ للحي الشرقي	292	وادي السير _ المعسر
230	مرج الحمام - ام عبهرة - القصير 66	293	القصبات - يادر وادي السير
231	مجمع المحمر _ ةطج الحمام	294	بدر الجديدة (سويسة - زبدة) وادي السير
232	مجمع المحطة _ مرج الحمام(اسكان) عالية	295	وادي السير - الرباحيه - سويسه - زبدة
233	مجمع المهاجريمر _ نج الحمام _ اسكان عالية	296	صووا _ حليدي السير
234	الجامعة الاردنية - مرج الحمام	297	صووا _ حليدي السير
235	المحطه _ طبربور (كليه الدعوه)	298	وادي السير _ المدينة الرياضية
236	المحالهاش _ ةطمي الشمالي	299	وادي السير- الجامعه الاردنية-خلدا
237	طارحي ا _ قلخزنة _ مستشفى الملكة علياء	300	مسار بلا عنوان
238	الحديمس _ بتشفى الملكة علياء	301	المحطه _ بيادر واد ي السا _ ريلجندويل
239	وادي السير - الرباحية 64	302	مجمع المهاجرين - حي الكرسي
240	صويلح - ام العروق	303	مجمع المحطوا _ ةدي السير و تفرعاته
241	مجمع الشمال - صويلح - شفا بدران	304	وادي السير - مجمع المهاجرين

ID	Route Name	ID	Route Name
242	دوار صويلح - تلاع مشوح	305	مجمع المهاجرين - وادي السير
243	سرفيس ابو نصير 1	306	حي نزال - ريفكو 29 أ
244	الجامعة الاردنية - اسكان ابو نصير	307	عمان - ام قصير
245	مجمع المحطضـ_ةاحية الرشيد	308	حي نزال _ حديقة الشورى 29 ب
246	مجمـ ابو _ لامشلا ع نصير	309	حي نزال - الجامع الكبير 29
247	سرفيس ابو نصير 2	310	المهاجرين - مرج الحمام 30
248	مجمع الشمااسـ_لكان ابو نصير	311	الجامعة الاردنية _ مجمع الجنوب
249	المحابو_ةط نصير	312	الدائري الجنوبي
250	مجمع المحطشفا_ة بدران	313	المهاجريسا _ نحة النوافال _ ريمقابليام _ ن قصري _ البنيات
251	داخل حدود بلدية الجبيهة وام زويتينة	314	سقف السيل _ نزال الاخضر
252	داخل حدود الجبيهة - صويلح	315	المهاجرين _ ساحة النوافال _ ريمقابليام _ ن قصري _ البنيات
253	جامعة العلوم التطبيقية - مجمع الشمال	316	داخل منطقة صويلح - الحي الشرقي
254	مجمع المحطجـ_ةلى الـنزهة _ ضاحية الامير الحسن	317	مركز انطلاق الشما ا _ للحي الشر قي
255	مجمع الجنوا_بـلمدينه الطبيه	318	مجمع الشماا_لـلجبيهة_صويلح
256	مجمع الشمال - جامعة العلوم التطبيقية	319	داخل منطقة صويلح
257	االـ_ةراوذ موحدات	320	يادر وادي السير - المدينة الطبية - مجمع صويلح - مؤقت)
258	مجمع المحطة - المنارة 2	321	مجمع المحطالصـ_هناعه
259	مجمع المحطا_ةلمنارة	322	يادر وادي السير - ابو السوس
260	مجمع المهاجرين _ بدر الجدةدي _ زبد	323	وادي السير _ ابو السوس
261	صويلح - جامعة العلوم التطبيقية	324	ام نجاصة _ البصة _ وادي السير
262	الجامعة الاردنية - مرج الحمام - القصير	325	وادي السير - البصة - ام الخنازير
263	مجمع المحطا_ةلأشرفية_المستشفيات	326	مجمع المهاجرين _ بدر الجدةدي _ زبدة
264	المحمجم_ةطع الشمال	327	المحطالجـ_ةامعة الاردنية
265	وادي السريـ_مستشفى الملكة علياء	328	وادي السالجـ_ريامعه الاردنيه (قرى) بدر
266	مجمع المحطجـ_ةلى الحسين	329	الدائرالداخلـ_ي
267	المهاجريسا _ نحة النوافريـ_جاحي _ او النور	330	مركز انطلاق الشما ا _ للحي الشرقي
268	مجمع المحطة _ عبدود _ نير غراب _ القيسية	331	مجمع المهاجريحي الكرسـ_ني
269	جسر المربط - دوار الداخلية 60	332	مجمع الشمال _ صويلح
270	سقف السلل _ لوحدات	333	صويلالجا _ جمعة الأردنية
271	سقف السي حـ_لي الزهور الغربي	334	مجمع المهاجرين - دوار ام الاسود
272	سقف السي حـ_لي ابو حليوه	337	مجمع الجنوب _ مجمع الشمال _ الوحدا _ تـلعبدلي المباشر
273	المحطالشمـ_ةيسانمجمـ_يع النقابات المهنية	338	مجمع المحطالـ_ةمهاجرين
274	داخل منطقة تلاع العلي	339	المهاجرين _ ساحة النوافريـ_ضاحية الامير علي
275	مجمع المحطدا_هبوق	340	المهاجرين _ ساحة النوافال _ ريعلكوميال _ ةتطوري _ ضاحية الاندلس

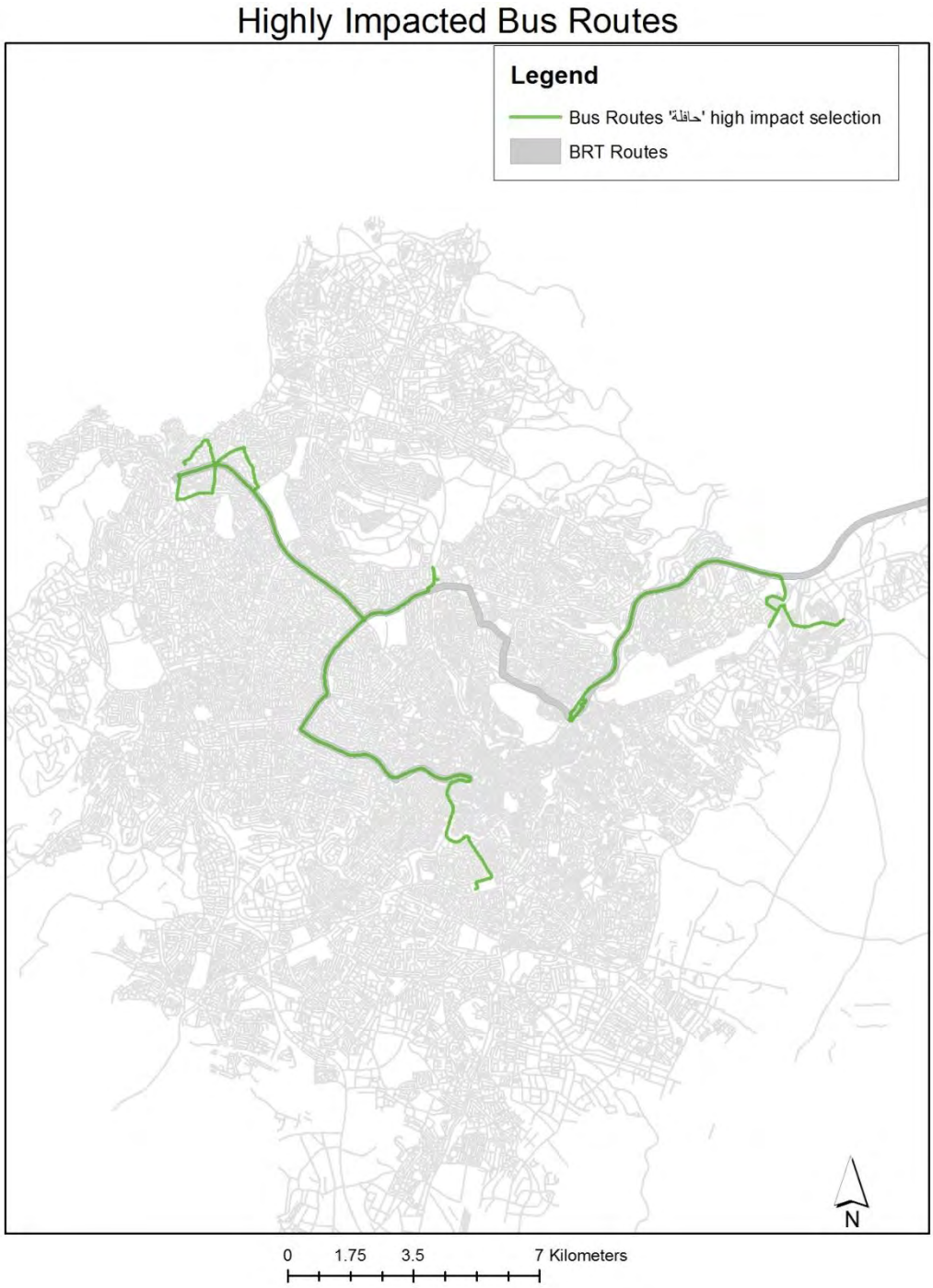
3. MAPS OF ROUTES OVERLAPPING BRT BY IMPACT LEVEL



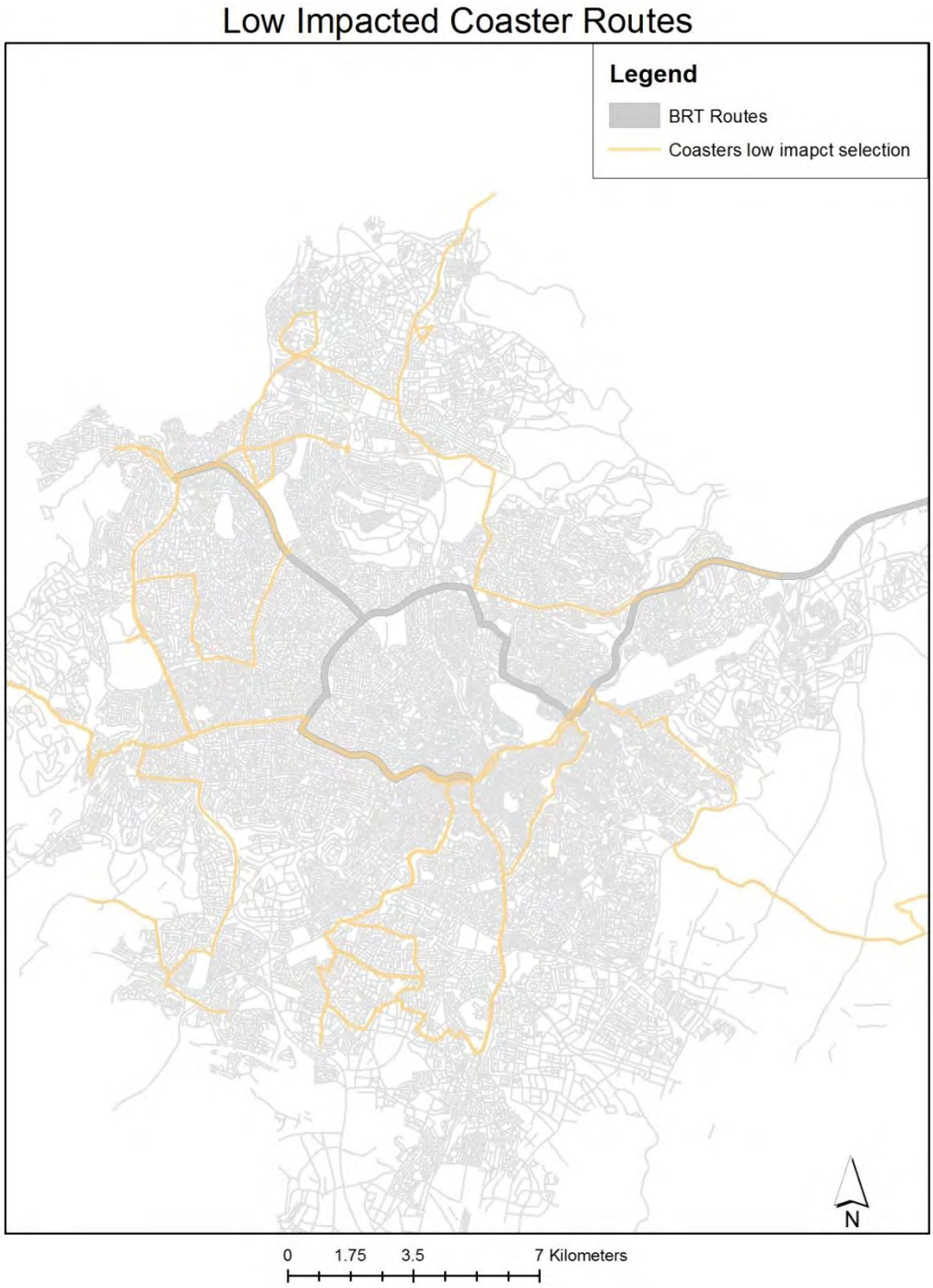
Low Impacted Bus Routes Overlaying Proposed BRT Routes



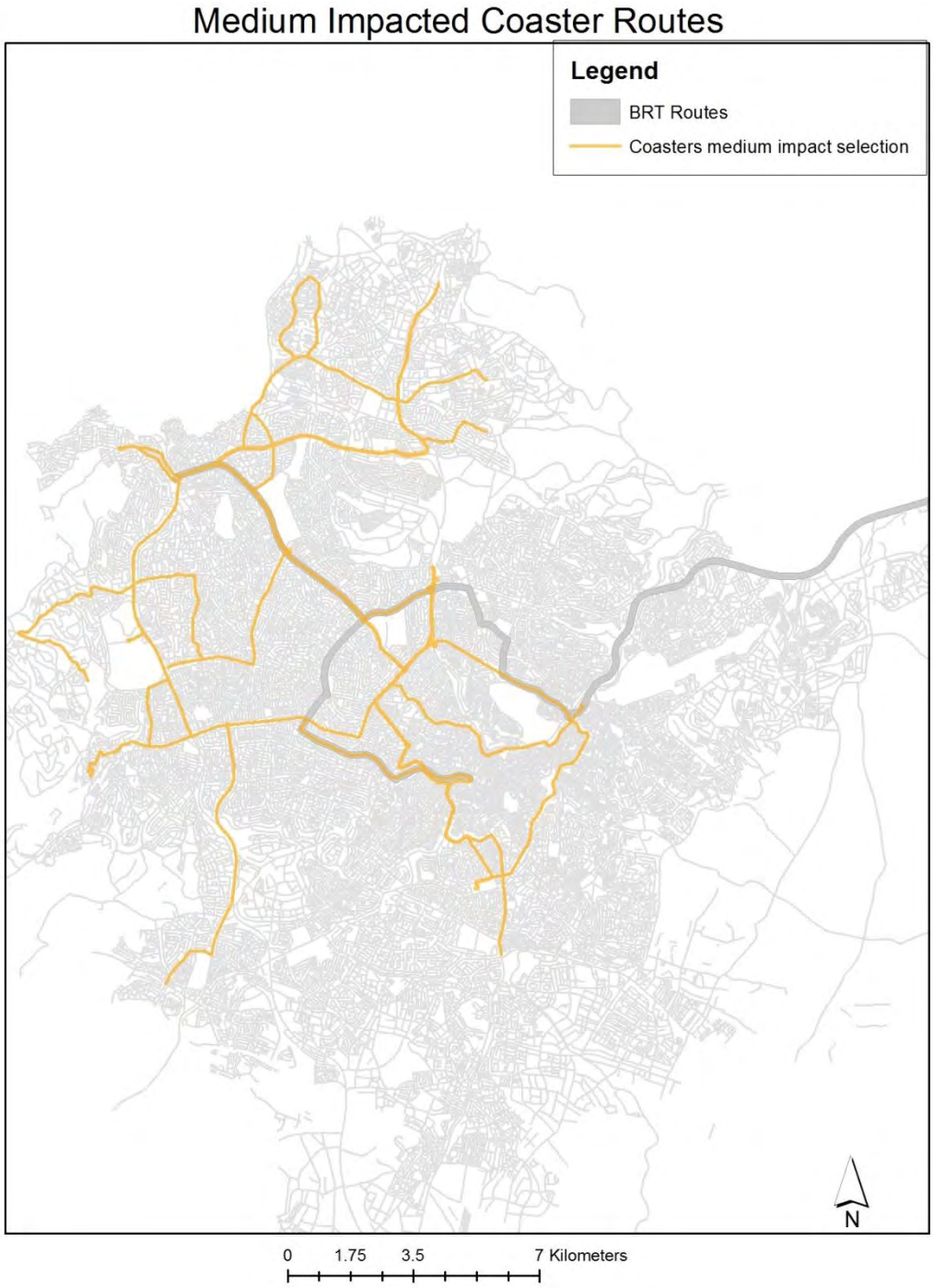
Medium Impacted Bus Routes Overlaying Proposed BRT Routes



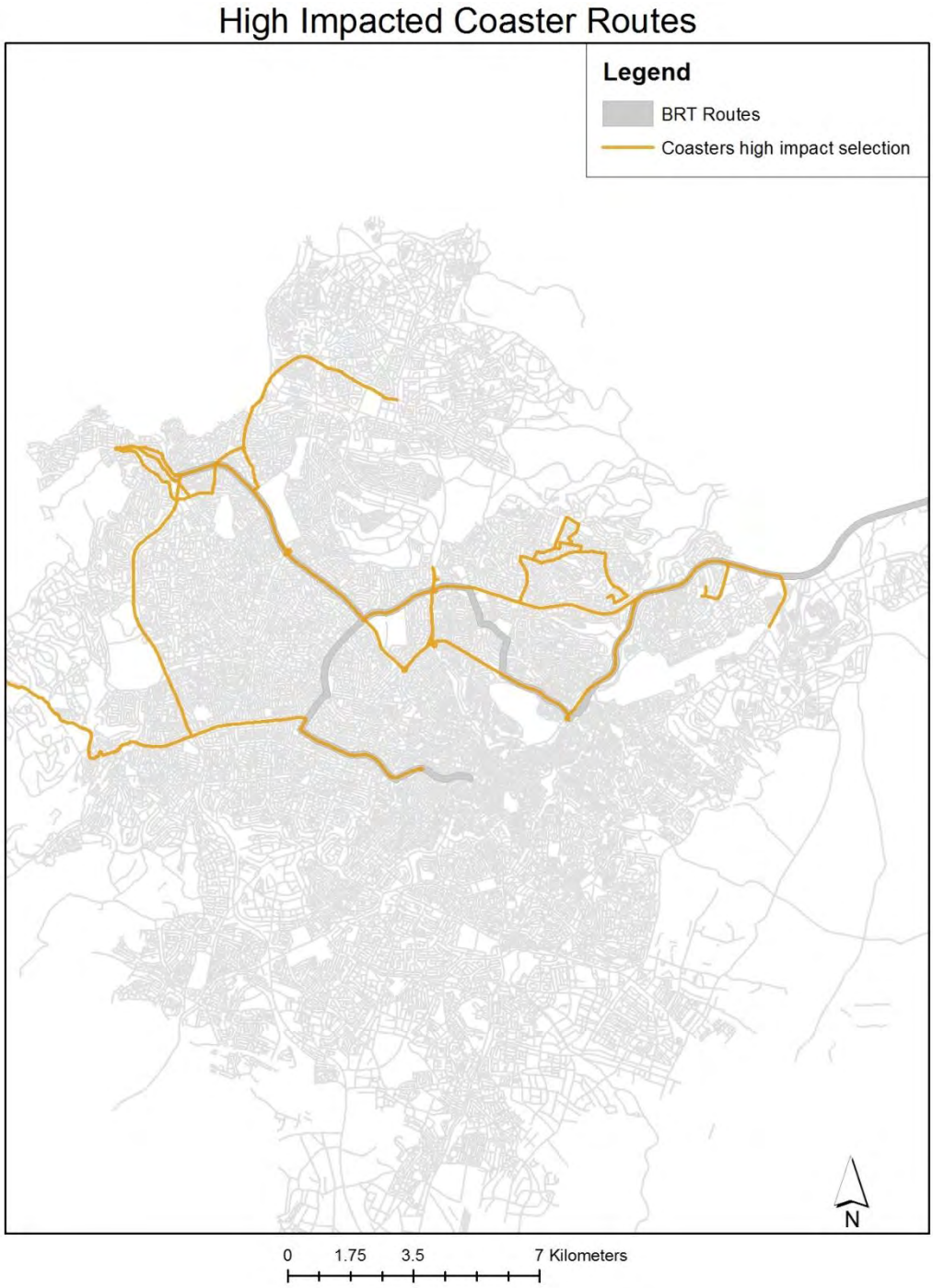
Highly Impacted Bus Routes Overlaying Proposed BRT Routes



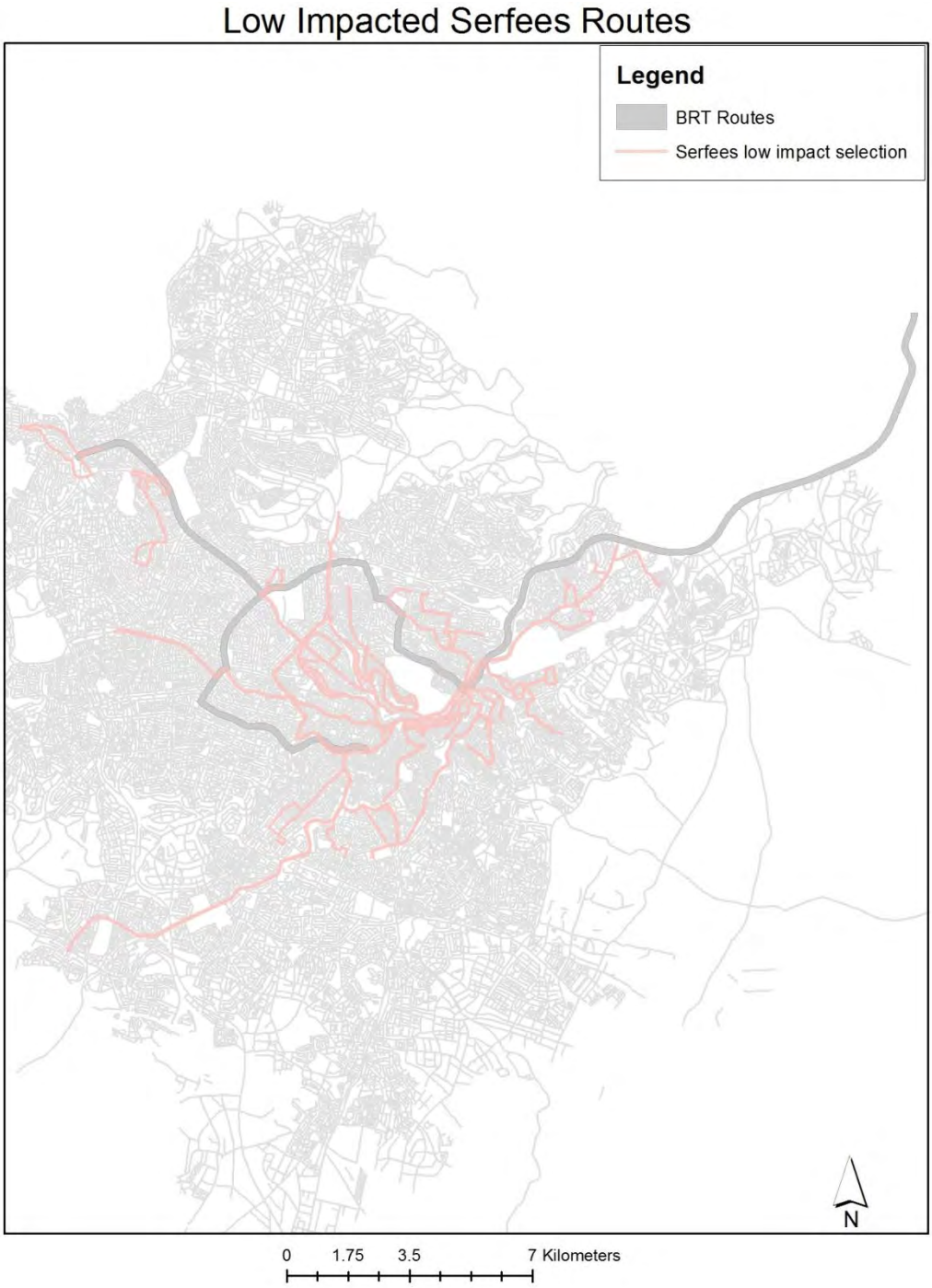
Low Impacted Coaster Routes Overlaying Proposed BRT Routes



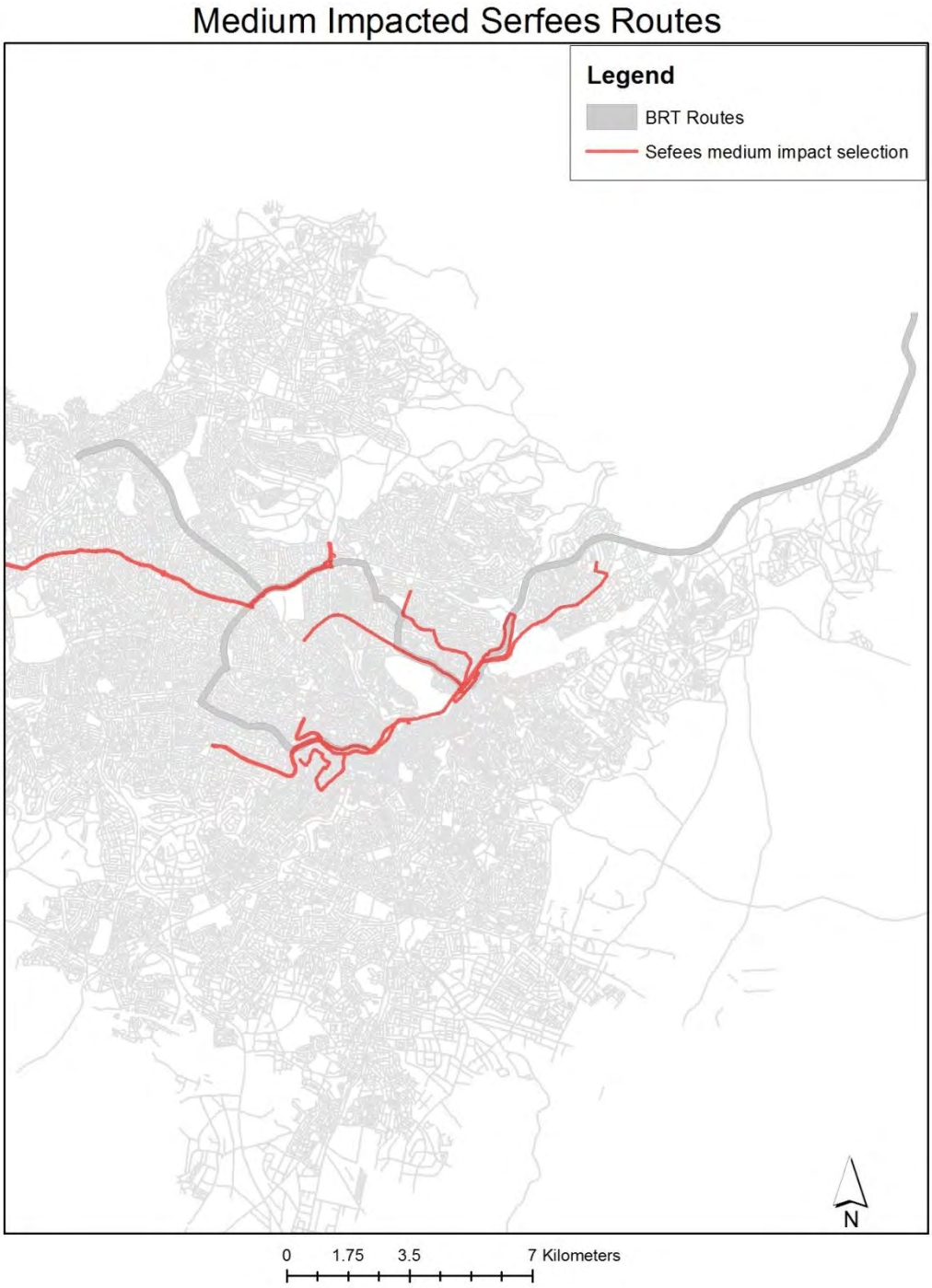
Medium Impacted Coaster Routes Overlaying Proposed BRT Routes



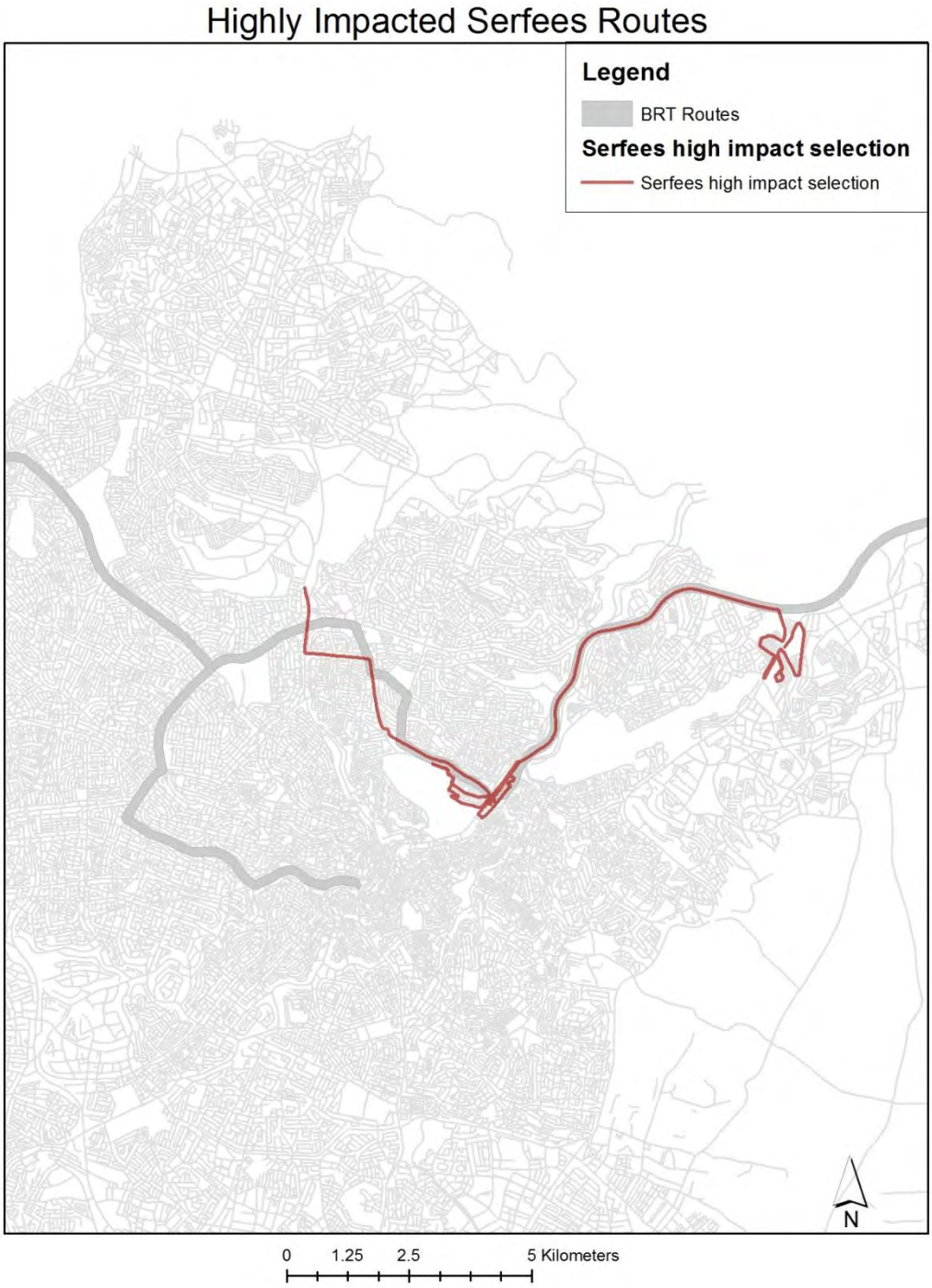
Highly Impacted Coaster Routes Overlaying Proposed BRT Routes



Low Impacted Serfees Routes Overlaying Proposed BRT Routes



Medium Impacted Serfees Routes Overlaying Proposed BRT Routes



High Impacted Serfees Routes Overlaying Proposed BRT Routes

APPENDIX B: AIR AND NOISE MONITORING REPORT

بن حيان BEN HAYYAN Aqaba International Laboratories	**BEN HAYYAN – Aqaba International Laboratories**	سلطة منطقة العقبة الاقتصادية الخاصة

Report Number: 3/95/17 **Date: 26 October 2017**

CUSTOMER INFORMATION	
Customer Name	: Messrs. engicon
Customer Address	: Amman, Jordan

SAMPLE INFORMATION	
Name / Type	: Ambient Air Quality Monitoring
Sample(s) Received on	: --------
Customer Reference Number	: --------
Number of Samples Received	: 3 Sites - Continuous Ambient Air Quality Monitoring: October 15 - 18, 2017
Analyses Order Number	: 317102600095

FINANCIAL INFORMATION	
Fees of This Service	: Five Thousands Three Hundred and Three (5303 JD)
Payment Method	: Upon invoicing
Invoice / Receipt Voucher Number	: --------

Eng. Mwaffaq Al-Khushman

Laboratories Manager

31.10.2017

- *Test results represent the sample that is sent to **BEN HAYYAN – Aqaba International Laboratories** by the customer. It may not represent the whole product.*
- *This report shall only be reproduced in full with the permission of **BEN HAYYAN – Aqaba International Laboratories Management**.*
- *This Test Report is considered invalid if not duly signed.*
- *The test results, extended uncertainties (if applicable) and test methods are given on the following pages which comprise a part of this report.*

سلطة منطقة العقبة الاقتصادية الخاصة AQABA SPECIAL ECONOMIC ZONE AUTHORITY
مدير مختبرات العقبة الدولية بن حيان

TEST REPORT No. (3/95/17)

Customer: Messrs. engicon
Address: Amman, Jordan
Attention: Dr. Eyad Batarseh

Sample Information:

Customer Information			BEN HAYYAN Information	
Customer Ref.	---------		Analyses Order No.	317102600095
Collection Form No.	---------		Sample(s) ID	----------
No. of Samples	(3 Sites - Continuous Ambient Air Quality Monitoring)		Invoice No.	----------
Samples Received on	----------		Date Of Test	15-18 Oct. 2017
Condition of received sample(s)	----------		----------	----------

Test Results:

Please see the attached Report.

Report prepared

Mr. Rami Sha'ath
EIA Officer

Eng. Mahmoud Alburdaini
Air Quality Monitoring Engineer

Approval of Test Results:

Eng. Hasan Almarayeh
Air Quality Division Head

بن حيان
BEN HAYYAN
قسم
قياسات نوعية الهواء
مختبرات العقبة الدولية
Aqaba International Laboratories

Note: This test report consists of (39) pages including the cover page. It shall only be reproduced in full. The results are only representing the samples measured in the field during the above shown period.

"Air Quality Monitoring"

Submitted to

engicon

Prepared By
Mr. Rami Sha'ath

Field Work Team
Mr. Rami Sha'ath
Eng. Mahmoud Alburdaini

BEN HAYYAN - Aqaba International Laboratories

October 2017

1. Introduction

BEN HAYYAN - Aqaba International Laboratories were approached by engicon to conduct an ambient air quality monitoring at Amman & Alzarqaa (Three Monitoring sites).

The air quality monitoring consists of monitoring criteria pollutants, will be utilized to conduct the following measurement:

- Particulate matter with diameter below 10 microns (PM_{10})
- Nitrogen oxides (NO, NO_2, NOx)
- Sulfur dioxide (SO_2)
- Ozone (O_3)
- Carbon Monoxide (CO)
- Meteorology

2. Methodology

Monitoring was conducted continuously 24 hours at each site utilizing state-of-the art equipment, whose principles of operation are shown in table (1) below.

▸Table (1): Monitored parameters and their measurement principles

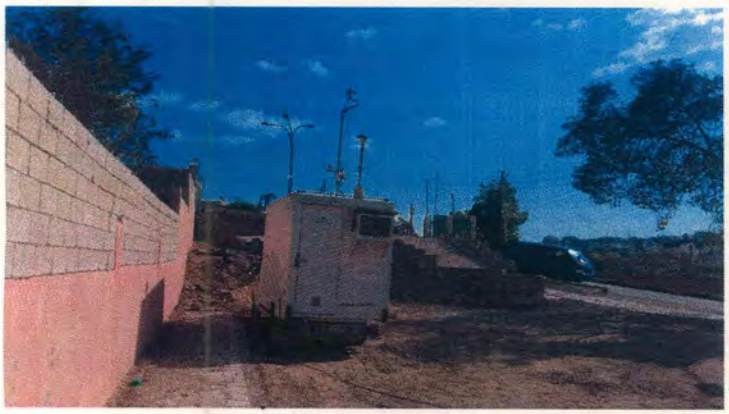
Monitored parameter	Principle of measurement
Inhalable particulates (PM_{10})	Beta Attenuation Method (BAM)
Nitrogen oxides (NO, NOx, NO_2)	Chemiluminescence
Sulfur dioxide (SO_2)	UV-Fluorescence
Carbon monoxide (CO)	Infrared absorption
Ozone (O_3)	UV-Photometry
Wind direction	Wind vane with potentiometer sensor
Wind speed	Cup wheel anemometer with optoelectronic sensor
Temperature	Thermo resistance
Humidity	Capacitive
Atmospheric pressure	Piezoelectric

3. Site coordinates

▶Table (2): Air quality monitoring sites and their coordinates:

Monitoring Site	ID	Monitoring Period	Coordinates	
			North	East
أمانة عمان الكبرى	GAM	15-16 October 2017	31.94583	35.92592
مجمع سفريات الشمال طبربور	TAB	16-17 October 2017	31.99592	35.9189
مركز صحي وادي الحجر	HAJ	17-18 October 2017	32.05461	36.0865

The following photos show the mobile laboratory during actual monitoring at the monitoring sites:



4. Result

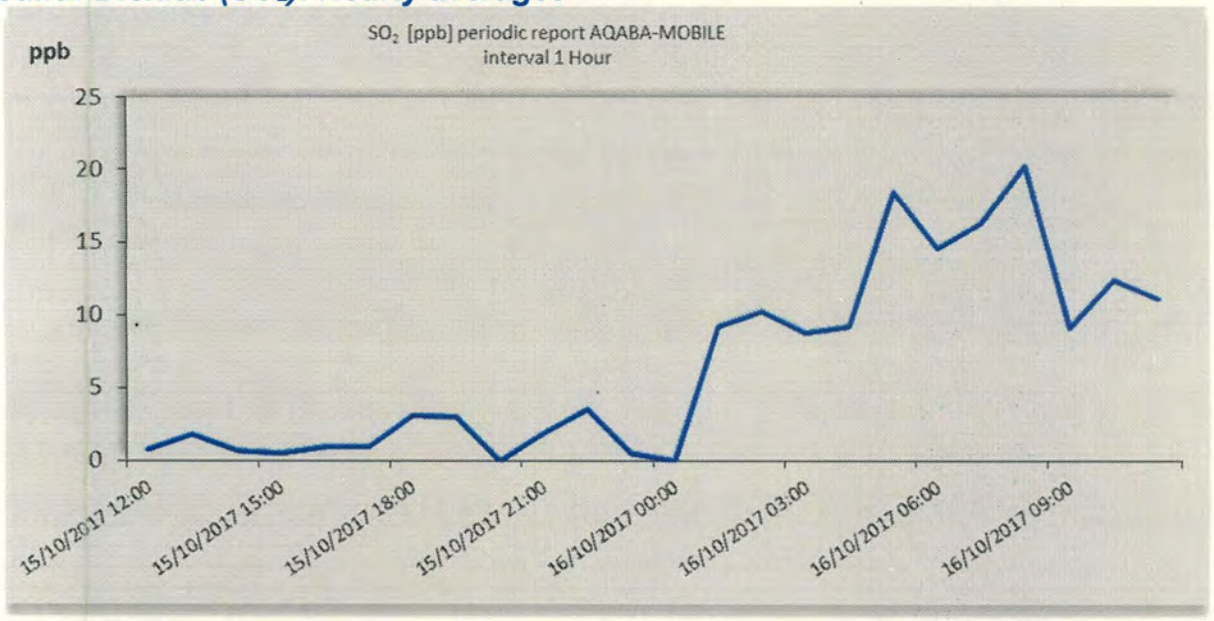
4.1 GAM

Results of air quality at GAM indicated by parameters specified in health, national and international standards during of *(15 October 11:00 – 16 October 2017 10:30)* showed that *air quality at GAM is compliant with Jordanian air quality standards (JS 1140/2006) and falls within limits specified in these standards.*

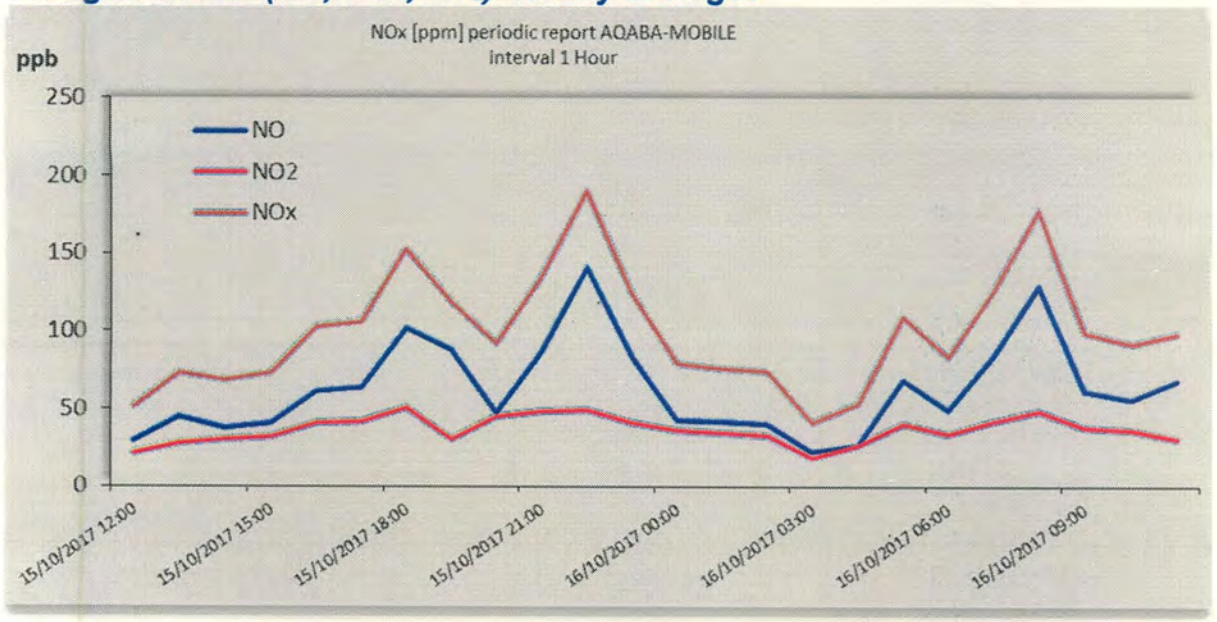
Pollutant	Max. 15min Average	Max. Hourly Average	Max. 8H Average	Daily Average	JS Allowable Max.	
					Hourly	Daily
Sulfur Dioxide (SO_2) ppb	28.9	20.2	---	6.2	300	140
Nitric Oxide (NO) ppb	191.8	141.1	---	63.9	---	---
Nitrogen Dioxide (NO_2) ppb	56.9	51.2	---	37.0	210	80
Nitrogen Oxides (NOx) ppb	226.3	190.6	---	100.9	---	---
Carbon monoxide (CO) ppm	7.38	7.23	2.46	---	26	9 *
Ozone (O_3) ppb	54.5	51.5	16.4	---	120	80 *
Particulate matter (PM_{10}) $\mu g/m^3$	107	98	---	68	---	120

*** This value is a maximum allowable limit for eight-hour average.**

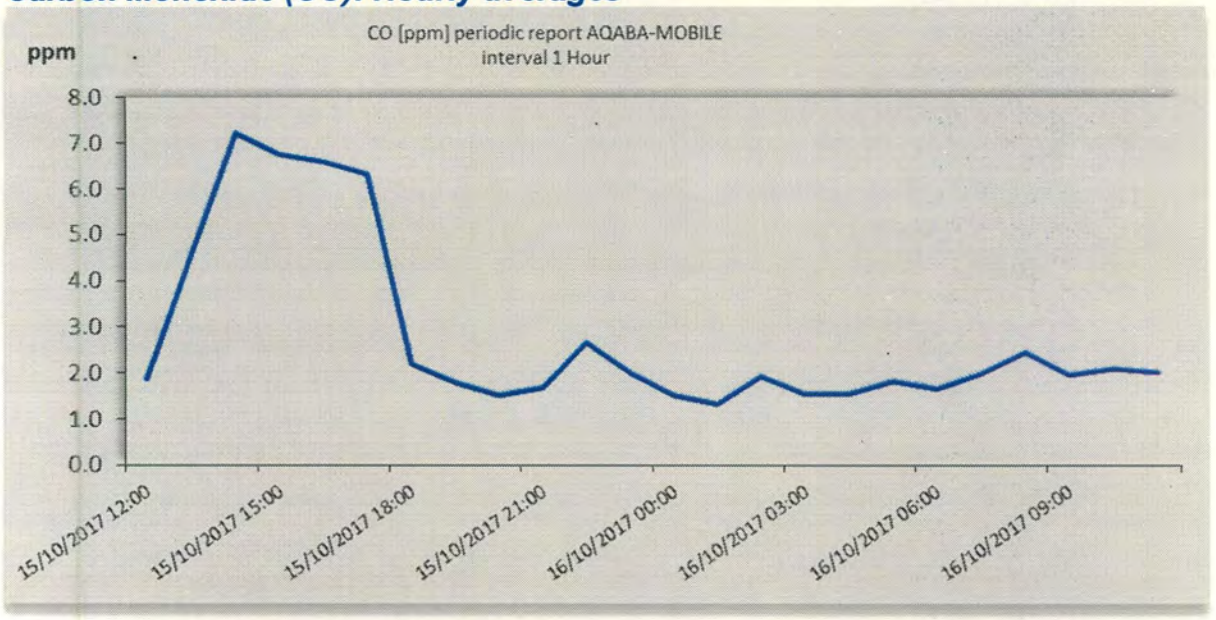
Sulfur Dioxide (SO_2): Hourly averages



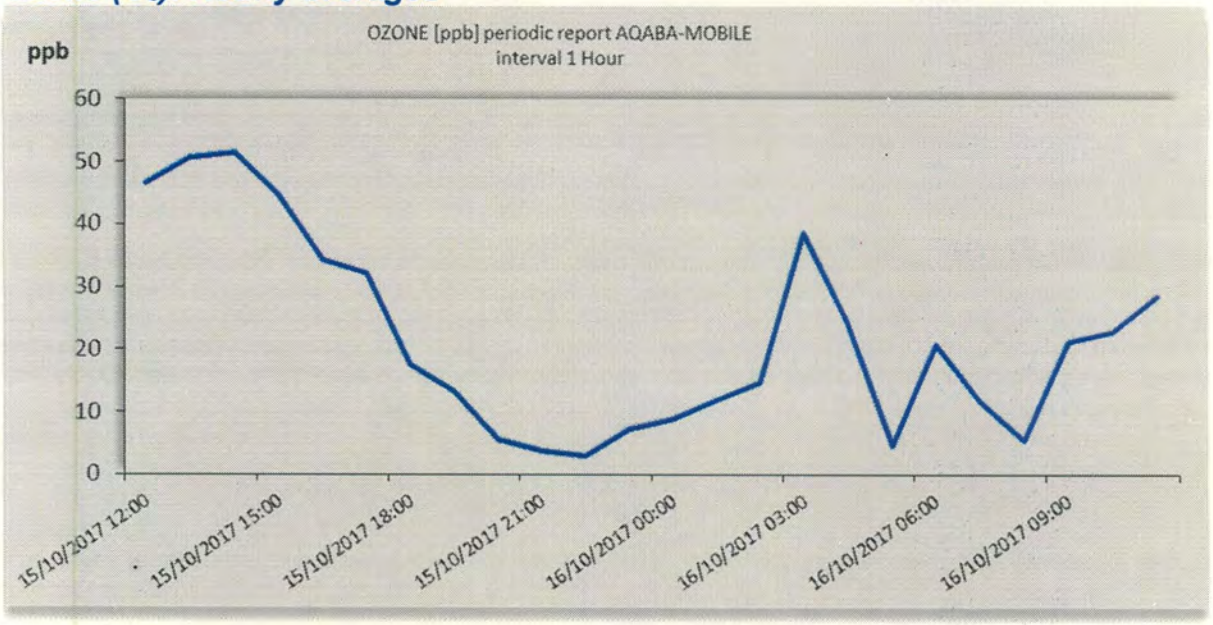
Nitrogen Oxides (NO, NOx, NO_2): Hourly averages



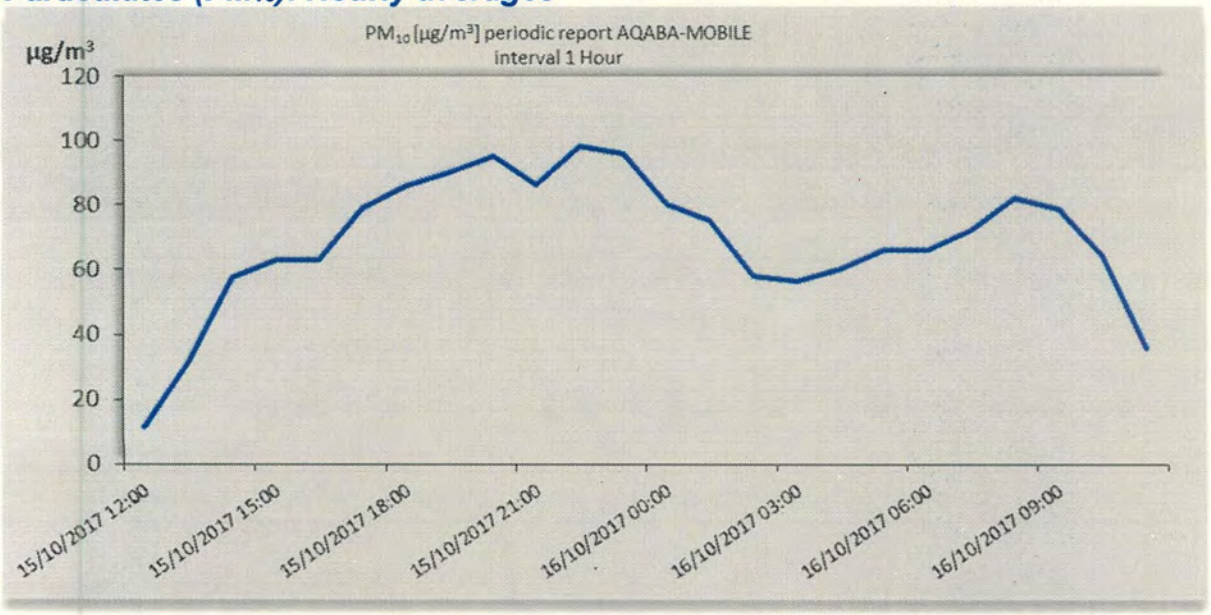
Carbon Monoxide (CO): Hourly averages



Ozone (O_3): Hourly averages



Particulates (PM_{10}): Hourly averages



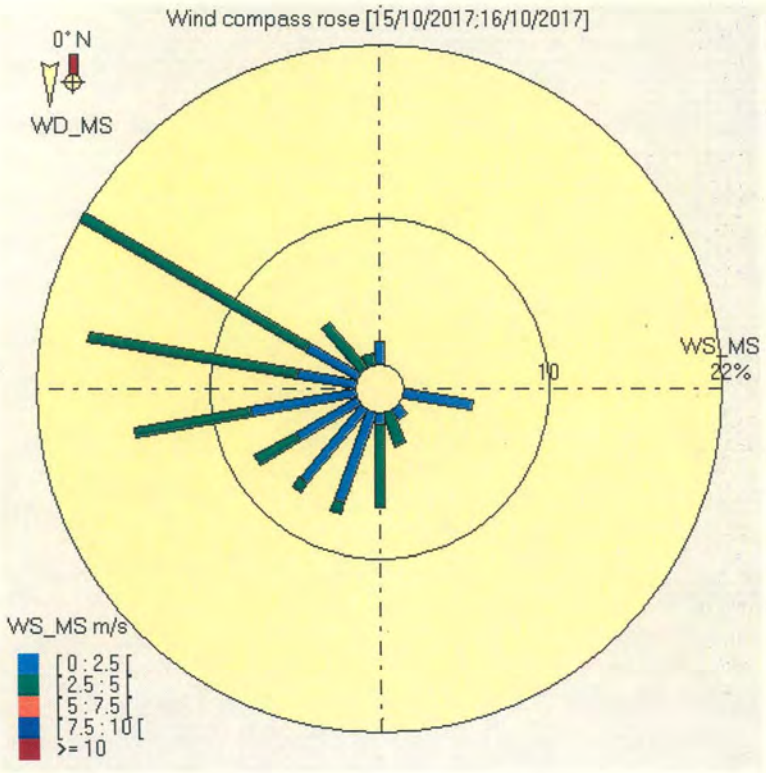
4.1.1 Meteorology

Regarding meteorology in GAM, the following observed:
Wind direction and Wind Speed measurements showed that:

Direction\speed	< 0	[0 : 2.5]	[2.5 : 5]	[5 : 7.5]	[7.5 : 10]	>= 10	Accumulation
[350 : 10]		1.6					1.6
[10 : 30]							
[30 : 50]							
[50 : 70]							
[70 : 90]							
[90 : 110]		4.9					4.9
[110 : 130]							
[130 : 150]		0.8					0.8
[150 : 170]			2.4				2.4
[170 : 190]		0.8	5.7				6.5
[190 : 210]		6.5	0.8				7.3
[210 : 230]		6.5	0.8				7.3
[230 : 250]		4.9	3.3				8.1
[250 : 270]		7.3	8.1				15.4
[270 : 290]		4.1	14.6				18.7
[290 : 310]		4.1	17.9				22
[310 : 330]			4.1				4.1
[330 : 350]			0.8				0.8
Accumulation		41.5	58.5				100%

Hourly Max, Min. and Averages Meteorology parameters were as follows:

Statistic	Wind Speed m/s	Temperature °C	RH %	Barometer mbar
MIN	0.3	16.3	60	945.8
AVG	**2.3**	**19.2**	**68**	**946.5**
MAX	3.4	22.4	74	947.8



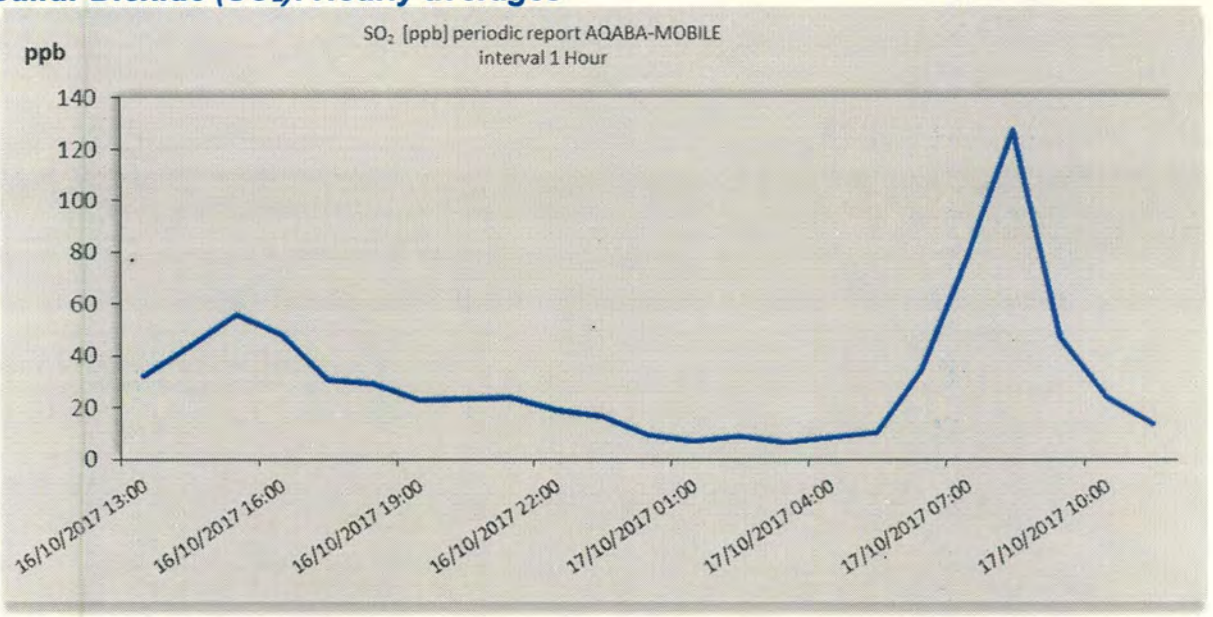
4.2 TAB

Results of air quality at TAB indicated by parameters specified in health, national and international standards during of *(16 October 11:45 – 17 October 2017 11:30)* showed that *air quality at TAB is compliant with Jordanian air quality standards (JS 1140/2006) and falls within limits specified in these standards.*

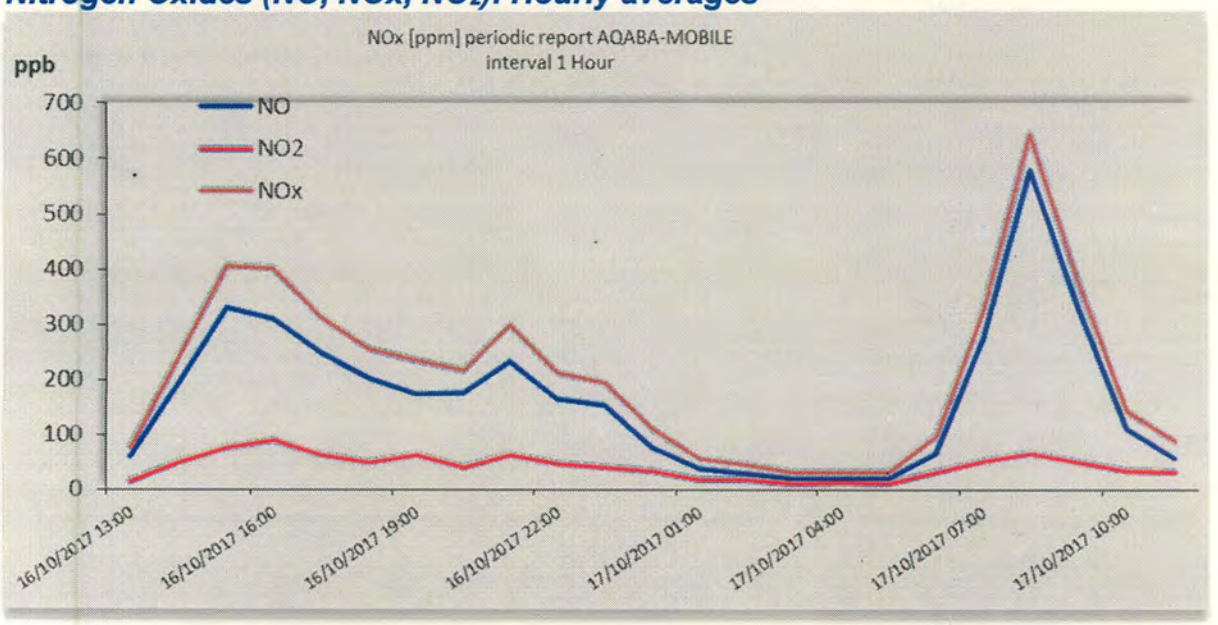
Pollutant	Max. 15min Average	Max. Hourly Average	Max. 8H Average	Daily Average	JS Allowable Max.	
					Hourly	Daily
Sulfur Dioxide (SO_2) ppb	164.2	127.3	---	31.1	300	140
Nitric Oxide (NO) ppb	639.9	577.5	---	163.6	---	---
Nitrogen Dioxide (NO_2) ppb	119.8	89.5	---	40.9	210	80
Nitrogen Oxides (NOx) ppb	700.0	643.6	---	204.6	---	---
Carbon monoxide (CO) ppm	6.41	5.83	2.53	---	26	9 *
Ozone (O_3) ppb	56.9	53.7	36.8	---	120	80 *
Particulate matter (PM_{10}) $\mu g/m^3$	209	209	---	80	---	120

*** This value is a maximum allowable limit for eight-hour average.**

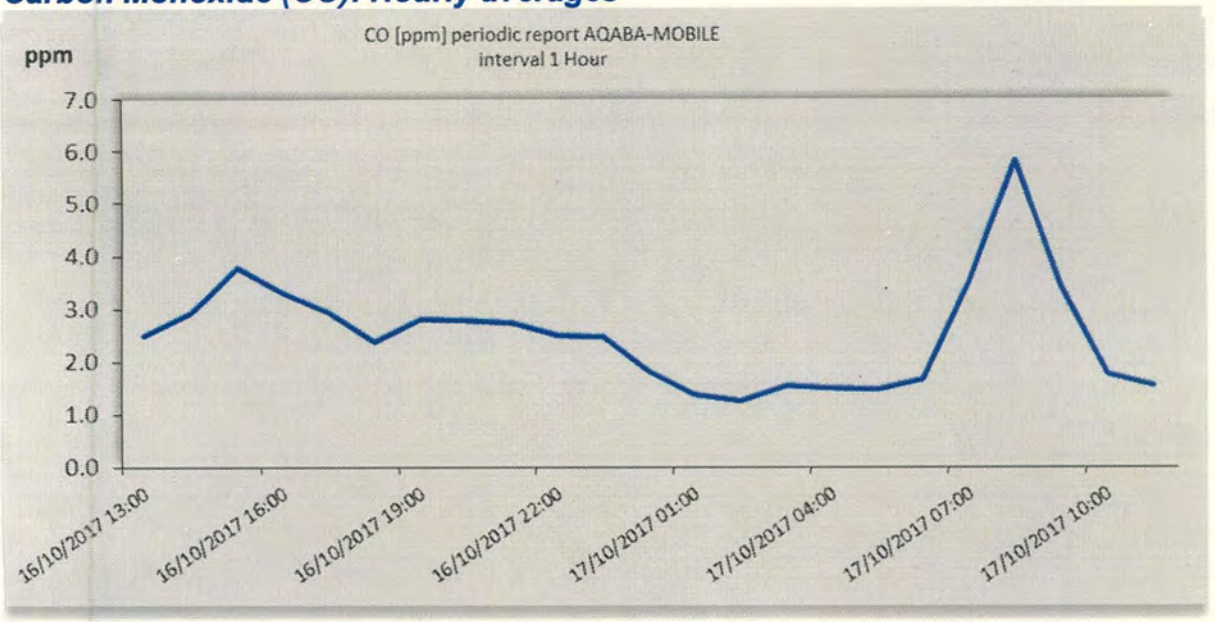
Sulfur Dioxide (SO_2): Hourly averages



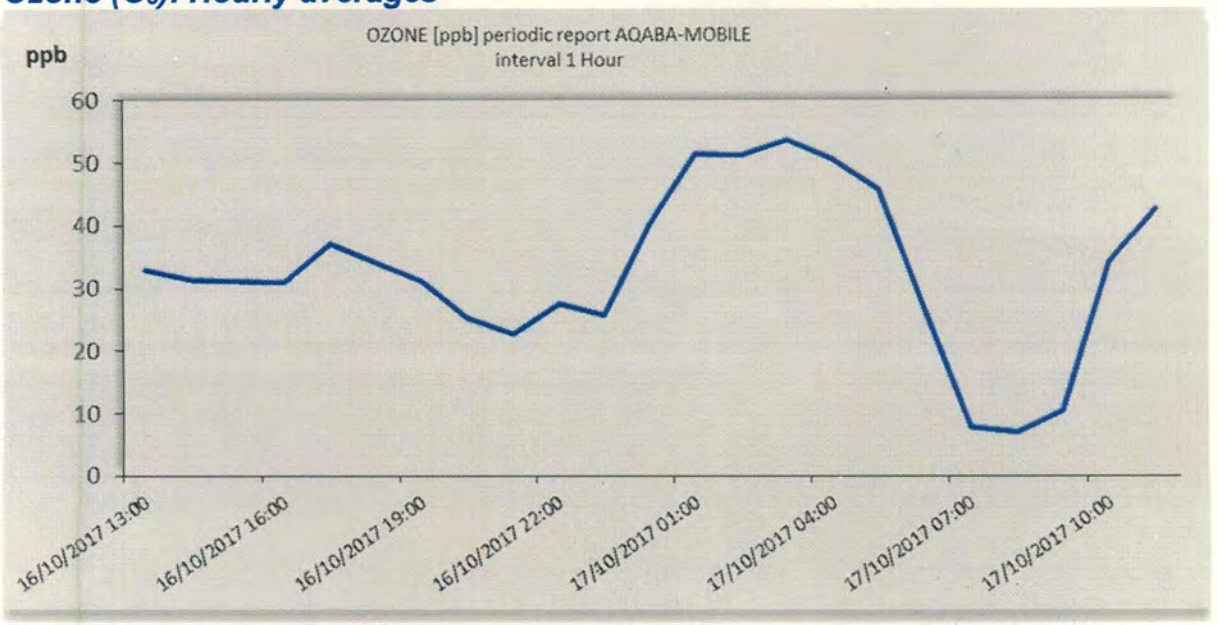
Nitrogen Oxides (NO, NOx, NO_2): Hourly averages



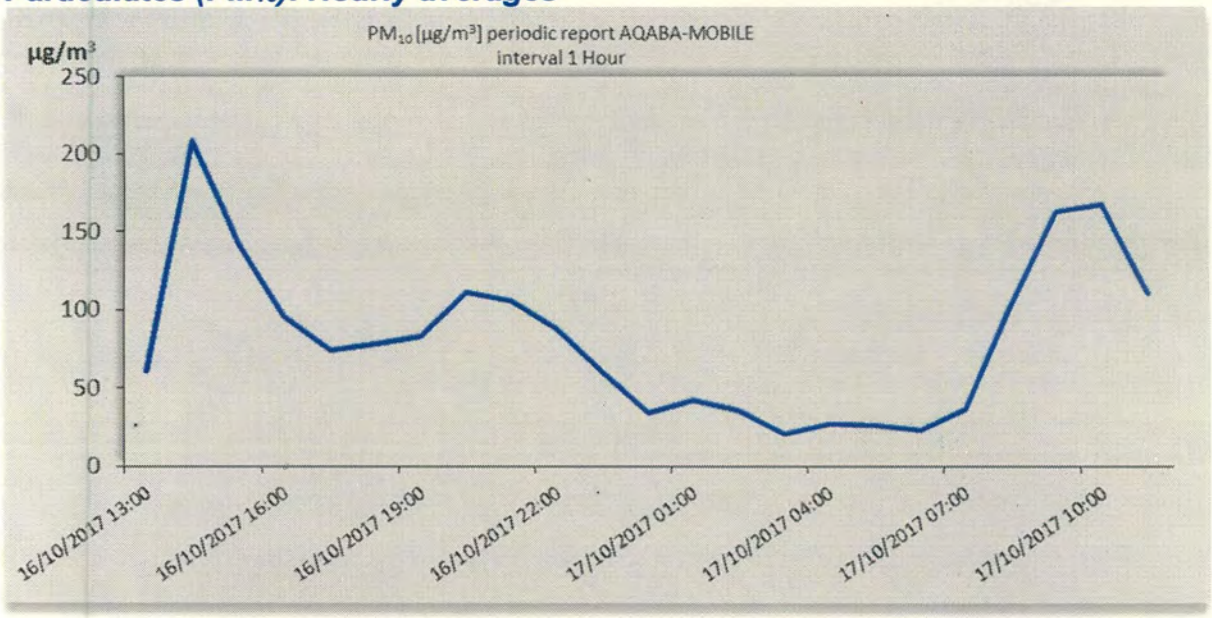
Carbon Monoxide (CO): Hourly averages



Ozone (O_3): Hourly averages



Particulates (PM_{10}): Hourly averages



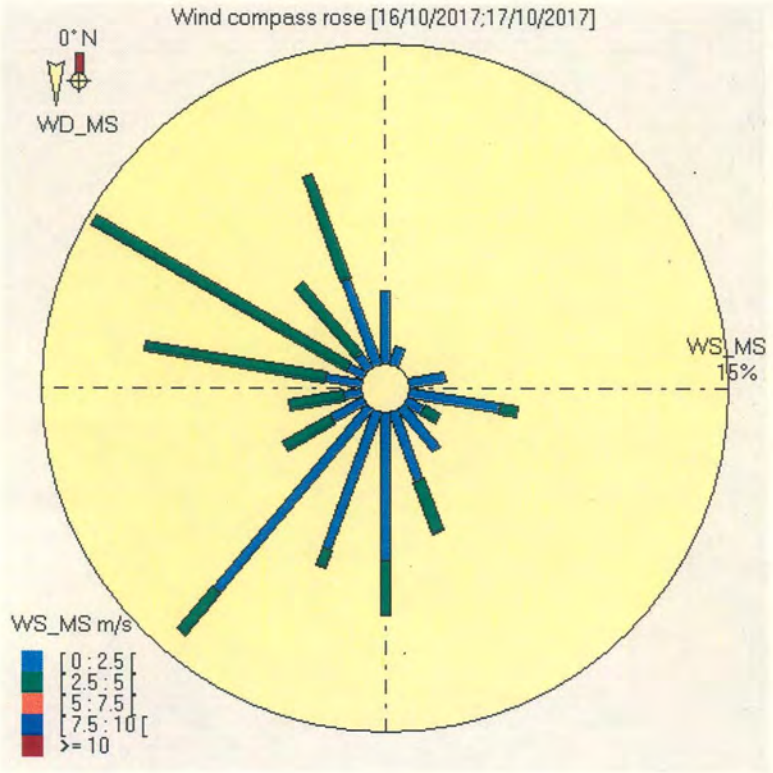
4.2.1 Meteorology

Regarding meteorology in TAB, the following observed:
Wind direction and Wind Speed measurements showed that:

Direction\speed	< 0	[0 : 2.5]	[2.5 : 5]	[5 : 7.5]	[7.5 : 10]	>= 10	Accumulation
[350 : 10]		3.4					3.4
[10 : 30]		0.9					0.9
[30 : 50]							
[50 : 70]							
[70 : 90]		1.7					1.7
[90 : 110]		4.3	0.9				5.2
[110 : 130]		0.9	0.9				1.7
[130 : 150]		2.6					2.6
[150 : 170]		3.4	2.6				6
[170 : 190]		6.9	2.6				9.5
[190 : 210]		6.9	0.9				7.8
[210 : 230]		11.2	2.6				13.8
[230 : 250]		1.7	2.6				4.3
[250 : 270]		0.9	2.6				3.4
[270 : 290]		1.7	8.6				10.3
[290 : 310]		0.9	13.8				14.7
[310 : 330]		0.9	4.3				5.2
[330 : 350]		4.3	5.2				9.5
Accumulation		52.6	47.4				100%

Hourly Max, Min. and Averages Meteorology parameters were as follows:

Statistic	Wind Speed m/s	Temperature °C	RH %	Barometer mbar
MIN	2.5	16.4	62	932.0
AVG	**3.1**	**18.4**	**73**	**932.6**
MAX	3.6	21.1	77	933.7



4.3 HAJ

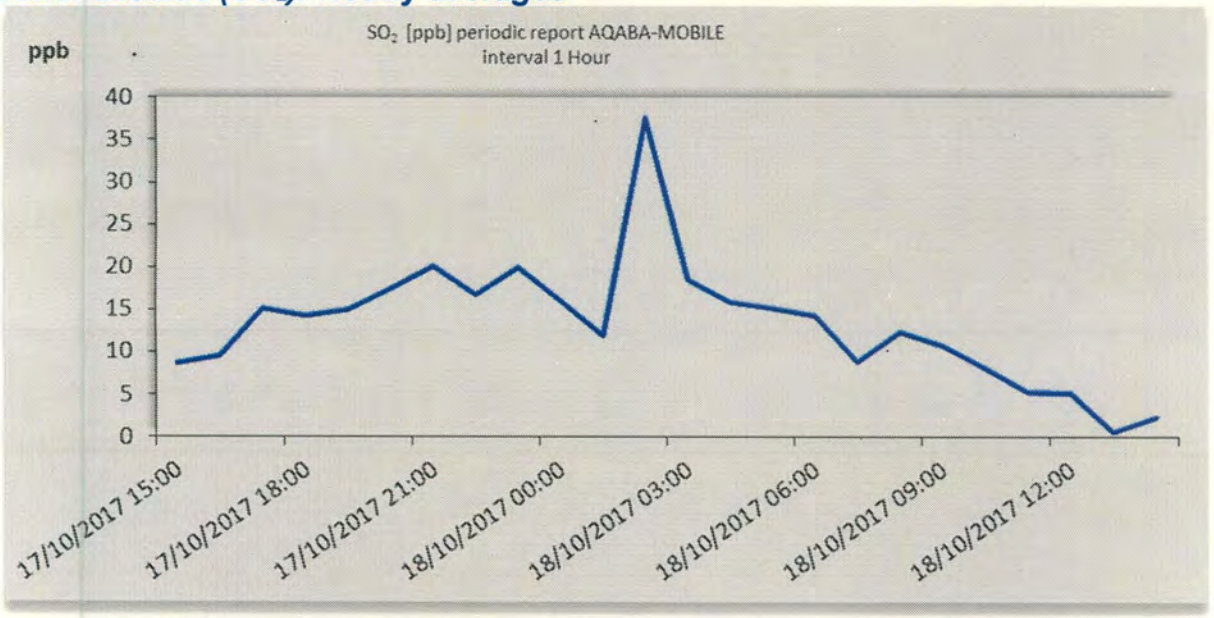
Results of air quality at HAJ indicated by parameters specified in health, national and international standards during of *(17 October 14:00 – 18 October 2017 14:00)* showed that *air quality at HAJ is compliant with Jordanian air quality standards (JS 1140/2006) and falls within limits specified in these standards except:*

- PM10 daily averages exceeded the daily maximum allowable limit of 120 µg/m^3.

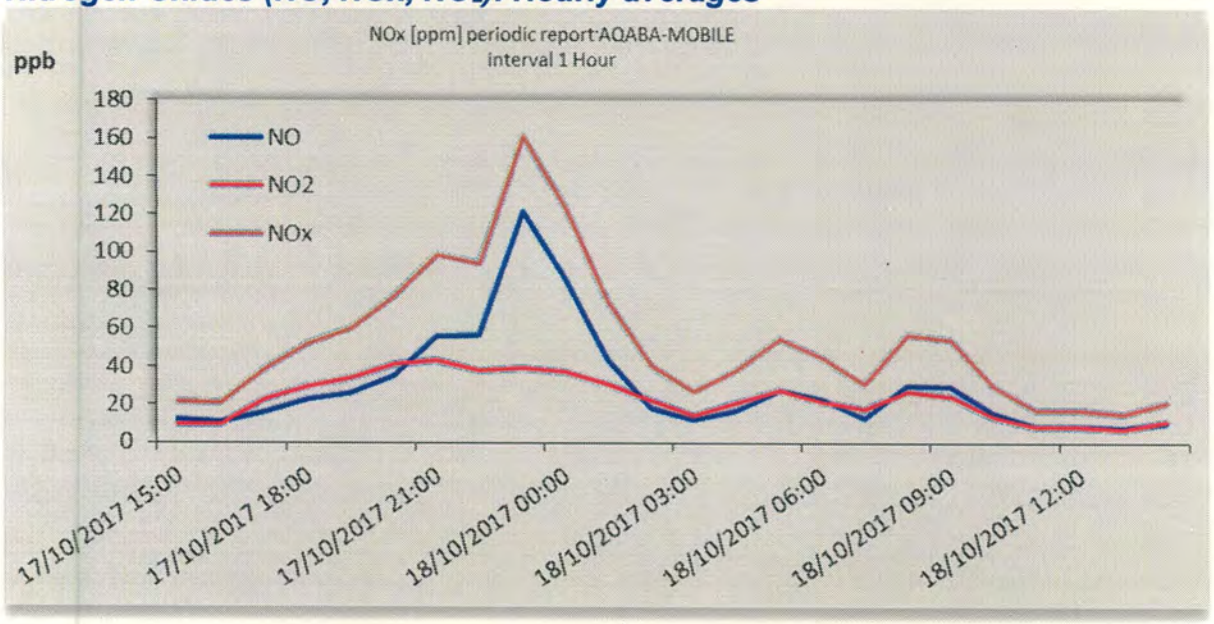
Pollutant	Max. 15min Average	Max. Hourly Average	Max. 8H Average	Daily Average	JS Allowable Max.	
					Hourly	Daily
Sulfur Dioxide (SO_2) ppb	61.4	37.6	---	13.4	300	140
Nitric Oxide (NO) ppb	127.4	121.4	---	29.3	---	---
Nitrogen Dioxide (NO_2) ppb	44.8	43.1	---	23.2	210	80
Nitrogen Oxides (NOx) ppb	168.0	160.9	---	52.5	---	---
Carbon monoxide (CO) ppm	2.53	2.47	1.87	---	26	9 *
Ozone (O_3) ppb	60.9	58.5	17.0	---	120	80 *
Particulate matter (PM_{10}) µg/m^3	301	283	---	145	---	120

*** This value is a maximum allowable limit for eight-hour average.**

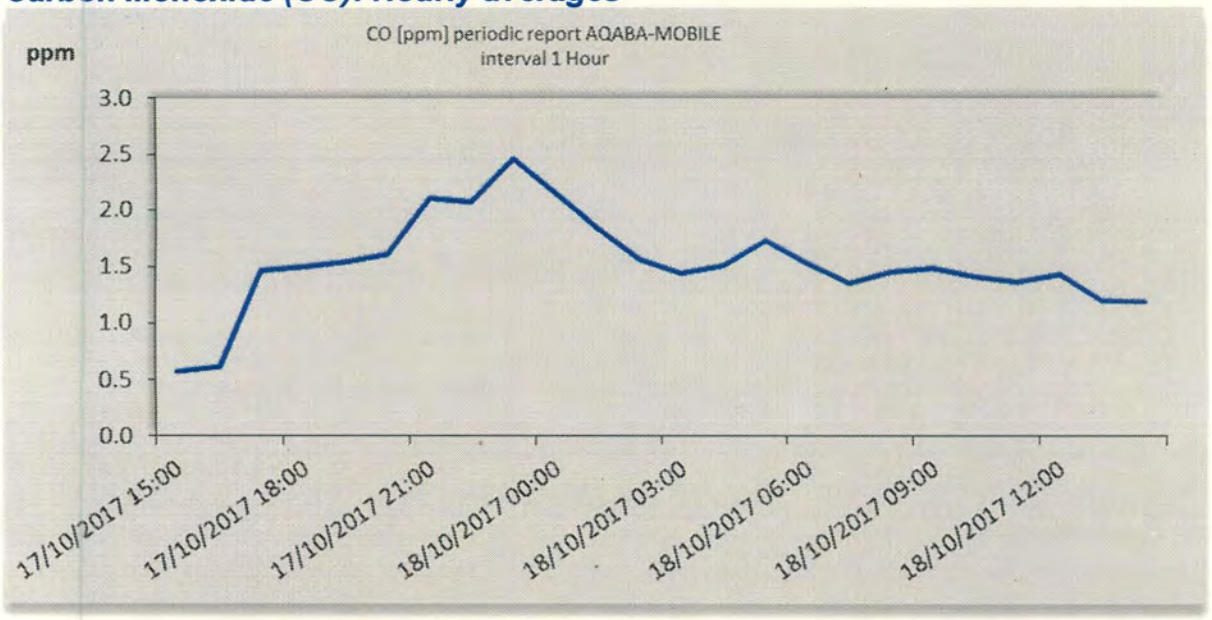
Sulfur Dioxide (SO_2): Hourly averages



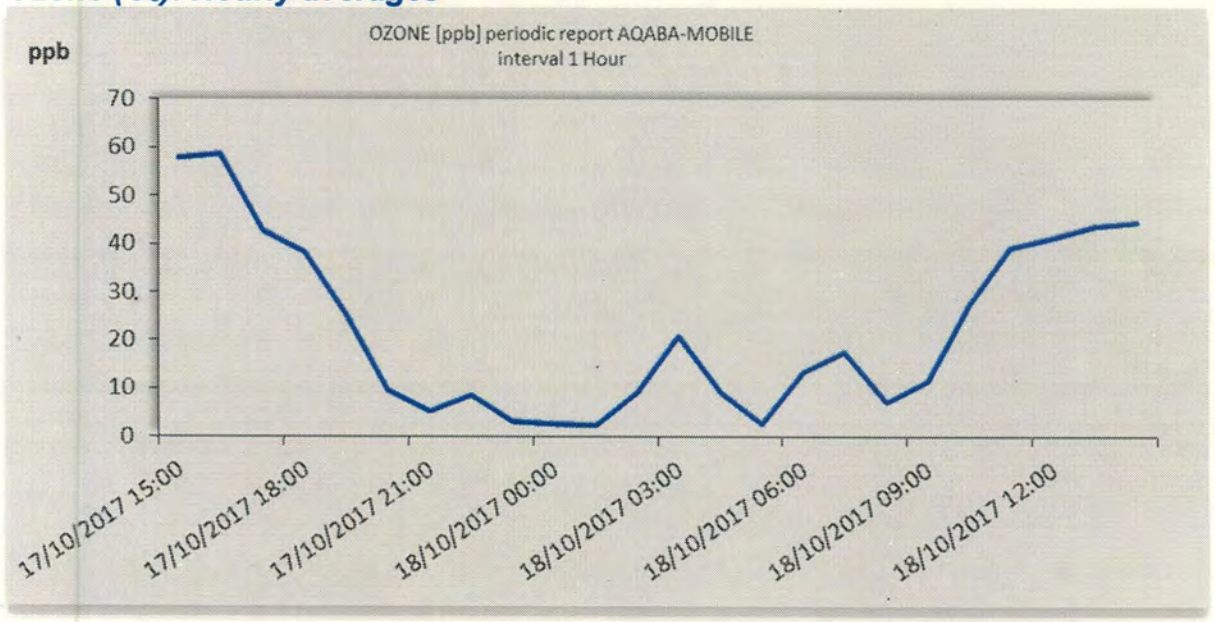
Nitrogen Oxides (NO, NOx, NO_2): Hourly averages



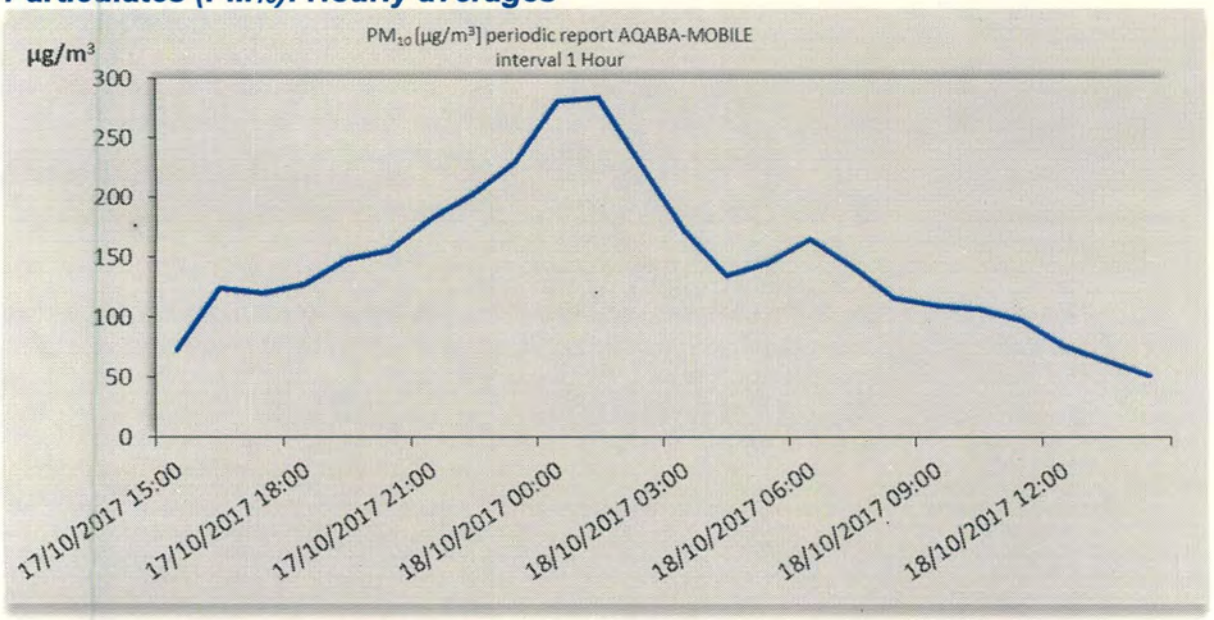
Carbon Monoxide (CO): Hourly averages



Ozone (O_3): Hourly averages



Particulates (PM_{10}): Hourly averages



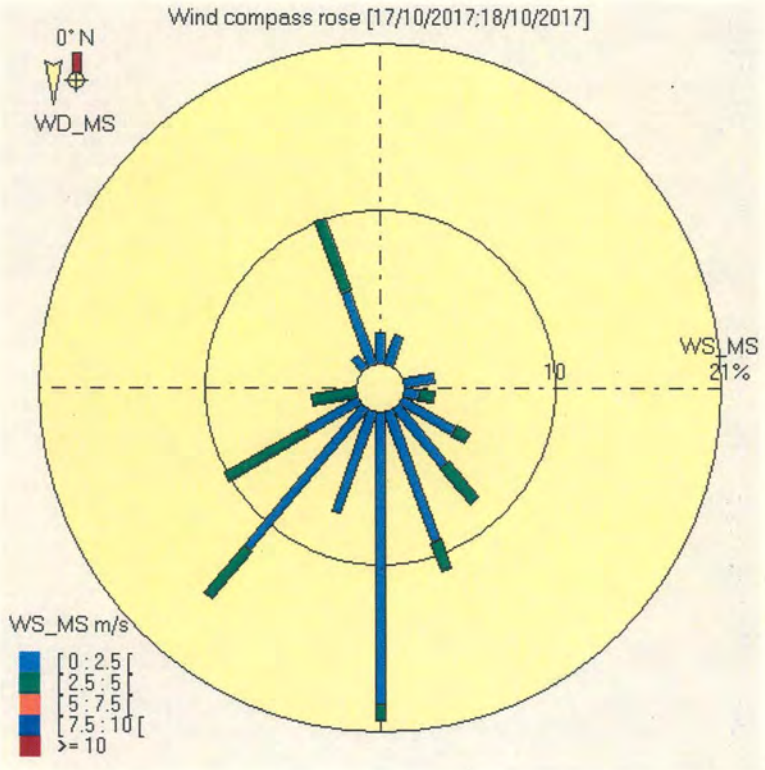
4.3.1 Meteorology

Regarding meteorology in HAJ, the following observed:
Wind direction and Wind Speed measurements showed that:

Direction\speed	< 0	[0 : 2.5]	[2.5 : 5]	[5 : 7.5]	[7.5 : 10]	>= 10	Accumulation
[350 : 10]		2					2
[10 : 30]		2					2
[30 : 50]							
[50 : 70]							
[70 : 90]		2					2
[90 : 110]		1	1				2
[110 : 130]		4	1				5.1
[130 : 150]		5.1	3				8.1
[150 : 170]		9.1	2				11.1
[170 : 190]		19.2	1				20.2
[190 : 210]		7.1					7.1
[210 : 230]		12.1	4				16.2
[230 : 250]		4	6.1				10.1
[250 : 270]			3				3
[270 : 290]							
[290 : 310]							
[310 : 330]		1					1
[330 : 350]		5.1	5.1				10.1
Accumulation		73.7	26.3				100%

Hourly Max, Min. and Averages Meteorology parameters were as follows:

Statistic	Wind Speed m/s	Temperature °C	RH %	Barometer mbar
MIN	1.3	16.9	61	961.5
AVG	**2.1**	**21.0**	**63**	**963.0**
MAX	2.8	25.9	67	964.3



Results of all measured parameters are shown in annex

15 minutes average values of monitored parameters at GAM during (15 - 16 October 2017)

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTION	PRESSURE
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
15/10/2017 11:00	0.0				0.00	43.6	0	19.3	60	2.6	179	947.8
15/10/2017 11:15	0.0				1.50	44.1	0	19.5	62	2.8	180	947.5
15/10/2017 11:30	0.8	22.3	20.2	42.5	1.60	46.2	0	19.7	63	2.7	181	947.4
15/10/2017 11:45	1.1	23.5	21.5	45.0	1.90	47.1	21	21.0	64	3.2	182	947.0
15/10/2017 12:00	1.2	43.7	24.5	68.1	2.49	48.7	24	21.3	64	2.9	189	947.0
15/10/2017 12:15	3.0	51.8	31.4	83.2	4.30	49.1	24	21.3	63	2.6	177	946.9
15/10/2017 12:30	0.1	35.8	23.4	59.2	5.00	52.7	24	21.4	64	2.5	199	946.7
15/10/2017 12:45	3.6	52.5	26.6	79.1	4.51	53.0	39	21.8	64	2.0	228	946.6
15/10/2017 13:00	0.6	40.5	32.7	73.2	4.30	47.7	39	22.0	65	1.7	247	946.5
15/10/2017 13:15	2.5	46.3	33.5	79.8		45.8	39	22.2	64	2.0	239	946.4
15/10/2017 13:30	0.1	33.6	28.5	62.1	7.38	54.5	57	22.2	64	2.1	180	946.3
15/10/2017 13:45	0.1	39.3	26.8	66.1	7.27	53.4	67	22.1	65	0.3	228	946.3
15/10/2017 14:00	0.0	32.8	32.6	65.4	7.05	52.4	67	22.3	64	2.4	225	946.2
15/10/2017 14:15	0.0	31.6	26.2	57.8	6.85	52.6	67	22.3	64	2.7	232	946.2
15/10/2017 14:30	1.5	44.0	37.0	80.9	6.88	42.5	63	22.0	65	3.4	290	946.2
15/10/2017 14:45	0.0	39.0	29.1	68.1	6.71	44.7	61	22.4	65	2.4	260	946.1
15/10/2017 15:00	0.3	50.7	37.3	88.0	6.61	38.9	61	22.3	65	2.0	267	946.1
15/10/2017 15:15	1.4	63.7	42.0	105.7	6.69	35.4	61	22.2	65	2.8	286	946.0
15/10/2017 15:30	0.0	51.4	36.7	88.1	6.56	37.6	63	22.2	65	2.6	282	945.9
15/10/2017 15:45	1.4	59.1	40.1	99.2	6.61	32.9	64	22.1	65	2.9	293	945.8
15/10/2017 16:00	1.0	73.0	45.2	118.2	6.58	31.5	64	22.1	65	3.1	290	945.8
15/10/2017 16:15	0.2	59.1	43.8	102.9	6.42	34.6	64	21.9	64	2.7	282	945.9
15/10/2017 16:30	1.5	55.7	43.0	98.7	6.33	36.2	78	21.7	65	2.6	279	945.9
15/10/2017 16:45	1.5	70.7	38.1	108.8	6.41	28.1	87	21.8	65	2.1	291	945.9
15/10/2017 17:00	0.5	71.2	42.2	113.4	6.17	29.3	87	21.5	65	3.0	292	945.9
15/10/2017 17:15	0.7	68.1	44.8	112.8		27.2	87	21.4	64	3.1	295	945.9
15/10/2017 17:30	0.1	92.3	51.5	143.8	2.11	17.0	86	21.3	64	2.7	302	945.9
15/10/2017 17:45	6.2	119.4	51.7	171.2	2.22	14.1	85	21.2	64	2.1	294	945.9
15/10/2017 18:00	5.2	128.0	56.9	184.8	2.23	11.5	85	21.1	64	2.5	303	945.9

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTION	PRESSURE
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
15/10/2017 18:15	4.5	85.0	24.0	109.0	1.94	13.4	85	20.9	64	2.9	295	945.9
15/10/2017 18:30	7.3	191.8	19.2	211.0	2.23	10.5	90	20.7	64	3.1	284	945.9
15/10/2017 18:45	0.0	32.0	36.5	68.4	1.37	18.6	93	20.1	64	3.3	257	946.0
15/10/2017 19:00	0.0	44.1	43.2	87.3	1.55	10.4	93	20.0	64	3.1	270	946.0
15/10/2017 19:15	0.0	47.1	45.6	92.7	1.61	8.9	93	19.8	63	3.1	271	946.1
15/10/2017 19:30	0.0	50.1	43.0	93.1	1.51	6.0	95	19.6	63	3.0	250	946.2
15/10/2017 19:45	0.0	42.2	45.5	87.7	1.48	4.0	96	19.4	63	3.2	239	946.3
15/10/2017 20:00	0.0	50.8	45.6	96.4	1.47	3.3	96	19.3	63	3.1	245	946.4
15/10/2017 20:15	0.0	56.4	47.2	103.6	1.53	3.4	96	19.3	63	2.8	261	946.4
15/10/2017 20:30	0.9	81.1	45.7	126.8	1.63	3.9	87	19.2	63	1.7	266	946.3
15/10/2017 20:45	2.6	92.0	50.0	142.0	1.62	4.2	81	19.1	63	2.2	256	946.3
15/10/2017 21:00	4.0	115.7	51.1	166.8	1.90	3.4	81	19.1	62	1.0	286	946.4
15/10/2017 21:15	2.5	121.7	53.3	175.0		3.1	81	19.0	63	1.8	264	946.5
15/10/2017 21:30	3.1	130.8	46.1	177.0	2.53	2.7	97	18.8	62	1.9	257	946.6
15/10/2017 21:45	3.0	148.2	48.4	196.6	2.74	2.9	107	18.6	62	2.8	177	946.6
15/10/2017 22:00	5.5	163.7	50.2	213.9	2.73	2.9	107	18.7	62	1.4	289	946.7
15/10/2017 22:15	1.8	142.7	45.9	188.5	2.57	2.7	107	18.6	61	1.5	252	946.8
15/10/2017 22:30	0.0	98.0	45.9	144.0	2.15	2.6	97	18.4	74	1.9	202	946.8
15/10/2017 22:45	0.0	48.9	35.1	84.0	1.64	13.6	90	18.3	74	2.8	251	946.8
15/10/2017 23:00	0.0	42.5	36.3	78.9	1.60	9.5	90	18.2	73	3.1	267	946.8
15/10/2017 23:15	0.0	31.9	32.5	64.5	1.48	14.1	90	18.1	73	2.7	282	946.7
15/10/2017 23:30	0.0	33.5	35.3	68.8	1.46	9.1	81	17.8	73	2.4	249	946.7
15/10/2017 23:45	0.0	42.0	38.2	80.2	1.45	6.8	75	17.8	73	2.1	265	946.7
16/10/2017 00:00	0.0	64.3	39.5	103.8	1.64	5.3	75	17.8	73	2.3	298	946.6
16/10/2017 00:15		51.6	39.0	90.6	1.48	6.4	75	17.7	73	2.1	276	946.6
16/10/2017 00:30	9.0	36.1	34.8	70.9	1.31	12.5	75	17.6	73	2.9	264	946.6
16/10/2017 00:45	8.0	27.5	29.5	57.0	1.15	18.6	75	17.6	72	3.2	264	946.5
16/10/2017 01:00	10.6	52.2	34.5	86.7	1.37	9.6	75	17.5	72	0.6	231	946.4
16/10/2017 01:15	9.5	34.2	31.9	66.1		13.8	75	17.3	72	2.8	238	946.4
16/10/2017 01:30	9.4	45.2	32.9	78.1	2.04	13.5	59	17.3	72	0.7	106	946.4
16/10/2017 01:45	12.0	51.3	38.9	90.2	2.01	9.1	49	17.2	72	1.2	104	946.5

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTION	PRESSURE
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
16/10/2017 02:00	10.1	32.4	29.8	62.2	1.74	21.7	49	17.2	72	2.1	198	946.6
16/10/2017 02:15	10.1	33.9	28.8	62.7	1.68	25.1	49	17.3	72	1.5	198	946.5
16/10/2017 02:30	8.6	22.4	17.5	39.9	1.52	40.2	56	17.4	72	3.2	260	946.5
16/10/2017 02:45	7.6	17.8	13.0	30.8	1.47	45.4	60	17.4	72	3.3	258	946.5
16/10/2017 03:00	8.7	16.8	13.8	30.6	1.50	43.5	60	17.3	72	2.4	237	946.5
16/10/2017 03:15	9.0	17.9	17.9	35.7	1.43	39.5	60	17.2	72	2.4	216	946.6
16/10/2017 03:30	9.1	19.2	19.8	39.0	1.45	33.8	60	17.1	71	1.7	198	946.5
16/10/2017 03:45	9.5	32.8	32.2	65.0	1.52	16.3	60	16.9	72	1.5	92	946.5
16/10/2017 04:00	9.2	37.7	36.9	74.5	1.74	7.4	60	16.7	72	1.8	93	946.4
16/10/2017 04:15		53.0	39.6	92.6	1.68	5.2	60	16.6	71	2.2	110	946.4
16/10/2017 04:30	12.3	73.0	41.7	114.6	1.86	3.7	65	16.4	71	1.2	105	946.4
16/10/2017 04:45	14.1	66.7	40.1	106.8	1.81	5.0	69	16.4	72	1.1	350	946.3
16/10/2017 05:00	28.9	82.6	40.0	122.6	1.85	4.2	69	16.4	71	1.1	357	946.3
16/10/2017 05:15	22.5	75.2	40.0	115.2		5.6	69	16.3	71	1.2	274	946.4
16/10/2017 05:30	11.7	44.4	29.1	73.5	1.66	28.4	66	16.9	72	1.4	217	946.5
16/10/2017 05:45	11.2	42.9	35.7	78.5	1.72	20.2	64	16.8	71	1.1	146	946.6
16/10/2017 06:00	12.7	36.0	29.4	65.3	1.59	28.4	64	16.9	71	1.1	241	946.7
16/10/2017 06:15	15.9	45.3	31.1	76.4	1.70	23.2	64	16.8	71	1.9	206	946.7
16/10/2017 06:30	9.9	42.6	40.9	83.5	1.72	12.9	72	16.8	71	2.9	180	946.8
16/10/2017 06:45	15.3	93.8	46.6	140.4	2.01	5.2	76	16.9	71	2.8	183	946.7
16/10/2017 07:00	23.9	154.0	48.5	202.5	2.51	5.1	76	16.9	71	2.9	169	946.7
16/10/2017 07:15	18.7	122.7	50.8	173.5	2.29	4.3	76	16.9	70	2.9	160	946.7
16/10/2017 07:30	24.8	181.3	45.1	226.3	2.87	4.1	82	17.1	71	3.4	224	946.8
16/10/2017 07:45	19.9	111.1	47.5	158.6	2.28	5.0	85	17.6	72	2.2	214	946.9
16/10/2017 08:00	17.3	100.1	51.1	151.2	2.31	8.1	85	17.8	72	3.0	165	947.0
16/10/2017 08:15		81.0	43.2	124.2	2.22	14.2	85	18.0	72	2.2	208	947.2
16/10/2017 08:30	5.6	50.0	39.2	89.2	1.84	23.4	79	18.1	73	3.1	198	947.2
16/10/2017 08:45	10.4	57.1	37.1	94.2	1.87	23.8	75	18.6	73	2.9	187	947.2
16/10/2017 09:00	11.5	57.4	31.3	88.7	1.81	23.1	75	18.9	73	1.4	197	947.2
16/10/2017 09:15	10.7	48.6	34.1	82.8		25.2	75	19.3	73	2.2	226	947.2

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTION	PRESSURE
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
16/10/2017 09:30	14.1	62.5	38.4	100.9	2.09	20.3	54	19.6	73	1.9	221	947.1
16/10/2017 09:45	16.5	78.4	43.8	122.2	2.19	20.1	41	19.6	74	3.3	289	947.2
16/10/2017 10:00	14.7	67.3	34.9	102.2	2.07	27.9	41	19.9	74	2.7	275	947.3
16/10/2017 10:15	10.7	66.2	30.6	96.8	2.03	28.9	41	19.8	74	2.5	260	947.3
16/10/2017 10:30	11.5	69.0	30.2	99.2	1.98	27.8	30	20.0	74	1.9	278	947.2
MAX	**28.9**	**191.8**	**56.9**	**226.3**	**7.38**	**54.5**	**107**	**22.4**	**74**	**3.4**	**357**	**947.8**
AVG	**6.2**	**63.9**	**37.0**	**100.9**	**2.76**	**21.9**	**68**	**19.2**	**68**	**2.3**	**235**	**946.5**
MIN	**0.0**	**16.8**	**13.0**	**30.6**	**0.00**	**2.6**	**0**	**16.3**	**60**	**0.3**	**92**	**945.8**

Hourly averages values of monitored parameters at GAM during (15 - 16 October 2017)

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTION	PRESSURE
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
15/10/2017 12:00	0.8	29.8	22.1	51.9	1.87	46.5	11	20.4	63	2.9	183	947.2
15/10/2017 13:00	1.8	45.1	28.5	73.7	4.53	50.6	32	21.6	64	2.2	213	946.7
15/10/2017 14:00	0.7	38.0	30.3	68.4	7.23	51.5	58	22.2	64	1.7	218	946.3
15/10/2017 15:00	0.5	41.3	32.4	73.7	6.76	44.7	63	22.2	65	2.6	262	946.2
15/10/2017 16:00	1.0	61.8	41.0	102.8	6.61	34.4	63	22.2	65	2.9	288	945.9
15/10/2017 17:00	0.9	64.2	41.8	106.0	6.33	32.0	79	21.7	65	2.6	286	945.9
15/10/2017 18:00	3.1	101.9	51.2	153.2	2.19	17.4	86	21.2	64	2.6	298	945.9
15/10/2017 19:00	3.0	88.2	30.7	118.9	1.77	13.2	90	20.4	64	3.1	276	946.0
15/10/2017 20:00	0.0	47.5	44.9	92.5	1.52	5.5	95	19.5	63	3.1	251	946.3
15/10/2017 21:00	1.9	86.3	48.5	134.8	1.67	3.7	86	19.2	62	1.9	267	946.4
15/10/2017 22:00	3.5	141.1	49.5	190.6	2.67	2.9	98	18.8	62	2.0	247	946.6
15/10/2017 23:00	0.5	83.0	40.8	123.8	1.99	7.1	96	18.4	71	2.3	243	946.8
16/10/2017 00:00	0.0	42.9	36.4	79.3	1.51	8.8	80	17.9	73	2.4	273	946.7
16/10/2017 01:00	9.2	41.8	34.4	76.3	1.33	11.8	75	17.6	72	2.2	259	946.5
16/10/2017 02:00	10.2	40.8	33.4	74.1	1.93	14.5	58	17.2	72	1.7	161	946.5
16/10/2017 03:00	8.8	22.7	18.2	41.0	1.54	38.6	56	17.3	72	2.6	238	946.5
16/10/2017 04:00	9.2	26.9	26.7	53.6	1.54	24.3	60	17.0	72	1.8	150	946.5
16/10/2017 05:00	18.4	68.8	40.3	109.2	1.80	4.5	66	16.4	71	1.4	231	946.4
16/10/2017 06:00	14.5	49.6	33.5	83.1	1.66	20.7	66	16.7	71	1.2	220	946.6
16/10/2017 07:00	16.2	83.9	41.8	125.7	1.99	11.6	72	16.8	71	2.6	184	946.7
16/10/2017 08:00	20.2	128.8	48.6	177.4	2.44	5.4	82	17.4	71	2.9	191	946.9
16/10/2017 09:00	9.1	61.4	37.7	99.1	1.94	21.1	79	18.4	72	2.4	198	947.2
16/10/2017 10:00	12.4	55.6	36.2	91.8	2.09	22.8	65	19.4	73	2.1	224	947.2
16/10/2017 11:00	11.1	67.6	30.4	98.0	2.01	28.3	36	19.9	74	2.2	269	947.3
MAX	**20.2**	**141.1**	**51.2**	**190.6**	**7.23**	**51.5**	**98**	**22.2**	**74**	**3.1**	**298**	**947.3**
AVG	**6.5**	**63.3**	**36.6**	**99.9**	**2.79**	**21.7**	**69**	**19.2**	**68**	**2.3**	**234.6**	**946.5**
MIN	**0.0**	**22.7**	**18.2**	**41.0**	**1.33**	**2.9**	**11**	**16.4**	**62**	**1.2**	**149.9**	**945.9**

15 minutes average values of monitored parameters at TAB during (16 - 17 October 2017)

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
16/10/2017 11:45					0.00			19.8	74	1.2	310	
16/10/2017 12:00	22.3	9.0	1.0	10.0	1.24	33.2	0	20.0	75	2.5	306	933.2
16/10/2017 12:15	28.6	200.6	29.0	229.6	1.38	35.8	0	20.0	76	3.3	313	933.0
16/10/2017 12:30	30.2	31.7	18.5	50.3	3.06	35.5	0	20.3	76	3.3	301	932.8
16/10/2017 12:45	32.1	6.2	6.8	13.0	2.79	31.5	122	20.6	77	3.2	286	932.7
16/10/2017 13:00	37.7	6.6	7.1	13.7	2.75	28.9	122	20.9	76	2.8	283	932.6
16/10/2017 13:15	39.2	12.4	10.7	23.0	3.05	30.0	209	20.8	76	3.1	291	932.5
16/10/2017 13:30								21.0	77	3.3	276	
16/10/2017 13:45	55.1	281.9	76.3	358.2	2.96	30.9	209	21.1	77	3.5	285	932.4
16/10/2017 14:00	37.0	286.9	61.4	348.3	2.77	33.2	208	21.0	78	3.5	284	932.3
16/10/2017 14:15	52.3	348.5	78.3	426.8		31.5	142	21.1	78	3.2	285	932.3
16/10/2017 14:30	63.2	321.6	97.9	419.5	3.89	28.2	142	21.2	77	3.3	271	932.2
16/10/2017 14:45	51.0	332.3	54.5	386.8	3.85	32.8	142	21.1	77	3.5	280	932.1
16/10/2017 15:00	57.5	319.2	74.4	393.5	3.58	32.2	142	21.1	77	3.4	298	932.1
16/10/2017 15:15	40.2	288.5	84.7	373.2	3.31	33.6	96	21.0	77	3.5	296	932.0
16/10/2017 15:30	52.0	280.2	86.6	366.8	2.89	34.1	96	20.9	77	3.5	305	932.0
16/10/2017 15:45	46.8	311.3	67.1	378.4	3.46	30.5	96	20.9	77	3.5	297	932.0
16/10/2017 16:00	52.4	362.8	119.8	482.5	3.55	25.5	96	21.1	77	3.3	300	932.0
16/10/2017 16:15	38.0	308.2	56.4	364.6	3.19	33.5	75	20.6	77	3.4	306	932.0
16/10/2017 16:30	34.6	287.7	84.2	371.9	3.34	33.8	74	20.5	77	3.5	304	932.0
16/10/2017 16:45	29.6	229.5	64.7	294.1	2.90	39.8	74	20.0	77	3.7	301	932.0
16/10/2017 17:00	20.2	172.1	48.3	220.3	2.22	41.5	74	19.8	77	3.6	302	932.1
16/10/2017 17:15	27.0	192.4	39.5	231.9	2.55	36.1	78	19.6	77	3.4	319	932.2
16/10/2017 17:30	35.2	245.4	58.4	303.8	2.53	30.7	78	19.5	76	3.1	323	932.3
16/10/2017 17:45	29.5	207.8	56.6	264.3	2.39	31.2	78	19.3	76	3.4	307	932.3
16/10/2017 18:00	24.6	174.3	46.7	221.0	2.05	38.4	78	18.8	76	3.6	307	932.4
16/10/2017 18:15	23.9	161.3	58.9	220.1		35.5	83	18.3	76	3.4	314	932.4
16/10/2017 18:30	19.8	164.5	52.2	216.7	2.77	31.8	83	18.1	76	3.3	313	932.5
16/10/2017 18:45	26.0	179.5	68.1	247.5	2.79	27.5	83	18.0	75	3.3	331	932.5

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
16/10/2017 19:00	23.1	188.7	73.5	262.2	2.80	29.8	84	17.9	74	3.5	305	932.5
16/10/2017 19:15	20.6	165.6	60.2	225.8	2.63	33.0	111	17.6	75	3.6	297	932.6
16/10/2017 19:30	24.9	142.8	18.9	161.7	2.72	24.2	111	17.6	75	3.0	308	932.7
16/10/2017 19:45	23.7	138.9	14.5	153.4	2.72	24.7	111	17.5	75	2.1	261	932.7
16/10/2017 20:00	25.3	258.9	66.4	325.3	3.00	19.4	110	17.4	75	2.9	266	932.7
16/10/2017 20:15	24.7	248.9	75.4	324.3	2.90	19.6	105	17.4	75	2.8	257	932.7
16/10/2017 20:30	27.3	255.4	74.4	329.8	2.97	21.3	105	17.3	75	2.7	244	932.7
16/10/2017 20:45	23.2	242.4	55.5	297.9	2.72	21.9	105	17.3	74	2.4	241	932.7
16/10/2017 21:00	20.6	190.8	50.6	241.4	2.29	28.1	105	17.3	74	2.7	248	932.7
16/10/2017 21:15	21.5	151.7	53.1	204.8	2.22	32.8	88	17.4	74	2.8	236	932.7
16/10/2017 21:30	19.7	147.3	53.1	200.3	2.34	29.4	88	17.4	74	3.0	243	932.8
16/10/2017 21:45	18.4	182.0	40.4	222.4	2.61	26.4	88	17.4	74	3.0	242	932.8
16/10/2017 22:00	17.2	181.5	45.5	227.0	2.74	21.2	87	17.3	74	2.8	243	932.8
16/10/2017 22:15	19.9	151.5	41.1	192.6		23.0	60	17.4	73	2.8	231	932.9
16/10/2017 22:30	20.8	188.4	34.7	223.1	2.77	18.1	60	17.3	72	3.0	239	932.9
16/10/2017 22:45	13.9	146.9	53.1	200.0	2.60	27.4	60	17.2	73	2.9	254	932.9
16/10/2017 23:00	12.9	124.7	36.7	161.4	2.06	34.5	60	17.4	73	3.0	253	932.8
16/10/2017 23:15	14.0	116.0	39.4	155.3	1.98	34.4	34	17.4	73	3.0	260	932.7
16/10/2017 23:30	8.9	68.8	31.8	100.6	1.75	40.3	34	17.4	72	3.0	253	932.6
16/10/2017 23:45	7.5	61.4	28.7	90.1	1.70	42.2	34	17.4	73	2.8	256	932.6
17/10/2017 00:00	7.3	63.7	30.4	94.2	1.75	44.7	34	17.1	73	2.9	261	932.6
17/10/2017 00:15		41.5	16.1	57.7	1.45	53.2	42	17.1	73	3.0	259	932.5
17/10/2017 00:30	7.7	40.0	18.9	58.9	1.42	51.5	42	17.1	72	3.1	257	932.4
17/10/2017 00:45	7.2	36.4	21.6	58.0	1.30	51.2	42	17.1	72	3.1	257	932.3
17/10/2017 01:00	6.9	36.6	18.6	55.2	1.32	50.0	42	17.0	72	2.9	272	932.3
17/10/2017 01:15	10.9	30.1	20.7	50.8	1.27	53.0	36	16.7	72	2.6	275	932.4
17/10/2017 01:30	10.5	26.9	14.8	41.7	1.23	52.9	36	16.7	72	2.9	262	932.5
17/10/2017 01:45	8.6	24.6	15.1	39.8	1.24	51.9	36	16.8	72	3.0	261	932.5
17/10/2017 02:00	6.8	31.0	17.5	48.5	1.24	47.2	35	16.7	71	2.9	268	932.5
17/10/2017 02:15	5.6	22.8	11.3	34.2		53.4	21	16.5	72	2.9	267	932.5
17/10/2017 02:30	7.2	23.2	16.7	40.0	1.59	49.0	21	16.6	71	2.8	282	932.4

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
17/10/2017 02:45	6.5	19.9	8.7	28.6	1.51	55.6	21	16.8	71	3.0	260	932.3
17/10/2017 03:00	6.2	15.1	8.7	23.8	1.48	56.9	21	16.9	71	3.1	253	932.2
17/10/2017 03:15	8.3	16.5	10.4	26.9	1.54	54.2	27	16.8	71	2.6	263	932.1
17/10/2017 03:30	8.2	20.6	10.2	30.8	1.53	52.5	27	16.7	71			932.1
17/10/2017 03:45	9.2	22.2	20.2	42.4	1.51	47.8	27	16.6	71			932.1
17/10/2017 04:00	7.4	16.6	10.5	27.0	1.40	48.3	27	16.4	71	2.3	292	932.2
17/10/2017 04:15		17.0	11.7	28.7	1.46	47.8	26	16.5	71	3.2	298	932.2
17/10/2017 04:30	4.2	16.8	10.6	27.4	1.47	47.0	26	16.3	71	3.1	287	932.2
17/10/2017 04:45	7.4	23.3	8.7	32.0	1.46	44.9	26	16.2	71	3.0	272	932.3
17/10/2017 05:00	19.9	26.7	14.3	40.9	1.43	43.8	26	16.4	71	2.6	269	932.3
17/10/2017 05:15	8.7	24.4	14.7	39.1	1.44	45.8	23	16.8	71	3.0	277	932.3
17/10/2017 05:30	33.0	65.3	34.6	100.0	1.57	29.3	23	17.0	71	3.1	263	932.4
17/10/2017 05:45	37.4	59.3	33.4	92.6	1.57	21.9	23	17.0	71	3.4	272	932.4
17/10/2017 06:00	60.0	111.8	44.5	156.3	2.09	10.5	23	17.0	70	3.3	271	932.4
17/10/2017 06:15	47.1	132.3	46.8	179.1		12.8	36	17.1	71	3.1	272	932.5
17/10/2017 06:30	80.1	239.8	47.3	287.1	3.01	6.8	36	17.2	71	3.1	258	932.5
17/10/2017 06:45	80.1	310.7	48.9	359.5	3.20	5.5	36	17.3	70	3.3	267	932.6
17/10/2017 07:00	106.8	421.5	61.9	483.4	4.36	6.1	38	17.6	70	3.3	284	932.7
17/10/2017 07:15	131.3	532.6	84.4	617.0	6.41	7.0	102	17.7	70	3.3	282	932.8
17/10/2017 07:30	164.2	639.9	60.1	700.0	6.33	7.7	102	18.0	71	3.3	291	932.9
17/10/2017 07:45	105.1	589.3	51.4	640.7	5.42	6.7	102	18.2	71	3.3	283	932.9
17/10/2017 08:00	108.7	548.3	68.5	616.7	5.15	6.3	104	18.6	71	3.1	286	933.1
17/10/2017 08:15		466.6	50.0	516.6	4.41	7.0	162	18.7	71	3.3	292	933.2
17/10/2017 08:30	53.5	328.2	52.9	381.1	3.61	7.7	162	18.8	72	3.4	289	933.4
17/10/2017 08:45	51.5	280.8	60.4	341.2	3.11	9.2	162	19.2	72	3.5	287	933.4
17/10/2017 09:00	36.7	234.9	30.3	265.2	2.56	17.2	162	19.4	72	3.4	287	933.5
17/10/2017 09:15	27.6	135.3	43.6	178.9	2.11	23.2	167	19.5	73	3.2	304	933.5
17/10/2017 09:30	29.2	131.4	35.8	167.2	1.86	31.6	167	19.8	73	2.9	307	933.6
17/10/2017 09:45	22.6	105.9	29.6	135.4	1.59	36.6	167	20.1	73	3.3	292	933.6
17/10/2017 10:00	15.9	67.0	25.7	92.7	1.48	45.2	166	20.2	73	3.4	292	933.7
17/10/2017 10:15	14.2	55.8	31.5	87.2		42.0	110	20.4	62	3.2	299	933.7

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
17/10/2017 10:30	13.5	57.8	29.8	87.6	1.54	43.3	110	20.6	62	3.2	299	933.7
17/10/2017 10:45	13.0	52.0	20.7	72.7	1.42	47.7	110	20.7	62	3.1	315	933.7
17/10/2017 11:00	14.0	50.2	21.7	71.9	1.44	47.6	110	20.8	62	3.3	291	933.7
17/10/2017 11:15	10.0	46.2	22.8	69.0	1.40	46.6	81	21.2	62	3.5	283	933.7
17/10/2017 11:30	13.3	48.4	25.8	74.2	1.38	47.2	81	21.2	63	2.9	294	933.7
MAX	**164.2**	**639.9**	**119.8**	**700.0**	**6.41**	**56.9**	**209**	**21.2**	**78**	**3.7**	**331**	**933.7**
AVG	**31.1**	**163.6**	**40.9**	**204.6**	**2.43**	**33.1**	**80**	**18.5**	**73**	**3.1**	**281**	**932.6**
MIN	**4.2**	**6.2**	**1.0**	**10.0**	**0.00**	**5.5**	**0**	**16.2**	**62**	**1.2**	**231**	**932.0**

Hourly averages values of monitored parameters at TAB during (16 - 17 October 2017)

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
16/10/2017 13:00	32.2	61.3	15.3	76.6	2.50	32.9	61	20.4	76	3.1	296	932.8
16/10/2017 14:00	43.7	193.7	49.5	243.2	2.93	31.4	209	21.0	77	3.3	284	932.4
16/10/2017 15:00	56.0	330.4	76.3	406.7	3.77	31.2	142	21.1	77	3.4	283	932.2
16/10/2017 16:00	47.8	310.7	89.5	400.2	3.30	30.9	96	21.0	77	3.4	300	932.0
16/10/2017 17:00	30.6	249.4	63.4	312.7	2.91	37.2	74	20.2	77	3.6	303	932.0
16/10/2017 18:00	29.1	205.0	50.3	255.3	2.38	34.1	78	19.3	76	3.4	314	932.3
16/10/2017 19:00	23.2	173.5	63.2	236.7	2.79	31.2	83	18.0	75	3.4	316	932.5
16/10/2017 20:00	23.6	176.6	40.0	216.6	2.77	25.3	111	17.5	75	2.9	283	932.7
16/10/2017 21:00	24.0	234.4	64.0	298.3	2.72	22.7	105	17.3	74	2.6	247	932.7
16/10/2017 22:00	19.2	165.6	48.0	213.6	2.48	27.4	88	17.4	74	2.9	241	932.8
16/10/2017 23:00	16.9	152.9	41.4	194.3	2.48	25.7	60	17.3	73	2.9	244	932.9
17/10/2017 00:00	9.4	77.5	32.6	110.0	1.80	40.4	34	17.3	73	2.9	258	932.6
17/10/2017 01:00	7.3	38.6	18.8	57.4	1.37	51.5	42	17.0	72	3.0	261	932.4
17/10/2017 02:00	9.2	28.1	17.0	45.2	1.25	51.2	36	16.7	72	2.9	266	932.5
17/10/2017 03:00	6.4	20.3	11.4	31.6	1.53	53.7	21	16.7	71	2.9	266	932.4
17/10/2017 04:00	8.3	19.0	12.8	31.8	1.50	50.7	27	16.6	71	2.5	277	932.1
17/10/2017 05:00	10.5	20.9	11.3	32.2	1.46	45.9	26	16.4	71	3.0	282	932.3
17/10/2017 06:00	34.8	65.2	31.8	97.0	1.67	26.8	23	16.9	71	3.2	271	932.4
17/10/2017 07:00	78.5	276.0	51.2	327.3	3.52	7.8	37	17.3	71	3.2	270	932.6
17/10/2017 08:00	127.3	577.5	66.1	643.6	5.83	6.9	103	18.1	71	3.3	285	932.9
17/10/2017 09:00	47.2	327.6	48.4	376.0	3.42	10.3	162	19.0	72	3.4	289	933.4
17/10/2017 10:00	23.8	109.9	33.6	143.5	1.76	34.2	167	19.9	73	3.2	299	933.6
17/10/2017 11:00	13.9	56.8	30.7	87.4	1.54	42.7	110	20.5	62	3.2	299	933.7
MAX	**127.3**	**577.5**	**89.5**	**643.6**	**5.83**	**53.7**	**209**	**21.1**	**77**	**3.6**	**316**	**933.7**
AVG	**31.4**	**168.3**	**42.0**	**210.3**	**2.51**	**32.7**	**82**	**18.4**	**73**	**3.1**	**280**	**932.6**
MIN	**6.4**	**19.0**	**11.3**	**31.6**	**1.25**	**6.9**	**21**	**16.4**	**62**	**2.5**	**241**	**932.0**

15 minutes average values of monitored parameters at HAJ during (17 - 18 October 2017)

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
17/10/2017 14:00		18.1	11.7	29.8	0.89	54.5	0	25.2	65	0.1	220	961.8
17/10/2017 14:15	6.6	13.0	9.3	22.3	0.70	57.8	0	25.6	64	1.7	180	961.7
17/10/2017 14:30	8.2	11.7	8.7	20.4	0.60	59.3	64	25.7	65	1.8	227	961.6
17/10/2017 14:45	9.0	10.4	8.1	18.6	0.48	59.4	114	25.9	65	2.2	179	961.6
17/10/2017 15:00	11.0	12.4	13.1	25.6	0.48	55.0	114	25.9	65	1.9	158	961.6
17/10/2017 15:15	11.1	12.9	12.3	25.2	0.58	59.9	114	25.6	65	1.1	142	961.5
17/10/2017 15:30	8.5	10.9	7.8	18.8	0.59	60.9	123	25.9	65	2.0	195	961.5
17/10/2017 15:45	9.5	10.0	8.4	18.3	0.61	59.1	130	26.0	65	1.7	181	961.5
17/10/2017 16:00	9.4	9.5	10.9	20.4	0.68	54.2	130	25.3	65	1.8	155	961.5
17/10/2017 16:15	10.9	10.6	14.0	24.6		48.8	130	24.7	65	1.3	170	961.5
17/10/2017 16:30	19.8	16.3	24.7	41.0	1.40	41.8	122	24.8	65	1.3	89	961.6
17/10/2017 16:45	13.3	16.4	22.0	38.3	1.39	44.2	115	24.8	65	1.9	346	961.6
17/10/2017 17:00	16.7	21.6	29.6	51.3	1.59	36.6	115	24.5	65	2.6	338	961.6
17/10/2017 17:15	16.0	23.4	32.3	55.6	1.55	34.3	115	24.3	65	3.0	335	961.7
17/10/2017 17:30	12.5	21.1	26.7	47.8	1.51	42.4	126	23.9	65	2.8	338	961.7
17/10/2017 17:45	14.7	23.1	31.2	54.3	1.51	37.2	134	23.6	64	2.4	344	961.8
17/10/2017 18:00	13.5	22.3	27.9	50.2	1.42	39.4	134	23.3	64	2.9	344	962.0
17/10/2017 18:15	15.4	24.9	32.9	57.8	1.57	30.0	134	23.1	64	2.2	348	962.0
17/10/2017 18:30	13.0	22.1	28.1	50.2	1.45	35.3	146	23.0	64	2.8	340	962.1
17/10/2017 18:45	14.5	23.6	33.9	57.6	1.49	23.9	156	22.7	64	1.3	359	962.2
17/10/2017 19:00	16.7	33.9	39.8	73.7	1.67	11.5	156	22.6	64	1.3	342	962.3
17/10/2017 19:15	16.5	32.1	39.0	71.1	1.61	14.9	156	22.4	64	1.0	8	962.4
17/10/2017 19:30	19.3	39.7	41.7	81.4	1.72	10.7	156	22.2	64	1.8	346	962.5
17/10/2017 19:45	20.5	42.0	43.4	85.4	1.64	6.7	155	21.9	64	1.0	321	962.7
17/10/2017 20:00	13.8	27.6	41.6	69.2	1.47	6.5	155	21.3	64	1.4	177	962.8
17/10/2017 20:15	18.5	59.7	43.6	103.3		4.2	155	21.3	64	1.6	140	962.8
17/10/2017 20:30		38.3	41.8	80.1	1.91	6.7	178	21.1	63	2.9	106	962.8
17/10/2017 20:45	23.4	71.1	44.8	115.9	2.32	4.4	197	21.1	64	1.6	93	962.9
17/10/2017 21:00	18.4	52.7	42.0	94.7	2.08	5.4	197	21.2	63	1.3	17	962.9

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
17/10/2017 21:15	16.2	52.9	39.2	92.1	2.04	8.6	197	20.9	63	2.0	86	962.9
17/10/2017 21:30	17.1	46.9	40.0	86.9	2.03	6.2	202	20.8	64	2.2	115	962.9
17/10/2017 21:45	13.0	26.1	32.9	59.0	1.69	14.0	206	20.7	63	2.6	125	962.9
17/10/2017 22:00	20.8	99.7	39.1	138.8	2.52	5.9	206	20.2	63	3.1	251	963.0
17/10/2017 22:15	19.3	117.1	39.2	156.2	2.47	3.7	206	19.7	64	0.9	173	963.0
17/10/2017 22:30	22.0	127.4	40.6	168.0	2.53	3.2	226	19.7	63	2.7	251	963.0
17/10/2017 22:45	20.5	122.1	39.4	161.5	2.44	3.1	242	19.5	63	2.5	216	963.0
17/10/2017 23:00	18.2	119.2	38.9	158.0	2.42	3.0	242	19.4	63	2.5	235	962.9
17/10/2017 23:15	17.3	109.3	38.6	147.9	2.44	3.0	242	19.2	63	2.5	211	962.9
17/10/2017 23:30	16.4	89.3	38.2	127.5	2.14	2.6	276	19.1	63	2.1	201	962.8
17/10/2017 23:45	15.8	83.1	36.5	119.6	2.12	2.5	301	19.0	62	2.5	240	962.8
18/10/2017 00:00	14.3	63.4	35.7	99.1	1.91	2.2	301	18.8	62	2.3	213	962.8
18/10/2017 00:15		53.8	33.3	87.1		2.1	301	18.7	63	2.1	217	962.8
18/10/2017 00:30	12.5	48.7	31.9	80.6	1.94	2.3	285	18.5	62	1.8	240	962.9
18/10/2017 00:45	11.7	42.4	29.9	72.2	1.87	2.2	273	18.3	62	3.2	254	963.0
18/10/2017 01:00	11.5	30.1	27.7	57.8	1.72	2.5	273	18.1	62	1.9	215	963.1
18/10/2017 01:15	22.8	20.4	23.8	44.2	1.60	5.7	273	17.9	62	2.3	194	963.1
18/10/2017 01:30	35.9	18.5	23.8	42.2	1.60	6.8	233	18.1	62	2.6	239	963.2
18/10/2017 01:45	61.4	18.0	23.9	41.9	1.62	7.6	202	17.8	62	2.0	156	963.3
18/10/2017 02:00	30.4	14.9	17.9	32.8	1.45	15.9	202	17.9	62	1.8	195	963.4
18/10/2017 02:15	19.5	12.8	15.9	28.7	1.47	18.8	202	17.9	62	1.2	184	963.4
18/10/2017 02:30	20.3	12.8	15.4	28.3	1.42	20.4	176	17.8	62	3.0	227	963.4
18/10/2017 02:45	16.7	12.4	13.2	25.6	1.45	22.1	156	17.6	62	2.3	213	963.4
18/10/2017 03:00	17.4	11.5	12.3	23.7	1.41	22.3	156	17.6	62	0.9	223	963.3
18/10/2017 03:15	17.0	11.6	15.1	26.7	1.48	17.0	156	17.5	61	1.5	238	963.3
18/10/2017 03:30	15.1	12.5	17.6	30.1	1.42	12.3	137	17.4	62	0.6	149	963.3
18/10/2017 03:45	17.0	17.2	23.8	41.0	1.52	4.2	122	17.2	61	2.2	176	963.3
18/10/2017 04:00	14.1	26.7	26.5	53.2	1.63	3.0	122	17.1	62	2.9	242	963.2
18/10/2017 04:15		27.6	26.9	54.5		2.6	122	16.9	61	2.0	220	963.2
18/10/2017 04:30	12.8	24.3	27.5	51.8	1.76	2.4	142	16.9	61	1.6	128	963.3
18/10/2017 04:45	12.0	23.6	27.0	50.6	1.68	2.7	157	16.9	61	1.3	127	963.4

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
18/10/2017 05:00	20.6	32.9	28.1	61.0	1.75	2.7	157	16.9	61	1.6	129	963.4
18/10/2017 05:15	20.9	31.6	27.2	58.7	1.67	2.5	157	16.9	61	1.2	142	963.4
18/10/2017 05:30	18.8	29.0	30.9	59.9	1.63	4.5	164	17.3	61	1.2	27	963.5
18/10/2017 05:45	10.7	17.7	19.3	37.0	1.46	17.0	170	17.7	62	1.1	171	963.5
18/10/2017 06:00	6.3	12.6	9.7	22.3	1.36	28.9	170	17.8	61	2.3	191	963.5
18/10/2017 06:15	6.9	9.9	12.4	22.3	1.34	25.5	170	17.7	61	1.3	215	963.6
18/10/2017 06:30	8.8	12.2	20.0	32.1	1.36	15.1	145	17.8	61	1.2	238	963.6
18/10/2017 06:45	11.3	15.8	21.9	37.8	1.41	11.5	126	17.7	61	2.1	236	963.7
18/10/2017 07:00	8.3	13.1	16.8	29.9	1.31	18.1	126	17.4	61	2.2	173	963.8
18/10/2017 07:15	10.5	20.7	22.8	43.5	1.41	9.6	126	17.6	61	2.7	168	963.8
18/10/2017 07:30	15.3	38.6	29.0	67.6	1.50	4.1	117	17.7	61	2.7	156	963.9
18/10/2017 07:45	11.6	29.4	26.4	55.8	1.42	7.2	111	17.8	61	2.3	157	964.0
18/10/2017 08:00	12.0	31.5	27.7	59.2	1.46	7.5	111	18.0	61	2.4	147	964.1
18/10/2017 08:15		37.6	27.6	65.3		6.2	111	18.4	61	2.8	142	964.1
18/10/2017 08:30	11.5	35.1	26.0	61.1	1.55	9.1	110	18.9	62	3.0	142	964.2
18/10/2017 08:45	11.0	23.4	22.3	45.7	1.44	15.0	109	19.3	62	2.1	150	964.2
18/10/2017 09:00	9.7	21.4	21.1	42.5	1.48	15.6	109	19.5	62	2.0	170	964.3
18/10/2017 09:15	13.1	23.5	19.5	43.0	1.44	17.1	109	20.2	62	2.8	149	964.3
18/10/2017 09:30	8.7	16.0	14.2	30.2	1.37	26.6	107	21.1	62	2.1	185	964.2
18/10/2017 09:45	5.7	12.5	11.8	24.3	1.42	31.4	105	21.7	63	2.3	184	964.3
18/10/2017 10:00	4.9	10.1	9.5	19.6	1.41	34.6	105	22.3	63	2.3	175	964.3
18/10/2017 10:15	4.5	8.6	8.4	16.9	1.37	37.6	105	22.6	63	2.2	167	964.2
18/10/2017 10:30	6.1	8.6	8.8	17.4	1.36	38.4	98	23.0	64	2.1	181	964.2
18/10/2017 10:45	5.5	8.2	7.8	16.0	1.35	39.9	92	23.3	64	2.0	180	964.1
18/10/2017 11:00	5.3	8.0	7.7	15.7	1.39	40.5	92	23.7	63	2.4	202	964.1
18/10/2017 11:15	4.8	8.5	8.3	16.8	1.45	40.2	92	24.0	65	2.5	190	963.9
18/10/2017 11:30	4.9	8.8	9.4	18.2	1.42	40.3	79	24.2	65	2.7	218	963.9
18/10/2017 11:45	5.2	7.8	7.6	15.5	1.45	42.1	68	24.4	65	2.5	211	963.8
18/10/2017 12:00	5.9	8.4	8.3	16.7	1.42	42.3	68	24.4	65	2.3	226	963.7
18/10/2017 12:15		8.0	7.5	15.6		42.8	68	24.9	66	2.4	201	963.5
18/10/2017 12:30	0.6	7.5	6.9	14.3	1.20	44.5	59	25.1	66	2.2	184	963.4

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
18/10/2017 12:45	0.8	7.4	8.0	15.5	1.22	44.2	53	25.2	66	2.4	189	963.3
18/10/2017 13:00	1.7	8.6	9.6	18.2	1.24	42.4	53	25.4	66	2.1	211	963.1
18/10/2017 13:15	2.1	9.8	9.9	19.8	1.22	43.1	53	25.5	67	2.6	235	963.0
18/10/2017 13:30	2.8	9.3	10.0	19.3	1.23	45.4	52	25.5	67	2.9	238	962.8
18/10/2017 13:45	1.5	7.9	8.9	16.8	1.16	46.4	51	26.1	67	2.1	183	962.7
18/10/2017 14:00	3.2	12.7	13.9	26.7	1.13	41.9	51	26.4	67	2.4	163	962.6
MAX	**61.4**	**127.4**	**44.8**	**168.0**	**2.53**	**60.9**	**301**	**26.4**	**67**	**3.2**	**359**	**964.3**
AVG	**13.4**	**29.3**	**23.2**	**52.5**	**1.51**	**22.9**	**145**	**21.1**	**63**	**2.1**	**199**	**963.0**
MIN	**0.6**	**7.4**	**6.9**	**14.3**	**0.48**	**2.1**	**0**	**16.9**	**61**	**0.1**	**8**	**961.5**

8 Hours average values of monitored parameters at GAM, TAB & HAJ during (15 - 18 October 2017)

Date & Time	CO_MS	O3_MS
	ppm	ppb
16/10/2017 00:00	2.46	11.34
16/10/2017 08:00	1.78	16.4
MAX	**2.46**	**16.4**

TAB

17/10/2017 00:00	2.53	30.51
17/10/2017 08:00	2.25	36.82
MAX	**2.53**	**36.8**

HAJ

18/10/2017 00:00	1.87	16.95
18/10/2017 08:00	1.54	10.23
MAX	**1.87**	**17.0**

Hourly averages values of monitored parameters at HAJ during (17 - 18 October 2017)

Date & Time	SO2	NO	NO2	NOX	CO	OZONE	PM10	TEMP.	HUMIDITY	SPEED	DIRECTIO	PRESSURI
	ppb	ppb	ppb	ppb	ppm	ppb	ug/m3	degreC	%	m/s	degre	mbar
17/10/2017 15:00	8.7	11.9	9.8	21.7	0.6	57.9	73	25.8	65	1.9	186	961.6
17/10/2017 16:00	9.6	10.8	9.9	20.7	0.6	58.5	124	25.7	65	1.6	168	961.5
17/10/2017 17:00	15.2	16.2	22.6	38.8	1.5	42.8	121	24.7	65	1.8	236	961.6
17/10/2017 18:00	14.2	22.5	29.5	52.0	1.5	38.3	127	23.8	64	2.8	340	961.8
17/10/2017 19:00	14.9	26.1	33.7	59.8	1.5	25.2	148	22.9	64	1.9	347	962.2
17/10/2017 20:00	17.5	35.4	41.4	76.8	1.6	9.7	156	21.9	64	1.3	213	962.6
17/10/2017 21:00	20.1	55.4	43.1	98.5	2.1	5.2	182	21.2	64	1.8	89	962.9
17/10/2017 22:00	16.8	56.4	37.8	94.2	2.1	8.7	203	20.6	63	2.5	144	962.9
17/10/2017 23:00	20.0	121.4	39.5	160.9	2.5	3.2	229	19.6	63	2.2	219	963.0
18/10/2017 00:00	15.9	86.3	37.3	123.5	2.2	2.6	280	19.0	63	2.4	216	962.8
18/10/2017 01:00	11.9	43.7	30.7	74.4	1.8	2.3	283	18.4	62	2.3	232	963.0
18/10/2017 02:00	37.6	17.9	22.3	40.3	1.6	9.0	228	17.9	62	2.2	196	963.3
18/10/2017 03:00	18.5	12.4	14.2	26.6	1.4	20.9	173	17.7	62	1.8	212	963.4
18/10/2017 04:00	15.8	17.0	20.8	37.7	1.5	9.1	134	17.3	61	1.8	201	963.3
18/10/2017 05:00	15.1	27.1	27.4	54.5	1.7	2.6	145	16.9	61	1.6	151	963.3
18/10/2017 06:00	14.2	22.7	21.8	44.5	1.5	13.2	165	17.4	61	1.5	133	963.5
18/10/2017 07:00	8.8	12.7	17.8	30.5	1.4	17.6	142	17.7	61	1.7	216	963.7
18/10/2017 08:00	12.4	30.1	26.5	56.5	1.4	7.1	116	17.8	61	2.5	157	964.0
18/10/2017 09:00	10.7	29.4	24.3	53.6	1.5	11.5	110	19.0	62	2.4	151	964.2
18/10/2017 10:00	8.1	15.5	13.7	29.3	1.4	27.4	107	21.3	63	2.4	173	964.3
18/10/2017 11:00	5.3	8.4	8.2	16.5	1.4	39.1	97	23.1	64	2.2	183	964.2
18/10/2017 12:00	5.2	8.4	8.4	16.8	1.4	41.2	77	24.3	65	2.5	211	963.8
18/10/2017 13:00	0.6	7.7	7.2	15.0	1.2	43.7	64	25.0	66	2.3	193	963.5
18/10/2017 14:00	2.4	9.9	10.7	20.6	1.2	44.2	52	25.9	67	2.5	205	962.8
MAX	**37.6**	**121.4**	**43.1**	**160.9**	**2.5**	**58.5**	**283**	**25.9**	**67**	**2.8**	**347**	**964.3**
AVG	**13.3**	**29.4**	**23.3**	**52.7**	**1.5**	**22.5**	**147**	**21.0**	**63**	**2.1**	**199**	**963.0**
MIN	**0.6**	**7.7**	**7.2**	**15.0**	**0.6**	**2.3**	**52**	**16.9**	**61**	**1.3**	**89**	**961.5**

BEN HAYYAN – Aqaba International Laboratories

Report Number: 3 /96/17 **Date: 29 October 2017**

CUSTOMER INFORMATION	
Customer Name	: Messrs. engicon
Customer Address	: Amman, Jordan

SAMPLE INFORMATION	
Name / Type	: Noise levels Measurements
Sample(s) Received on	: --------
Customer Reference Number	: --------
Number of Samples Received	: 3 Sites
Analyses Order Number	: 317102600096

FINANCIAL INFORMATION	
Fees of This Service	: Upon the service agreement
Payment Method	: Upon invoicing
Invoice / Receipt Voucher Number	: --------

Eng. Mwaffaq Al-Khushman

Laboratories Manager

31.10.2017

- *Test results represent the sample that is sent to **BEN HAYYAN – Aqaba International Laboratories** by the customer. It may not represent the whole product.*
- *This report shall only be reproduced in full with the permission of **BEN HAYYAN – Aqaba International Laboratories Management**.*
- *This Test Report is considered invalid if not duly signed.*
- *The test results, extended uncertainties (if applicable) and test methods are given on the following pages which comprise a part of this report.*

مدير مختبرات العقبة الدولية بن حيان

Aqaba Special Economic Zone Authority (ASEZA), P.O. 2565, Aqaba 77110, Jordan
Tel: +962 3 20 90 666 Ext.156 Fax: +962 3 20 90 688 Email: labcrm@aseza.jo

Customer: Messrs. engicon
Address: Amman, Jordan
Attention: Dr. Eyad Batarseh

Sample Information:

Customer Information			BEN HAYYAN Information	
Customer Ref.	---------		Analyses Order No.	317102600096
Collection Form No.	---------		Sample(s) ID	----------
No. of Samples	3 Site		Invoice No.	----------
Samples Received on	----------		Date of Test	15-18 Oct. 2017
Condition of received sample(s)	----------		----------	----------

Test Results:

Please see the attached Report.

Report prepared

Mr. Rami Shaath
EIA Officer

Eng. Mahmoud Alburdaini
Air Quality Monitoring Engineer

Approval of Test Results:

Eng. Hasan Almarayeh
Air Quality Division Head

بن حيان
BEN HAYYAN
قسم
قياسات نوعية الهواء
مختبرات العقبة الدولية
Aqaba International Laboratories

Note: This test report consists of (8) pages including the cover page. It shall only be reproduced in full. The results are only representing the samples measured in the field during the above shown period.

"Noise Levels Measurements"

Submitted to

engicon

Prepared By
Mr. Rami Sha'ath

Field Work Team
Mr. Rami Sha'ath
Eng. Mahmoud Alburdaini

BEN HAYYAN - Aqaba International Laboratories

October 2017

1. Introduction

BEN HAYYAN - Aqaba International Laboratories were approached by engicon to conduct measurement noise levels at three Monitoring sites.

2. Methodology

Noise Levels Measuring was conducted to measure noise levels for two times (day-time & Night Time) one hour each time (4 samples, 15 minutes average each sample) utilizing state-of-the-art Sound Level Meter.

3. Site coordinates

▶Table (2): Air quality monitoring sites and their coordinates:

Monitoring Site	ID	Monitoring Period	Coordinates	
			North	East
أمانة عمان الكبرى	GAM	15-16 October 2017	31.94583	35.92592
طبربور مجمع سفريات الشمال	TAB	16-17 October 2017	31.99592	35.9189
مركز صحي وادي الحجر	HAJ	17-18 October 2017	32.05461	36.0865

4. Results

4.1 Noise Levels Measurements

Noise Parameters as Measured are:

- *L_{Aeq}: The A-weighted equivalent continuous sound pressure level. A representation of a continuous sound level containing the same amount of sound energy as the measured varying noise over the measurement period.*
- *L_{Amax}: The highest A-weighted noise level recorded during a noise measurement period.*
- *L_{AE}: The noise level that would be generated if all the energy from a discreet noise was compressed into 1 second. This measurement is used to compare the noise energy contained in discreet events that may last different lengths of time.*
- *L_{A90}: The A-weighted sound pressure level that is exceeded for 90% of the measurement period, this is commonly used as the Background Noise Level for assessing the effects of industrial noise.*
- *L_{A10}: The A-weighted sound pressure level that is exceeded for 10% of the measurement period.*
- *L_{Cpeak}: Peak sound pressure, maximum value of the C-frequency weighted instantaneous noise pressure.*

Noise parameters for each site are presented in tables below.

4.1.1 Noise Parameters as Measured at GAM in 16 October. 2017:

Day-Time Noise (GAM)

Noise index	Sample 1 (dB)	Sample 2 (dB)	Sample 3 (dB)	Sample 4 (dB)	AVG
L_{Aeq}	71.4	76.3	78.3	78.2	76.1
L_{Amax}	97.2	101.4	111.5	116.8	106.7
L_{AE}	101.1	96.1	107.9	107.8	103.2
L_{A90}	65.6	57.2	69.4	71.2	65.9
L_{A10}	74.6	69.0	80.9	80.3	76.2
$L_{C\ peak}$	106.9	111.3	123.1	123.3	116.2

Night-Time Noise (GAM)

Noise index	Sample 1 (dB)	Sample 2 (dB)	Sample 3 (dB)	Sample 4 (dB)	AVG
L_{Aeq}	59.8	58.8	58.5	57.8	58.7
L_{Amax}	102.7	101.1	100.5	101.5	101.5
L_{AE}	88.0	86.7	86.2	89.3	87.6
L_{A90}	47.0	46.3	46.0	47.4	46.7
L_{A10}	61.5	60.5	60.2	61.7	61.0
$L_{C\ peak}$	106.8	105.1	104.5	104.5	105.2

4.1.2 Noise Parameters as Measured at TAB in 17 October. 2017:

Day-Time Noise (TAB)

Noise index	Sample 1 (dB)	Sample 2 (dB)	Sample 3 (dB)	Sample 4 (dB)	AVG
L_{Aeq}	72.7	70.5	73.9	71.7	72.2
L_{Amax}	108.6	102.6	108.6	103.2	105.8
L_{AE}	102.3	100.8	103.5	101.6	102.1
L_{A90}	65.6	64.3	66.7	64.5	65.3
L_{A10}	75.6	73.1	75.3	75.1	74.8
$L_{C\ peak}$	111.5	104.3	122.1	106.5	111.1

Night-Time Noise (TAB)

Noise index	Sample 1 (dB)	Sample 2 (dB)	Sample 3 (dB)	Sample 4 (dB)	AVG
L_{Aeq}	68.4	67.0	69.9	68.8	68.5
L_{Amax}	98.4	103.1	103.6	99.7	101.2
L_{AE}	97.6	95.6	98.4	97.0	97.2
L_{A90}	62.0	61.3	65.0	58.8	61.8
L_{A10}	71.5	69.3	74.2	71.9	71.7
$L_{C\ peak}$	105.4	108.1	108.0	115.3	109.2

4.1.3 Noise Parameters as Measured at HAJ in 18 October. 2017:

Day-Time Noise (HAJ)

Noise index	Sample 1 (dB)	Sample 2 (dB)	Sample 3 (dB)	Sample 4 (dB)	AVG
L_{Aeq}	54.6	66.6	55.5	55.2	58.0
L_{Amax}	92.9	97.7	84.9	102.7	94.6
L_{AE}	85.0	90.2	85.0	88.9	87.3
L_{A90}	51.7	51.5	51.7	52.6	51.9
L_{A10}	56.5	58.0	58.0	56.3	57.2
$L_{C\ peak}$	99.6	100.3	95.9	103.9	99.9

Night-Time Noise (HAJ)

Noise index	Sample 1 (dB)	Sample 2 (dB)	Sample 3 (dB)	Sample 4 (dB)	AVG
L_{Aeq}	43.0	42.6	41.6	41.1	42.1
L_{Amax}	66.2	80.8	75.9	72.2	73.8
L_{AE}	66.8	70.2	69.7	59.6	66.6
L_{A90}	41.0	38.6	39.0	38.3	39.2
L_{A10}	44.2	44.3	43.3	41.2	43.3
$L_{C\ peak}$	72.9	81.8	75.6	71.4	75.4

5. Conclusion

Maximum Allowable Noise Exposure Limit (**L_{Aeq} Max**) for eight hours is **85 dB** according to 'the Instructions for the protection of workers and institutions from the risks of the work environment under article (79) of the Jordanian labour law No. 8 of 1996'.

Furthermore, the **L_{Aeq}** and **$L_{C\ peak}$** for both sites are within the exposure limit values and exposure action values in respect of the daily noise exposure levels and peak sound pressure that are specified in **EUROPEAN DIRECTIVE 2003/10/EC** "the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)" where:

- Exposure limit values: $L_{EX,8h}$ = 87 dB(A) and P_{peak} = 140 dB(C)
- Upper exposure action values: $L_{EX,8h}$ 85 dB(A) and P_{peak} = 134 dB(C)
- Lower exposure action values: $L_{EX,8h}$ = 80 dB(A) and P_{peak} = 135 dB(C)

► Noise Parameters and Maximum Allowable Noise Exposure Limit

Site	Time	L_{Aeq} (dB)	$L_{C\ peak}$ (dB)
GAM	Day-Time	76.1	116.2
	Night-Time	58.7	105.2
TAB	Day-Time	72.2	111.1
	Night-Time	68.5	109.2
HAJ	Day-Time	58.0	99.9
	Night-Time	42.1	75.4
Jordanian Instructions		**85**	**140**
European Directive		**87**	**140**

6. General Recommendation

According to the Jordanian labor law No. 8 of 1996:
"Employer must conduct a preliminary examination for determining the efficiency and level of hearing to the worker in a work exposed to noise before employing and conduct a periodic medical examination at least twice a year to determine the efficiency and level of hearing during work".

APPENDIX C: CO_2 CALCULATION

BRT Route 1 CO2 Calculations for the baseline and BRT

Sources of data:
Traffic flow: from PTV VISUM model for the baseline and BRT cases
Mile per Gallon data: from US Department of Transportation
Fuel to CO2 data factors: from UK's Departemnt for Environment Food and Rural Affairs

	L/100 kn	L/km		
L per 100 Km Diesel for Public bus and BRT	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Diesel for school bus	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Diesel for Goods vehicle	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Gasoline for taxi / car	**9.8**	**0.09802**	MpG	**24**

Litre	kg CO2e/L
Diesel	2.67193
Gasoline	2.30075

Base flow and BRT flow

BRT Route 1	Distance (km)	Passenger	Public bus/d	Auto/d	Goods V/d	School bus/d	Taxi/d	BRT/d*	Total Gasoline L/yr	Total PB Diesel/yr	Total SB Diesel/yr	Total GV Diesel/yr	Total BRT Diesel/yr	Total CO2e (ton)/yr
Swuayleh Terminal-Yajouz	1.4	23425	706	36156	1192	389	2394	480	1930839	121163	66877	204632	82428	5711.8
Swuayleh Terminal-Yajouz	1.4	4282	129	38533	2636	274	3088	480	2084646	22147	47017	452586	82428	6410.6
Yajouz-University Street	1.7	15904	479	6305	180	105	725	480	427597	99889	21839	37614	100091	1677.0
Yajouz-University Street	1.7	9454	285	33019	1037	132	2630	480	2168164	59378	27465	216154	100091	6065.4
University Street-Jordan University Hospital	1.2	17236	519	26483	313	45	5962	480	1392891	76417	6602	46002	70652	3738.2
University Street-Jordan University Hospital	1.2	21110	636	65737	1726	349	8169	480	3172902	93592	51340	254101	70652	8555.0
Jordan University Hospital-Mahmoud al-Kiswani	1	13461	405	70662	1098	170	14677	480	3053075	49731	20803	134675	58877	7730.0
Jordan University Hospital-Mahmoud al-Kiswani	1	12532	377	47175	2239	328	5767	480	1894052	46299	40221	274697	58877	5480.2
Mahmoud al-Kiswani-Press Tunnel	1.1	11994	361	54063	1121	149	10985	480	2559876	48746	20144	151236	64765	6650.8
Mahmoud al-Kiswani-Press Tunnel	1.1	9456	285	60547	2605	501	7230	480	2667257	38431	67533	351523	64765	7532.1
Press Tunnel-Sports City	1	13369	403	46542	1526	267	10295	480	2033381	49393	32725	187220	58877	5555.3
Press Tunnel-Sports City	1	10766	324	89704	3064	606	10743	480	3593609	39777	74338	375865	58877	9734.5
Sports City-Al-Riyadhah	1.2	12319	371	94627	4412	397	10267	480	4503244	54617	58456	649416	70652	12586.9
Sports City-Al-Riyadhah	1.2	3055	92	61265	3877	652	7397	480	2947745	13546	95981	570655	70652	8788.2
Al-Riyadhah-North Terminal	1.2	10995	331	86747	4252	320	8884	480	4105519	48744	47120	625868	70652	11563.0
Al-Riyadhah-North Terminal	1.2	1864	56	42740	3166	357	4810	480	2041345	8264	52510	466067	70652	6293.1
North Terminal-Al-Aqsa	0.9	18234	549	86549	4625	413	9162	480	3081753	60632	45648	510607	52989	8880.2
North Terminal-Al-Aqsa	0.9	1746	53	69676	4159	523	5998	480	2436585	5805	57711	459078	52989	7143.9
Al-Aqsa-Tarek Interchange	1	20135	606	58811	6696	438	5760	480	2310099	74392	53711	821303	58877	8009.0
Al-Aqsa-Tarek Interchange	1	2233	67	60649	4194	492	4566	480	2333132	8249	60292	514480	58877	7083.1
Tarek Interchange-Prince Hamzah Hospital	0.8	2431	73	8567	782	112	2171	480	307326	7184	10965	76696	47102	1086.4
Tarek Interchange-Prince Hamzah Hospital	0.8	16490	497	33473	998	587	3515	480	1058623	48739	57590	97897	47102	3107.2
Prince Hamzah Hospital-Al-Istiqlal	1.1	0	0	4981	245	72	1338	480	248699	0	9648	33063	64765	859.4
Prince Hamzah Hospital-Al-Istiqlal	1.1	0	0	40219	476	241	5148	480	1785340	0	32508	64219	64765	4539.1
Al-Istiqlal-Al-Mahatta Terminal	2.4	6048	182	38837	1515	212	6208	480	3867742	53625	62381	445984	141305	10777.9
Al-Istiqlal-Al-Mahatta Terminal	2.4	6231	188	58634	1250	327	5180	480	5479229	55252	96386	367919	141305	14372.1

Total CO2 (tons/yr) 179,930.3

Baseline flow NO BRT

Passenger	Public bus/d	Auto/d	Good V/d	School bus/d	Taxi/d	Total Gasoline L/yr	Total PB Diesel/yr	Total SB Diesel/yr	Total GV Diesel/yr	Total CO2e (ton)
28430	856	42923	1893	613	3083	2304312	147050	105300	325081	6844.5
17188	518	40573	2475	302	3319	2198412	88902	51779	424938	6569.3
26604	801	15672	682	152	1324	1033674	167094	31643	142200	3289.2
33630	1013	43670	1622	223	3283	2855588	211226	46418	338168	8162.0
39147	1179	38494	915	105	7467	1973168	173557	15504	134628	5404.6
59291	1786	76727	2364	441	8786	3671148	262868	64919	348001	10252.1
42034	1266	95686	1701	291	19583	4123868	155298	35733	208693	10556.0
43809	1320	68022	3329	525	8079	2722569	161857	64451	408367	7959.8
42389	1277	81068	1726	259	16137	3825350	172271	34899	232878	9977.0
39251	1182	86922	3590	778	10103	3818260	159518	104934	484430	10785.8
48431	1459	71104	2221	436	15323	3092003	178934	53533	272489	8463.1
40510	1220	112238	4020	802	13248	4489414	149666	98377	493105	12309.3
32613	982	123660	5193	612	14601	5935715	144589	90083	764436	16326.1
10654	321	87551	4874	1092	10407	4205476	47233	160743	717431	12148.4
30497	919	115936	5119	537	13080	5538809	135208	79075	753425	15329.1
7767	234	62336	3966	647	7240	2986972	34437	95266	583767	8778.6
48002	1446	108997	5955	655	12615	3915720	159614	72320	657399	11385.3
8570	258	84805	4709	740	7584	2974769	28496	81702	519810	8527.5
48342	1456	66816	6443	601	6638	2627887	178606	73760	790275	8832.0
6533	197	63408	4005	572	5026	2448266	24135	70182	491304	7197.6
7046	212	8397	502	119	2001	297590	20827	11726	49300	903.4
35376	1066	27788	984	705	3278	889128	104561	69187	96556	2767.9
0	0	5154	272	74	1322	254864	0	10025	36727	711.3
0	0	31697	403	236	4306	1416828	0	31846	54331	3490.0
32982	993	44518	1568	240	6721	4399509	292451	70597	461604	12325.6
14413	434	57539	1573	419	5120	5380027	127800	123277	463130	14286.4

Total CO2 (tons/yr) 223,581.8

*Assuming 40 BRT per hour each way operating for 12 hours per day

BRT Route 2 CO2 Calculations for the baseline and BRT

Sources of data:

Traffic flow: from PTV VISUM model for the baseline and BRT cases

Mile per Gallon data: from US Department of Transportation

Fuel to CO2 data factors: from UK's Departemnt for Environment Food and Rural Affairs

	L/100 km	L/km		
L per 100 Km Diesel for Public bus and BRT	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Diesel for school bus	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Diesel for Goods vehicle	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Gasoline for taxi / car	**9.8**	**0.09802**	MpG	**24**

Litre	kg CO_2e/L
Diesel	2.67193
Gasoline	2.30075

Base flow and BRT flow

Line 2	Distance (km)	Passengers	Public bus/d	Auto	GV	S	Taxi	BRT/d	Total Gasoline L/yr	Total PB Diesel/yr	Total SB Diesel/yr	Total GV Diesel/yr	Total BRT Diesel/yr	Total CO2e (ton)
Sports City-Abdulhameed Sharaf	0.8	2946	89	49199	2762	529	6920	480	1606164	8706	51923	271056	47102	4707.5
Sports City-Abdulhameed Sharaf	0.8	2221	67	85440	3405	300	11161	480	2764792	6565	29407	334102	47102	7475.8
Abdulhameed Sharaf-Omar bin Abdulazeez	0.6	537	16	29584	898	282	4602	480	733819	1191	20789	66120	35326	2018.1
Abdulhameed Sharaf-Omar bin Abdulazeez	0.6	2202	66	45286	1182	161	5313	480	1086140	4881	11837	87020	35326	2870.5
Omar bin Abdulazeez-Al-Imam Muslem	0.8	284	9	26360	651	194	5041	480	898723	839	19042	63862	47102	2417.3
Omar bin Abdulazeez-Al-Imam Muslem	0.8	636	19	48284	861	425	6210	480	1559665	1881	41657	84469	47102	4056.3
Al-Imam Muslem-Makkah al-Mukarramah	0.7	7882	237	43665	478	402	5861	480	1240299	20384	34505	41082	41214	3220.2
Al-Imam Muslem-Makkah al-Mukarramah	0.7	3564	107	41272	444	181	5909	480	1181553	9217	15513	38113	41214	2996.5
Makkah al-Mukarramah-Moh'd Ali Jinnah	0.8	3054	92	41994	590	301	6376	480	1384401	9028	29498	57928	47102	3568.7
Makkah al-Mukarramah-Moh'd Ali Jinnah	0.8	1462	44	45431	584	368	5802	480	1466342	4322	36117	57326	47102	3760.8
Moh'd Ali Jinnah-Fawzi al-Qawuqji	0.6	3164	95	29801	278	157	5452	480	756737	7014	11523	20491	35326	1939.7
Moh'd Ali Jinnah-Fawzi al-Qawuqji	0.6	1541	46	21266	470	427	2581	480	511893	3415	31418	34618	35326	1457.7
Fawzi al-Qawuqji-Moh'd Ali Bdair	0.4	2008	60	29312	276	147	5355	480	496097	2967	7189	13565	23551	1267.7
Fawzi al-Qawuqji-Moh'd Ali Bdair	0.4	1239	37	20847	465	552	2771	480	337981	1831	27075	22792	23551	978.7
Moh'd Ali Bdair-Barada	0.6	2158	65	25332	249	77	4670	480	644017	4785	5673	18306	35326	1653.0
Moh'd Ali Bdair-Barada	0.6	994	30	16497	536	564	2022	480	397513	2203	41538	39433	35326	1231.2
Barada-Prince Ali bin Al-Hussein	1.2	2247	68	25226	277	65	4693	480	1284439	9961	9577	40720	70652	3305.0
Barada-Prince Ali bin Al-Hussein	1.2	879	26	16938	685	589	2084	480	816639	3895	86766	100832	70652	2579.3
Prince Ali bin Al-Hussein-King Hussein Cultural Centre	1.2	2279	69	28191	619	35	6162	480	1474829	10105	5080	91123	70652	3866.0
Prince Ali bin Al-Hussein-King Hussein Cultural Centre	1.2	7158	216	17228	171	1795	3556	480	892275	31737	264202	25224	70652	3099.8
King Hussein Cultural Centre-City Hall	0.5	0	0	0	0	0	0	480	0	0	0	0	29439	78.7
King Hussein Cultural Centre-City Hall	0.5	10041	302	12253	133	1698	3444	480	280790	18548	104108	8160	29439	1074.2
City Hall-Al-Muhajareen Terminal	0.6	0	0	0	0	0	0	480	0	0	0	0	35326	94.4
City Hall-Al-Muhajareen Terminal	0.6	27255	821	58768	960	499	11620	480	1510938	60418	36743	70645	35326	4019.0

*Assuming 40 BRT per hour each way operating for 12 hours per day

Total CO2 (tons/yr) 63,736.0

Baseline flow NO BRT

Passengers	Public bus/d	Auto	GV	S	Taxi	Total Gasoline L/yr	Total PB Diesel/yr	Total SB Diesel/yr	Total GV Diesel/yr	Total CO2e (ton)
7799	235	65763	3043	862	9717	2160302	23052	84600	298653	6055.9
5980	180	100817	3593	414	13936	3284318	17674	40600	352555	8654.1
3407	103	37072	1027	394	5413	911981	7552	28992	75588	2397.9
6991	211	50284	1150	164	6328	1215210	15498	12043	84602	3095.5
1566	47	26553	605	215	4799	897335	4629	21144	59404	2292.1
4507	136	40774	649	340	5289	1318361	13321	33319	63688	3328.0
12176	367	48664	542	494	6632	1384790	31490	42380	46523	3507.7
6403	193	40148	379	188	5914	1153545	16560	16124	32541	2828.3
5353	161	36758	460	282	5819	1218590	15821	27711	45187	3040.7
3637	110	37709	520	262	5132	1226139	10749	25740	51005	3054.8
11198	337	28243	267	168	5375	721636	24822	12335	19643	1812.1
6078	183	20708	540	234	2335	494632	13474	17219	39717	1326.2
11333	341	27782	265	158	5284	473199	16749	7770	13000	1189.0
5561	168	24478	625	307	2968	392758	8219	15086	30657	1047.8
12475	376	24741	232	83	4730	632624	27653	6133	17093	1591.5
4641	140	21291	703	331	2486	510390	10287	24372	51774	1405.2
13702	413	24516	254	68	4734	1255719	60750	9983	37400	3178.0
4315	130	21669	847	354	2537	1039202	19131	52160	124620	2914.4
8992	271	16160	298	54	3779	856010	39867	8008	43833	2214.5
16981	511	45989	761	736	7136	2280693	75285	108269	111943	6036.9
0	0	0	0	0	0	0	0	0	0	0.0
20447	616	53362	1159	603	8813	1112178	37771	37008	71111	2948.6
0	0	0	0	0	0	0	0	0	0	0.0
58408	1759	65759	1001	511	13093	1692605	129475	37627	73666	4537.6

Total CO2 (tons/yr) 68,456.8

BRT Route 3 CO2 Calculations for the baseline and BRT

Sources of data:

Traffic flow: from PTV VISUM model for the baseline and BRT cases

Mile per Gallon data: from US Department of Transportation

Fuel to CO2 data factors: from UK's Departemnt for Environment Food and Rural Affairs

	L/100 km	L/km		
L per 100 Km Diesel for Public bus and BRT	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Diesel for school bus	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Diesel for Goods vehicle	**33.6**	**0.33606**	MpG	**7**
L per 100 Km Gasoline for taxi / car	**9.8**	**0.09802**	MpG	**24**

Litre	kg CO_2e/L
Diesel	2.67193
Gasoline	2.30075

Base flow and BRT flow

Route 3	Distance (km)	Passenger	Public bus/d	Auto/d	Goods V/d	School bus/d	Taxi/d	BRT/d	Total Gasoline L/yr	Total PB Diesel/yr	Total SB Diesel/yr	Total GV Diesel/yr	Total BRT Diesel/yr	Total CO2e (ton)
Al-Mahatta Terminal-Muhammad Diyaa Al Hak Rd	2.7	8291	250	38553	2406	168	4210	480	4130706	82711	55796	796843	158968	12427.7
Al-Mahatta Terminal-Muhammad Diyaa Al Hak Rd	2.7	8291	250	47999	3626	316	3881	480	5011386	82711	104548	1200965	158968	15663.9
Muhammad Diyaa Al Hak Rd-Ein Ghazal Interchange	1.2	5605	169	31392	2629	100	3022	480	1477453	24850	14691	386980	70652	4727.7
Muhammad Diyaa Al Hak Rd-Ein Ghazal Interchange	1.2	5605	169	32462	3135	292	1992	480	1479165	24850	42918	461469	70652	5006.1
Ein Ghazal Interchange-Marka Rd	3	9203	277	50828	3065	139	3243	480	5803314	102005	51077	1128012	176631	17246.9
Ein Ghazal Interchange-Marka Rd	3	9203	277	48676	7733	324	2810	480	5525878	102005	119074	2845617	176631	21379.6
Marka Rd-Zarqa terminal	12.4	6333	191	37011	4822	39	1360	480	17022309	290121	59053	7334230	730075	61644.3
Marka Rd-Zarqa terminal	12.4	6333	191	41417	14899	115	1135	480	18877113	290121	175152	22661305	730075	107174.8
														245,271.0

Baseline flow NO BRT

Passenger	Public bus/d	Auto/d	Good V/d	School bus/d	Taxi/d	Total Gasoline L/yr	Total PB Diesel/yr	Total SB Diesel/yr	Total GV Diesel/yr	Total CO2e (ton)
37124	1118	39369	2106	195	4571	4244457	370325	64744	697569	12791.8
37124	1118	47387	3245	389	4146	4977790	370325	128776	1074730	15657.8
37090	1117	30176	2634	84	2802	1415747	164440	12422	387768	4765.9
37090	1117	32187	2804	331	1997	1467558	164440	48720	412658	5048.6
36721	1106	51799	3371	159	3083	5890392	407010	58449	1240291	18110.0
36721	1106	56628	8204	319	2995	6399237	407010	117565	3018959	24191.1
32764	987	38978	5675	42	1277	17858034	1500998	64140	8631355	68331.2
32764	987	43013	17482	117	1045	19545235	1500998	177395	26589507	120498.5
										269,395.0

*Assuming 40 BRT per hour each way operating for 12 hours per day

APPENDIX D: NOISE IMPACT ASSESSMENT SHEET

Federal Transit Administration
Noise Impact Assessment Spreadsheet

version: 7/3/2007

Project:	**FTA Example 5-1, Part 1**

Receiver Parameters	
Receiver:	**Receiver 1**
Land Use Category:	**3. Institutional**
Existing Noise (Measured or Generic Value):	**40 dBA**

Noise Source Parameters	
Number of Noise Sources:	**2**

Noise Source Parameters		**Source 1**
	Source Type:	Highway/Transit
	Specific Source:	Automobiles and Vans
Noisiest hr of Activity During Sensitive hrs		
	Speed (mph)	13
	Number of Events/hr	5914
Distance	**Distance from Source to Receiver (ft)**	170
	Number of Intervening Rows of Buildings	0
Adjustments	**Noise Barrier?**	No

Noise Source Parameters		**Source 2**
	Source Type:	Highway/Transit
	Specific Source:	Buses (diesel-powered)
Noisiest hr of Activity During Sensitive hrs		
	Speed (mph)	13
	Number of Events/hr	438
Distance	**Distance from Source to Receiver (ft)**	170
	Number of Intervening Rows of Buildings	0
Adjustments	**Noise Barrier?**	No

Project Results Summary

Existing Leqh:	40 dBA
Total Project Leqh:	57 dBA
Total Noise Exposure:	57 dBA
Increase:	17 dB
Impact?:	**Moderate**

Distance to Impact Contours

Dist to Mod. Impact Contour (Sources 1+2):	253 ft
Dist to Sev. Impact Contour (Sources 1+2):	111 ft

Source 1 Results

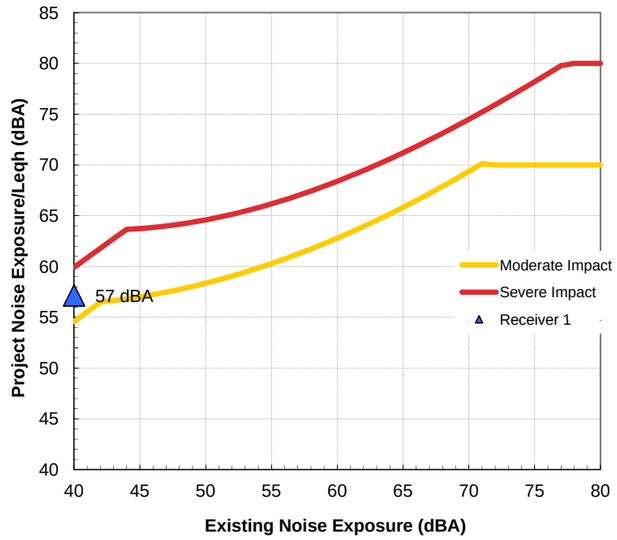
Leqh: 50.6 dBA

Source 2 Results

Leqh: 56.1 dBA

Incremental Leqh (Src 1-2): 57.2 dBA

Noise Impact Criteria
(FTA Manual, Fig 3-1)



Increase in Cumulative Noise Levels Allowed
(FTA Manual, Fig 3-2)