**Abstract**

The mass transit Metro system will be part of the Rider-Intensive Transportation System (RITS) serving the Tel Aviv metropolitan area. The Metro will run alongside the light rail lines (they have been approved, and some are currently under construction), and is designed to provide a solution for the future transportation demands in the Tel Aviv metropolitan area, to link the mass transit network of the Tel Aviv metropolitan area to the more distant suburbs, and to significantly shorten travel times to employment centers in the metropolis. Three lines are being designed for the metro system under three different projects:

National Infrastructures Project (NIP) 101 -- Metro Line M1 - A north–south radial line linking Herzliya to Raanana in the north, Tel Aviv in the center, and Rehovot-Ramla in the south. Due to its length, this line has been divided into two projects: NIP 101 A for the southern section, and NIP 101 B for the northern section.

National Infrastructures Project (NIP) 102 -- Metro Line M2 - An east–west line linking north Holon and south-central Tel Aviv in the west, with Petach Tikva (including the Sirkin district) in the east through Givatayim, Ramat Gan, Bnei Brak, and Givat Shmuel (seven municipalities). The line is about 24 km long, with one depot and 24 stations (23 are underground and one street level station near the depot complex).

National Infrastructures Project (NIP) 103 -- Ring Line M3 - Provides circumferential peripheral service to the south, east and north of the metropolis. It passes through 11 municipalities. The line is 39 km long, with 29 stations, and one depot complex.

This overview was prepared for NIP 102 Metro Line M2 (henceforth "the project"), and contains, in accordance with the directives of the National Infrastructures Committee (NIC) staff: examination of alternatives for routes and other aspects of the system, a description of the project, the work and the operation, specifications, and an examination of environmental impacts and directives to minimize environmental hazards and impacts.

**Chapter A - Background**

**General Description of the Project**

Metro Line M2 is an east–west line providing service to seven municipalities: Holon (northwest), Tel Aviv (southwest and downtown), Givatayim, Ramat Gan, Bnei Brak, Givat Shmuel (including Bar Ilan University) and Petach Tikva (including the future Sirkin district (. The project allows either of two alternatives for the section between the Haroeh Station Ramat Gan and Bar Ilan University: a Bnei Brak (North) option and a Ramat Gan (South) option, of which one will be selected in the detailed design stage. After this selection, the length of the actual route will be approximately 24 km and include about 21 or 22 stations, depending on the selected alternative, and one depot in the open area east of Petach Tikva, next to which is planned an elevated station (the rest of the stations are underground). The following table presents the main sites included in Line M2, with a total of 24 stations (marked on the table in orange; of these, 21 or 22 will be included in the line, as stated above), 12 branch sites, and a depot site for control and logistics that includes one station:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **City** | **Number** | **Facility** | **Station/Branch** | **Near activity hub/ Coinciding metro lines**  |
| Holon | 1 | Station | Wolfson Hospital | Wolfson Hospital |
| C1 | Branch site | Wolfson branch | End of the line near the station |
| Tel Aviv | 2 | Station | Nes Lagoyim | Academic College of Tel Aviv-Yaffo |
| C2 | Branch site | Nes Lagoyim | Near Nes Lagoyim station |
| 3 | Station | Shlabim | Bloomfield |
| 4 | Station | Carmelit | Carmel Market |
| C3 | Branch site | Carmelit branch | Near Carmelit station |
| 5 | Station | Magen David Square Station | Betzalel Market / Purple Light Rail line crossing |
| 6 | Station | Habima South | Habima Theater/Green Light Rail line crossing |
| 7 | Station | Hahashmonaim | Sarona / Red Light Rail line crossing |
| 8 | Station | Hashalom | Interface with Metro Line M1 interchange |
| C4 | Branch site | Hashalom branch | Near Hashalom Station |
|  | T1 | Substation | Hashalom Substation | Near Hashalom Station |
| Givatayim | 9 | Station | Noga Square | Givatayim Center |
| 10 | Station | Katsanelson | Givatayim Center |
| Ramat Gan (Alternative1)\* | 11 | Station | Haroeh | Ramat Gan Center |
| 12 | Station | Harav Levin | Bus Terminal |
| 13 | Station | Bar Ilan University (2) | Bar Ilan University / Purple Light Rail line crossing |
| C5 | Branch site | Bar Ilan branch | Near Bar Ilan Station |
| Bnei Brak (Alternative 2)\* | 14 | Station | Hazon Ish | Bnei Brak Cemetery |
|  | Branch site | Hazon Ish branch | Near Hazon Ish Station |
| 15 | Station | Kahanman | Bus Terminal |
| 16 | Station | Bar Ilan University | Bar Ilan University / Purple light rail crossing |
| Petach Tikva | 17 | Station | Kfar Ganim | Interface with Metro Line M3 interchange |
| C6 | Branch site | Kfar Ganim branch | Near Kfar Ganim Station |
| T2 | Substation | Kfar Ganim Substation | Near Kfar Ganim Station |
| 18 | Station | Ben Gurion | Feinberg school |
| 19 | Station | Arlozorov | Rabin Medical Center Beilinson Campus |
| 20 | Station | Petach Tikva municipality | Petach Tikva municipality |
| C7 | Branch site | Petach Tikvah Wolfson branch | Near Petach Tikvah Wolfson Station |
| 21 | Station | Petach Tikva East | Sirkin junction |
| 22 | Station | Sirkin South | Sirkin complex (operations center 1076 |
| C8 | Branch site | Sirkin South branch | Near Sirkin South Station |
| 23 | Station | Sirkin North | Sirkin complex (operations center 1076 |
| C9 | Branch site | Sirkin Center branch | Near Sirkin North Station |

C9

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **City** | **Number** | **Facility** | **Station/Branch** | **Near activity hub/ Coinciding metro lines**  |  |
|  | C10 | Branch site | Sirkin North branch | Near Sirkin North Station |  |
| 24 | Station | Segula | Depot complex /Segula junction |
| 24D | Depot | Petach Tikva East depot | Control and logistics site--end of the line |

\*Includes Givat Shmuel\*

**The Transportation System**

• **Main road system**: In the area of the planned line, there are several major highways:

* Highway 20 - crossed by the Metro near Wolfson Station and Hashalom Station.
* Menachem Begin Road/ Hamasger -- near Hahashmonaim Station
* Highway 471 - connects Bar Ilan interchange and Highway 40 - located south of the planned line, parallel to it.
* Highway 4 - passes near Bar Ilan University
* Highway 481 (Jabotinsky Road) - located north of the planned line and parallel to it.
* Highway 40 - near Sirkin Junction

• **Interface with metro stations**:

ס Connects with Metro Line M1 at Hashalom Station, Tel Aviv

ס Connects with Metro Line M3 at Kfar Ganim Station, Petach Tikva

* **Israel Railways**: The following railway tracks pass through the area of the project:

ס The coastal railway that connects Haifa to Tel Aviv - The track is crossed by M2 at Hashalom Interchange.

ס Tel Aviv Bnei Darom track -- connects Tel Aviv and Yavne, and from there to the Lod track. Line M2 connects with Israel Railways at Wolfson Station, Holon.

* + Hasharon track - Segula Station

• **Light Rail:** In the Tel Aviv area, there are 4 light rail lines in the mass transit network (MTAN). The light rail lines interface with the Metro M2 line at the following stations:

* Red line - Yehudit Station (Light Rail) and Hahashmonaim Station (Line M2).
* Green Line - Interface between Kaplan Station (Light Rail) and Habima Station (Line M2).
* Purple Line - Interface between Allenby Bar Ilan Station (light rail), and Magen David Station and Bar Ilan Station (Line M2) and Kfar Ganim Station (Line M2).

• **Future roads and tracks**: NIP programs being promoted in the area include electrification of the coastal track (NIP 18 - approved), and addition of tracks on the Ayalon. (fourth track, NIP 33 - approved). Of these infrastructures, the only one relevant is the addition of the infrastructure on the coastal track which interfaces with the Metro line at Hashalom station (at that point there will be electrification and addition of tracks 4, 5-6) and at Wolfson Station (electrification of the track only).

**Chapter B -- Review of Alternatives**

**Macro alternatives for line routes and stations**

The proposed reviewed route is based on alternative assessment reports prepared by SYSTRA in the initial planning stage, and included route alternatives for three different sections of the M2 line.

**Western segment** - Alternative A1 (northern) was found to be preferable over the other two alternatives (A2, A3), as it has important advantages in terms of service: there are many more activity hubs, the area is more heavily populated, it interfaces with other metro lines (M1 and M3), and it should lead to a greater reduction in the use of private cars. Its environmental impact will be more moderate (hazards, electromagnetic fields/interference), it is more remote from pump drilling protective radii, and the construction cost is lower than that of both alternatives.

**Central segment** - Alternative B1 (central route) was found to be preferable to the three remaining alternatives. It connects with the Purple Light Rail line, it passes closer to the area suspected of having soil and ground water contamination than the other options, it passes through a less built-up area which reduces statutory difficulties, and it is not expected to greatly impact environmental considerations.

**Eastern segment - (Rosh Haayin area)** - During the initial planning stage, Alternative C2 (northern route) was found to be preferable, however, this option and others that were chosen in this segment were found to be problematic, and their development was discontinued (see below).

**Changes examined for the selected macro alternatives**

During the early planning stage, additional surveys were conducted, additional alternatives were examined, and changes were made accordingly to the route selected in the initial planning stage.

**Eastern segment (Rosh Haayin)** - The Rosh Haayin segment included examination of seven planning alternatives -- C1, C2, C3 (selected in the original planning phase), Shabazi, Northern, Southern, and the overpass (these were looked into as part of the planning process.)

Comparison of the various alternatives, showed that none of them meet the mandatory condition of avoiding the risk of irreversible damage to a central national water resource, and therefore, it is not possible to advance any of the alternatives of the eastern segment. Furthermore, they all have many significant operational and environmental disadvantages:

• All the alternatives examined constitute a risk to the sensitive mountain aquifer and drilling for water there; this is true for both the underground and surface alternatives.

• Lack of connection with the Metro system -- The effect of the Rosh Haayin section on the two additional lines is negligible (this is true for all the alternatives).

• Efficiency of service is significantly lower than that of other segments because of a lack of urban continuity throughout this section (true for all alternatives).

* It passes through vast areas where no people are being served at all. Rosh Haayin is not contiguous to the Gush Dan metropolis, and therefore there would be 3-6 km where there are no additional passengers, while travel time is increased and level of service is lowered.
* The Rosh Haayin section would serve only about 7% of the riders on Line M2, but it constitutes about 30% of the line's distance.
* Partial implementation of the route option for M2 between Sirkin and Tel Aviv (without the Rosh Haayin section), about two thirds of the distance of the line, retains over 90% of the riders.
* Therefore, the line is significantly less cost-effective than the other line segments.

• Low demand on the Rosh Haayin segment indicates low development intensity that cannot support building a Metro line in this area, as opposed to the high level of demand in segments west of Highway 6 (true for all the alternatives).

• Risk to sites of major archeological value (Tel Afek, including Antipatris Fort) and ecological value in the Yarkon river sources in the Yarkon National Park (which are based on an abundance of groundwater in this area) -- Alternatives C2 and Shabazi.

• Lack of appropriate ground conditions because of the passage through a cracked area with karst cavities (true for all alternatives).

• Low feasibility of being carried out because of significant planning conflicts (common to all the alternatives) -- serious conflict with the Water Authority and the Health Ministry (all the alternatives) and, a conflict with Israel Nature and Parks Authority and Israel Antiquities Authority because of the routing and stations in the national park, and archaeological sites of major importance (Alternatives C2, Shabazi), and crossing of key infrastructures (elevated bridge) .

• Because of the abovementioned (violation of a mandatory pre-condition for planning, and many significant disadvantages), it was decided in a wider forum that included representatives of the Finance Ministry, Planning Directorate, the Ministry of Transportation, and NTA to cancel the Rosh Haayin segment and end Metro Line M2 at Sirkin North station.

**Bar Ilan** **alternatives** - Selected Alternative B1 passes within the boundaries of Bnei Brak. Because of the difficulty in ensuring certainty for the period of the implementation, it was decided to add to this area an additional alternative in Ramat Gan (Southern Alternative) that would be included in the plan and would enable building the line on an alternative route. The plan will include both alternatives and allow their implementation. If at the detailed planning stage, the Bnei Brak alternative is not allowed, the subcommittee has the authority to decide to build the Ramat Gan alternate.

**Central Petach Tikva alternatives** - Alternative B1 which was selected in the initial planning stage had the route run on Ahad Ha'am Street, a relatively narrow and secondary street in southern Petach Tikva. Another alternative was examined in that area, based on the Arlozorov-Wolfson artery, a more central route north of B1. A comparison of the two alternatives found the Arlozorov option to be preferable due to service considerations: it passes through an area with high building densities, on a central artery that serves many more and more central activity hubs in the city than the original option.

**Hashalom-Habima, Tel Aviv section alternatives** - Alternative A1, which was selected during the initial planning stage passes north of the Habima Theatre, via Kaplan Street and the Sarona Station. As part of the requirements of the Tel Aviv municipality to create an interface with the Red Light Rail line, two alternatives passing on a more northern route based on Haarbaah and Hahashmonaim Streets were examined. Comparison of the three options found the Hahashmonaim alternative preferable as it offers several advantages: optimal connectivity with the light rail, no detriment to historic buildings, relatively insignificant damage to buildings (damage to old low office buildings that can be repaired), a central location serving many points of interest, with no significant planning conflicts.

**Examining alternatives for the depot site**

Metro Line M2 contains one depot complex - an operational logistics complex for the railway in an area of about 300 dunams that has facilities for several main functions: train storage rails, train car washing, maintenance and infrastructure facilities, test ride tracks, and more. The depot is connected to the metro route through the portal extension, the first part (600 m) constructed by digging and covering, and the continuation in 400 m of open trench.

Several depot location options were considered in the initial planning phase, and 17 options were considered in the early planning stages. The options were considered against the threshold conditions for planning, and in accordance with a variety of engineering, design, and environmental criteria. The vast majority of the alternatives were found not to meet the threshold conditions, and to have essential deficiencies, and were therefore ruled out in the early stages. Two of the alternatives were found to meet the threshold conditions.

• Givat Hashlosha -- located in an agricultural area northwest of Rosh Haayin, next to the junction of Highway 40 and the railway track , (Mesilat Hasharon), about 1,000 meters from the route, distant from residential areas.

• Petach Tikva East -- located in an agricultural area northeast of Petach Tikva, located between the new route and the planned route of Highway 40, adjacent to Segula Interchange.

Comparison of these two options found that the Petach Tikva East option had significant advantages, and it was therefore selected for planning:

• This alternative does not create a new development hub, but is adjacent to existing buildings in an urban area, in an area adjacent to development and intended for development in Petach Tivka's new master plan.

• It is located on the coastal aquifer and on the edge of Protective Radius C for boreholes in the Sources of the Yarkon area, and therefore its potential impact on these boreholes is significantly lower than that of the Givat Hashlosha option. In addition, at this time, there are proceedings to reduce the area of Protective Radius C so that it will be possible to place in it functions that are in conflict with Protective Area C.

• It is located on the edge of an ecological corridor and is adjacent to planned and existing development. However, it is next to the area of Nahal Shilo and Nahal Mazor (defined as part of the core of the corridor), but it almost does not affect the area of these streams since bridges are planned to ensure the passage of animals along the channel.

For these reasons, the Petach Tikva East alternative was determined to be preferable, and integrated into the project.

**Reviewing micro-alternatives**

**Options for logistical areas**: The Metro Line M2 route contains several different types of logistical areas:

• Delivery site -- main sites, which contain the TBM entry point, logistical facilities, and offices.

• Contractor camps (offices) and piling areas -- these areas are intended for all works on the line.

• Local logistical areas for stations -- these areas are for use in building underground metro stations.

Placement of the delivery areas along the route is determined in accordance with the following planning specifications:

• Minimum area size - in accordance with its various functions.

• Allowing distances between the logistical areas along the route.

• Location considerations - Proximity to the route without planning for future development: parks, public gardens, etc.

Along Line M2 there were three delivery sites that meet the design requirements, and other sites intended for waste piling and contractor camps (offices).

**Alternatives types of stations**

All the metro stations are underground. During the planning, three possible types of stations were considered: wide station, station with one tunnel passing through the station box and one tunnel adjacent to it, and mining construction station:

• Wide station - Built on three levels (technical floor, ticketing floor, and track platform floor using the C&C cut and cover method, and characterized by an island (center) platform positioned between two tracks. This type of station enables on the one hand, a high level of service; and on the other hand, it must be very wide (27.4 meters), and creates construction problems in places where the width of the road does not allow digging from above. It requires extensive demolition of buildings and as a result significant compensation to land rights holders.

• Station with one tunnel passing through the station box and the other tunnel passing next to it, connected manually to the station building. The station is built on three levels using C&C. This method creates a building that is narrower than with the wide station (19.7 meters), but it does not obviate the need for most of the demolition of buildings above the station, since the station building is positioned using the cut and cover method - as opposed to the excavation station (described below), almost entirely positioned using the New Austrian tunneling method (NATM).

• Mining construction station - This model consists of two connected parts: the first, is the platform hall (including also ticketing facilities) constructed under the street using mining (NATM), by widening the track tunnels (which were constructed previously with a TBM), and connecting them. In addition, a station entry building is constructed using cut and cover in the field next to the platform hall (but outside of the track route). This type of station minimizes the need to demolish buildings, and obviates the need to destroy rows of buildings as is required in implementing the wide station on especially narrow streets. This type of station also has several advantages during the construction stage - regarding environmental hazards (such as dust and acoustic hazards), and damage to the urban fabric (blocking arteries and negatively affecting local businesses); it minimizes the need to relocate infrastructures. However, the major disadvantage is the complexity of construction, given the lack of experience in both planning and construction of stations of this type in Israel.

In conclusion, there are tradeoffs between the different types of stations -- mainly between the mining station and the wide station. The mining station reduces to a minimum building demolition, traffic and road function disruptions, and environmental impacts during the work, but increases the complexity of construction as there is a lack of experience and know-how in Israel in building this type of station. Wide stations can be built easily in Israel. Stations of that type were constructed for the light rail, and they have a higher level of service than the mining stations. However, in cases where the road is narrow, the wide station requires extensive destruction of buildings, creates a wider potential for exposure to hazards and nuisances during construction, as well as significant disruption of traffic and street function. In view of these tradeoffs, it was decided to use both types in planning Metro Line M2 - the wide station and the mining station. In situations in which the road is wide enough, and in situations where building demolition is not expected to cause significant damage to the urban fabric, wide stations will be built. On narrow streets where a wide station would lead to extensive building demolitions, the mining method will be used to construct stations, obviating the need for most of the demolition. It was also decided to allow planning flexibility in four stations - planning the station according to the mining model, but allowing flexibility to plan in the future also according to the wide station model in cases where the mining station model would not be feasible. In view of this, on Metro Line M2 it was decided to build five mining stations, four stations with planning flexibility with preference for a mining station, and 14 stations according to the wide station model.

The station model with one track inside the station box and one outside would not be included in the plan as it was found unsuitable for conditions along the metro line route.

**Alternative methods for constructing underground stations**: three main methods were considered:

• **Cut/dig and cover (C&C)** - constructing perimeter retaining walls around the station (external box), and afterwards digging from above in the area trapped between the walls using mechanical tools, to create the station hall. If the station is below groundwater level, the groundwater must be pumped out during the entire construction period.

Advantages

o This is an accepted construction technique in Israel, and there are people who are experienced in it.

o There is flexibility in placement of station entrances.

o There would be a fixed plan for the stations, which would be uniform all along the line.

Disadvantages:

o It requires demolition of buildings in the station area.

o Streets would be closed and traffic diverted during the construction period.

o There would be significant relocation of infrastructures in the station areas.

o Environmental hazards - noise and dust.

o Negative effects on local businesses.

o The groundwater would need to be lowered throughout the period of excavating the station.

• **Tunnel construction using New Austrian Tunneling Method (NATM) mining** - with this method, the station is constructed using conventional mining - initially a vertical entry shaft is dug alongside the location of the station, as well as a relatively short tunnel connecting it to the mining site for the station.

Then the station building itself is tunneled into the adjacent field, where the access tunnel is used to bring in construction materials and remove excavation waste.

Advantages

o This method does not require closing streets and diverting traffic during construction.

o Building demolition is reduced.

o Limited infrastructure relocation - there is flexibility in the form of the station.

o Reduction of environmental hazards - noise, dust.

o Reduced harm to local businesses.

Disadvantages:

o The method requires a contractor and planner with experience in this type of construction.

o There are greater risks in building a tunnel with this method than with cut and cover.

o The groundwater would need to be lowered throughout the excavation period.

o Geologic conditions are required that allow excavation with this method (to prevent liquefaction of the land) - this method requires land improvement below the groundwater level on a large scale.

In conclusion, for Metro Line M2, it was decided in the initial stage to design stations using the C&C method along the entire route. Later on, in view of the extensive demolition and expropriation required as a result of building stations on narrow streets, it was decided to build stations using the NATM method on these streets, and thus minimize the potential damage. On Line M2, nine stations are planned using the NATM method, and the remaining stations using the C&C method.

**Alternatives methods for excavating tunnels:**

Tunnel excavation can in principle be carried out using three different methods:

• **Cut & Cover (C&C)** - excavation from above of the entire route of the tunnel, building the structure, and covering it.

• **New Austrian Tunneling Method (NATM)** - Bringing in backhoes etc. and construction equipment via side delivery shafts and short connecting tunnels to excavate the space for the station.

• **TBM method** - allows excavating a tunnel from underground, with minimum surface impact, and relatively quickly, (in comparison with NATM.)

The metro route is characterized by a dense urban environment. In view of this, the C&C method, in which tunnels are excavated from top to bottom, was ruled out completely, since it causes extensive damage on the surface. With the NATM method, the excavation speed is much slower, one to two meters per day, and it is much more expensive than the TBM method. For these reasons, the TBM method was selected for building the planned route. However, the NATM method is not limited in terms of work radii (turns) and so it will be used locally in sections that are not suitable for TBM.

**Alternatives for switch locations:**

A switch is a railroad track apparatus that enables transfer of a train from one track to another--and thus includes a diagonal track linking the two tracks, and switching devices that move the train from one track to the other. The switches were intended for various operational purposes such as: moving trains onto a route that bypasses a section where there is a malfunction, or regulation of excessive traffic loads in a certain direction.

Placement of the switches is determined according to the operational specification of the line received from the developer (planned by SYSTRA): horizontal and vertical route limit, located near two terminal stations (Wolfson and Sirkin), in order to enable the train to change direction before entering the station. Location of switches at central hubs along the route in order to enable detours and changes in traffic during emergencies, location of a switch that enables entry to a depot from both tracks.

The possible methods for building switches are identical to methods for building stations, but on Line M2 it was decided to build all the switches that are under built-up areas (residences, institutions, etc.) using NATM in order to avoid building demolition and traffic disruption on the street, except for a 10x10 square meter shaft to be constructed using C&C for the purposes of entry and removal of excavation equipment and materials. This shaft will be maintained and used in the operational phase for ventilation and emergency escape, after adapting the size of the opening to what is generally accepted for this purpose. Switches located under roads or open areas can be constructed using one of the two methods (to be determined during the detailed planning stage).

**Principles for determining escape means:**

Escape means are planned in accordance with the NTA operational specification. The main safety means for escape from the main tunnels that the tracks pass through are the connecting tunnels (cross passages) which are meant for use as passages between two metro tunnels in an emergency. In places where it is not possible to position cross passages, vertical emergency shafts will be constructed to allow escape to the surface. The cross passages are constructed using NATM, and the escape shafts are constructed using C&C. According to the safety guidelines, the distance between the cross passages/escape shaft is to be 250 meters, and there are to be a total of about 70 such escape means (some are cross passages and some are other solutions - escape shafts etc.) along the line.

**Description of the project and its environment**

**Description of project components**

• Transit stations with RITS lines - the Metro system has Lines M1 and M3 in addition to M2. The connection to Line M1 is at Hashalom Station, and to Line M3 at Kfar Ganim Station, Petach Tikva. There are connections to existing light rail lines in several places:

o Purple line - at Magen David Square Station, Bar Ilan Station, and Kfar Ganim Station.

o Green line - at Habima Station

o Red line - at Hahashmonaim Station.

• **Passenger stations along the route** - There are 24 stations planned in the program: 23 are underground, and there is a street level station adjacent to the depot complex, between Wolfson Station from the west and Segula Station from the east. Locations of the passenger stations were planned in accordance with the urban fabric, hubs of demand, connection to public transportation networks, and accessibility for the general public. The entrances to the stations are to be accessible.

• **Depot** - Line M2 operations and maintenance complex. The complex is on the Petach Tikva East alternative, on an area of about 300 dunams, north of Highway 483, and east of the existing Highway 40.

• **Portal** - is a passage connecting between the street level portion and the underground portion of the track. The depot is connected to the route by means of a connecting track (portal) approximately 1000 meters long, where the first 600 meters are constructed using C & C, and the remaining 400 meters in an open trench until it connects to the depot.

• **Metro route** - the route is composed of three different segments:

o Eastern segment - begins at Wolfson Station in Holon, and ends at Noga Square Station, Givatayim. The segment includes nine stations, and is in the heart of the Tel Aviv metropolitan area. This segment serves many central activity areas such as Wolfson Hospital, Academic College of Tel Aviv-Yaffo, Habima Theater, Hashalom [Azriel] Mall and more.

o Central segment - begins at Katsanelson Station in Givatayim, and terminates at Petach Tivka East Station (Sirkin Junction). In the area of Bar Ilan University, the plan allows either of two alternatives - North (Bnei Brak) and South (Ramat Gan). This segment includes 12 stations.

o Eastern segment - Sirkin District, Petach Tikva. This segment includes three stations -- two are in the district planned in the Sirkin complex (Sirkin South Station and Sirkin North Station), and Segula Station in the boundaries of the depot -- "Petach Tikva East."

• **Longitudinal view** - The entire metro route runs underground, except for the depot complex and the portal, where a 600-meter length is exposed in an open trench. The depth of the metro tunnel with respect to street level ranges from 43 meters (end of the line - Wolfson Station Holon) to approximately 21 meters (Nes Legoyim Station, Shlabim Station, Harav Levin Station, and Kfar Ganim Station), and 22 meters at Sirkin North Station. The route was planned based on a maximum slope of 4%. At the northeast end, the line rises to ground level and ends at Segula Station, Petach Tikva, a ground level station adjacent to the depot.

• **Cross-section** - Widthwise, there are two adjacent parallel tunnels, containing one track each. The external diameter of each tunnel is approximately 7.5 meters, and the distance between them is about 6 meters.

**Description of works being performed outside the area of the route -**

• Relocating infrastructures and changes in traffic management arrangements -- works for the construction of the metro route include underground work (excavating tunnels) and street level work to build stations, switches, and the depot. Street level works require relocating infrastructures (to be coordinated during the detailed planning stage) and closing streets.

• Setting up logistical sites - Construction works require several logistical sites that are located along the route -- delivery sites for the TBM machine, piling areas, work camps, storage of equipment, and more.

• Construction of electrical corridors and accompanying facilities -- in accordance with the NTA decision; electrical connection to the metro is through overhead power lines (but flexibility remains to connect it at high voltage if that is what is decided during detailed planning), and accordingly the project includes two substations located adjacent to an overhead power line, and short corridors to connect the substation to the metro line. The project allows both methods in building (overhead power line or high voltage), and if the decision regarding connecting electricity to the metro is changed (high voltage for example) a supplementary plan is to be submitted.

**List of information required ahead of the advanced planning stages-**

This section represents the continued environmental planning required from the NIP approval stage until execution:

Infra 1 - Process of building the heavy engineering components of the project (excavating the tunnels and digging the stations). At the time of this stage, environmental documents are prepared regarding the preliminary engineering works and establishing the railway infrastructure. These documents include several aspects: logistical sites, noise and vibration, soil contamination, excess dirt , movement, hydrogeology, and dust. Execution documents for the construction phase are to be submitted for approval to an authorized environmental body. For the execution phase, an extensive environmental monitoring system is to be established -- on behalf of NTA, project management, and the contractor.

Infra 2 - Installation phase of all the railway systems - tracks, signaling, electrification, and more. Ahead of this phase, all the environmental analyses must be carried out to the stage of metro operation. Ahead of the operational phase, an environmental document for the operational stage is prepared, proving compliance with required criteria specified in the environmental impact survey or criteria applicable at the time of the detailed design.

**Track route**

Engineering criteria - The metro tracks are designed for movement of trains that are 2.8 meters wide and about 109-127 meters long (8 cars), with average capacity of about 1000 riders per train. The metro stations were designed with a gross length of approximately 193 meters, about 1 - 1.5 kilometers one from the next along the route. The track route is planned according to the criteria that comply with criteria for vertical and horizontal radii, and in accordance with slopes at the stations.

Descriptions of the tunnels - Metro Line M2 is an underground rail system about 24 km long (minus either the Bnei Brak or Ramat Gan alternative, whichever is not selected for implementation), part of which is located below the groundwater level of the coastal aquifer. The route is built of two main parallel tunnels about six meters apart from each other, with an outer diameter of 7.5 meters and an internal diameter of about 6.5 meters, and they range in their average depths of 25-55 meters below the surface. The metro tunnel system contains several facilities and systems, among them a ventilation and security system in emergency situations - a system for regulating the temperature around the clock, particularly the busy hours, and emergency safety systems for smoke evacuation during a fire.

The tunnels are excavated using the TBM system, which is delivered underground via delivery shafts. This system is capable of working below the groundwater level, preventing water from entering the cavity of the tunnel being excavated, and therefore lowering the groundwater during excavation is not required. Rate of excavation progression is about 10 meters per day, with the works being carried out non-stop every day of the week.

In addition to the two main tunnels, cross passages (emergency crossings) are constructed along the route - short tunnels that connect the two main tunnels. In places where cross passages cannot be constructed, vertical emergency shafts are made to serve as means to escape to the surface. Along the route are planned escape means about every 250 meters -- a total of 70 escape means along the line. The NATM method is used continuously to excavate the cross passages in order to minimize distortion and subsidence of the ground. This method requires soil improvement (jet grouting) by injecting solidifying materials (grouting) or freezing underground before starting the excavation in order to ensure stability of the ground and sealing between the two main tunnels. At points at which it is impossible to construct cross passages, vertical delivery shafts are constructed to connect the main tunnels with the surface using the C&C method.

Switches - connecting tracks for transfer of trains from one track to another in case of malfunction or operational need. They are constructed using the conventional NATM method. On the M2 route, 12 switches are planned - two end switches (at terminus stations) and 10 switches in the center of the route.

**Stations**

As part of the Metro Line M2, 24 stations are planned (23 underground stations and one street-level station - Segula Station). Of these stations, 21 or 22 are to be constructed (two or three stations will become superfluous in accordance with the alternative to be chosen in the Bnei Brak - Ramat Gan area), whose location is determined based on the urban fabric, demand centers, and connection points between the existing and planned public transportation systems.

Along the line, two types of stations are planned - wide stations and mining stations, which each consist of a technical floor, a ticketing floor, and a platform hall. The stations have a central platform and two parallel tracks, with width of about 27.4 meters for a wide station, and 18 meters in a mining method station, with length of about 170 meters. All the stations enable a high level of service -- level C and above, and in each one,1 - 4 entrances are planned - entry structures on the street level, including a ventilation system. The stations contain several elements, among them: electric rooms, ventilation, control and communication, security rooms, water, and more. All the stations are adapted to people with disabilities and ensure their accessibility in accordance with regulations.

Urban-architectural development principles of the entrances to the stations -- Planning the stations is carried out according to the following principles, intended to integrate them into the existing urban fabric and encourage and create availability of the urban space in areas intended for future development:

• Connection to points of interest - located near major centers.

• Connection to public transportation, bike path, and pedestrians.

• Service for large crowds and accessibility to the general public, including people with disabilities.

• Tree preservation - maximum preservation of existing vegetation with scenic and historical value.

• Improved appearance of the street (in the vicinity of the stations): pleasant street atmosphere - ground tiling, furniture, and street trees.

• Wide sidewalks - wide and accessible for a free flow of people in approaching the stations.

• Accessibility to stations by clear entrances/exits, that are convenient and accessible to patrons.

• Bicycle paths - optimal connection, separating between pedestrians and bicycles.

• Gardening - reducing street asphalt.

• Architectural uniqueness - creating a unique identity for the metro entry building.

• Integration of entry building into the environment - aspects of size and architectural design.

• Destruction of buildings - minimized demolition of existing buildings when building the station.

• Maximum shading for climatic comfort at accesses and plazas afforded by planting trees and colonnades.

**Energy systems and accompanying infrastructures**

Electrical systems for the metro are designed using overhead power lines - with connections to be designed and produced by the Israel Electric Company.

If a decision is changed regarding the electrical connection to the metro (high voltage for example), a supplementary plan is to be submitted. The electrical systems include technical rooms and electrical rooms at the stations, stationary electrical systems along the route to feed the trains, electrical lines, and an emergency array that includes generators and back up facilities (in the station buildings and in the depot), and two substations. High voltage systems include two main components - a metro electrification system designed to propel the metro, and an electrical services system designed to supply electricity to the station and the tunnel.

Since the metro route is underground, and thus there are no security considerations for pedestrians, power is fed to locomotives via a low connection, obviating the need for poles and a hanging infrastructure. The lower feed can be carried out using the **third rail or fourth rail** systems. The third rail system is considered safer in terms of the effect of electromagnetic fields which have the disadvantage of creating stray currents through train tracks for adjacent metallic elements. The fourth rail system does not create stray currents, but it increases the effect of the electromagnetic fields. The decision regarding the metro electrification system is determined during the detailed design stage.

**Depot**

Depot on route M2 - Metro Line M2 contains one depot at the Petach Tikva East site at the eastern terminus of the line, about 100 meters from the urban area in northeast Petach Tikva. The site is located mostly on agricultural land and on the edges, on the existing channels of Nahal Shilo and Nahal Mazor. Forthe agricultural land, national, district, and local statutory plans do not impose significant restrictions on development, it is intended as an area for urban development that is adjacent to existing and planned development. The eastern and northeastern edges of the complex are located adjacent to Nahal Shilo and Nahal Mazor, on which national and district statutory plans impose significant restrictions on the development. These edges are designated in NOP 1 Streams as drainage arteries, as a forest park, and in DOP 3.10 as a strip of nature, designated as a linear park of great ecological value.

Stages of depot construction - The depot will be built in two stages: land preparation, and excavation and foundation work. Building the depot is expected to take about three to four years after the land has been prepared.

Principles of architectural landscape design - recessing and concealment of the perimeter fence by planting trees and suitable vegetation, and maintaining as moderate slopes as possible on the access road, for maximum integration in the open field landscape, and planting trees along it.

Portal at the entry to the depot -- The portal is a passage connecting the part on street level with the underground part of the track. The only portal on the line is located at the southeast end of the depot. It is composed of 600-meter-long open trench in the agricultural area northwest of Givat Hashlosha, and an exit point to the street level near the depot and the Segula Station terminus.

Importance of the depot location in relation to the drainage system - The depot is planned for the flood plain of Nahal Shilo and Nahal Mazor. Design of the drainage system for the depot complex is influenced by its close surroundings, including the planned drainage of Highway 40 into Nahal Shilo, thus requiring coordination on the design of a drainage system for this road.

Survey of trees at the depot - The tree survey is attached as Appendix 7. The survey includes a review of 342 trees in the area of the depot at the Petach Tikva East site, including the upper route of the spur and the portal through which it exits. A total of 168 trees (49%) were designated for preservation, and 174 (51%) for clearing.

Operational and traffic data - The operational specification of the line was put together by SYSTRA, and includes estimated average operational data for peak hours and throughout the day, and data of numbers of riders at peak hours and frequency of trains per hour. The maximum planned speed of the ride divided over various segments along the route is a function of the radius of the bend in any segment and the length of the train, and it is expected to range from 40 to 80 km/hour in any segment. In the detailed design stage, the exact ride speeds are calculated for each segment separately.

**Principles and stages of construction work**

Construction method for the main railway tunnels - Two main parallel tunnels are planned, separated from each other by a natural strip of soil / rock. The process of excavation for them starts in digging the delivery shafts for lowering the TBM machine and accompanying equipment. Excavation works for the shaft are similar to those of the stations and include setting up slurry walls (including lowering the groundwater level at the sites, excavating from top to bottom, removal of waste dirt, storing it temporarily at the logistical sites, and transferring it to approved removal destinations in accordance with the quality of the material removed.

After lowering the TBM to the starting point, the machine is assembled for completing the shaft. After being positioned, the machine is activated and excavates the tunnel non-stop at an average rate of 10 meters per day, removing the excess dirt behind it as it works. As the tunnel is created, reinforced concrete rings are installed in watertight connections, forming the tunnel's inner sleeve. The excavation is performed using the EPB method, which prevents entry of water to the digging in sections below the groundwater table.

Construction of cross passages - The connecting tunnels are constructed using one or more of the following methods:

• Underground construction - requires stabilizing the earth (jet grout), from the surface, and takes about two months.

• Ground construction - requires treating the tunnels as if they were stations, but much smaller. This takes about six months to build.

Building delivery shafts - the purpose of the shafts is lowering and assembling the parts of the TBM and removal of the waste soil during the tunnel-digging process. During the digging of each of the shafts, the walls of the shaft are lined with slurry walls to prevent entry of water (groundwater or surface runoff). Digging and building the shaft takes about a year.

Constructing cross passages - The digging work of the connecting tunnels is performed using NATM, for practical building reasons, and to minimize time on the street level.

Lowering the groundwater level - The water level in the entire station area can be lowered using intensive pumping in a borehole array that includes about 20-30 boreholes at each station. Lowering the water level is required from the stage where the depth of the digging approaches the groundwater level, and until the stage where the floor casting and sealing work and the like are completed. The pumped water is removed according to location, determined in coordination with the local water corporation, the draining authority, and the water authority.

In certain segments (where tracks split off or at switches), there might be NATM excavation. This system requires dry conditions, i.e. in segments where NATM is to be used under the groundwater level, the water level must be lowered. The volume of water to be pumped is greater than the volume required for lowering water in a wide station.

Construction stages - stages of construction for the underground route are fundamental at this stage:

• Drilling and casting slurry walls at the stations and delivery sites.

• Excavating tunnels using TBM.

• Installing electrification infrastructures and finishing stages – Infra 2.

Temporary traffic management plan - The metro project is executed for the most part underground, except for the depot complex and building the stations, switches, and delivery sites, which require temporary traffic management plans. The traffic plans operate according to the following guidelines:

• Free traffic flow is to be maintained.

• There are to be appropriately tailored paths for pedestrians, bicycles, and people with disabilities.

• There is to be proper access to public transportation.

Final traffic management arrangements - Every station is to interface with follow-on transportation in the best possible way - buses, light rail lines, bicycle paths, and more.

Initial recommendations to prevent hazards during construction - As part of the recommendations for preventing hazards during construction, several issues are taken into account:

• Location of logistical sites - At these sites, environmental hazards such as noise and vibrations, dust, damage to the urban continuum, and disturbances to pedestrians are liable to be created. In order to minimize these problems, the site is planned to be as close as possible to the construction site, and is required to meet all binding criteria.

• Storage of hazardous materials - Small enough quantities of these materials are stored so as not to require a poisons permit. The contractor is to comply with all requirements of the Environmental Protection ministry, fire-fighting services, etc.

• Prevention of groundwater pollution - Emphasis is to be placed on preventing seepage and leaks from oil reservoirs, sanitary effluents, and leachates from contaminated soil.

• Preventing hazards - The contractor drafts an environmental management plan to include activities and means to prevent undue noise and vibration, and dust; and solutions for environmental incidents, employee training, and more.

• Proper municipal function - The contractor formulates a temporary traffic management plan for the construction period.

Assessment of sensitive areas during the construction period - Areas sensitive to environmental hazards and repercussions during construction are divided into two categories - natural environment, and human environment. Since the metro route mostly passes through a densely-populated urban environment, all the areas adjacent to above-ground facilities can be classified as areas with environmental sensitivity. The depot area, which is adjacent to Nahal Shilo and Nahal Mazor, can also be classified as a sensitive area, adjacent to the protective radius of borehole drilling.

Description of buildings for demolition - As stated, part of the construction works for the stations are carried out above ground, and as such require, when necessary, building demolition. In this context, in view of testing performed, it was decided that five stations would be built according to the mining station model, 14 according to the wide station model, and about four other stations would be allowed flexibility - preference would be for a mining station, but it would be possible to construct them as wide stations, with the decision for these being made ahead of the detailed planning for construction.

 The quantity of buildings for demolition would change in accordance with the model to be used at the stations whose model has yet to be selected, or the option selected in the detailed planning stage in Bnei Brak--Ramat Gan.

Most of the buildings marked for demolition are residential buildings with existing statutory validity. At this stage, there is no knowledge of buildings containing asbestos, and which is checked as part of the detailed planning stge.

Description of the works required for building cross passages and escape shafts - this work is to be carried out using internal excavation (NATM) for the cross passages, and C&C for the escape shafts. The environmental repercussions from this construction are expected to be less than those of building the stations. In places where the shafts/tunnels are to be built below groundwater level, the water needs to be lowered for the entire construction stage, or alternatively, grouting is required to seal the ground. Grouting prevents penetration of water to the hewn area by injecting concrete at high pressure to stabilize the ground.

Description of the work for construction of switches - Switch sites under built-up areas are to be constructed using NATM, and accordingly the environmental repercussions involved in the construction are less than with the C&C method which creates the potential for environmental hazards from dust, noise, vibrations, lowering water if necessary, waste soil, building demolition, and blocked roads. During the detailed design stage, an environmental-acoustical appendix is submitted for works to prevent hazards. Switches in other areas (under roads, open areas, etc.) NATM or C&C are to be used (to be decided during the detailed planning stage.

**Logistical areas**

These areas are required as an important component in the process of building the metro route, and they are located all along the route. The logistical areas are divided into several groups: delivery areas, contractor camps, piling areas, and station and switch building sites. The access roads to the sites are based on existing roads, and are included in the temporary traffic management plans.

Delivery sites contain areas for taking in waste dirt (piling areas). The calculation of quantities of waste dirt approaches about 6,762,000 cubic meters, and a comprehensive solution is required to handle all the excavated material.

According to the methodology of handling waste soil, the material is temporarily piled up for 48 hours, is sampled to determine its quality, and then it is removed to its final destination based on its quality. Ground found to be contaminated is taken to special sites approved by the Environmental Protection Ministry for acceptance and handling according to its type and concentration.

In addition to the earth removed to form the tunnels, in certain places along the route, water is pumped to lower the groundwater level. Water disposal destinations are determined according to a water disposal report, depending on the findings of the sampling and in coordination with relevant authorities. On Line M2, water needs to be lowered at 12 stations, and therefore, about 38-46 million cubic meters needs to be pumped from the aquifers.

**Environmental Implications**

Infrastructure systems-As part of planning work, infrastructure coordination was conducted with local authorities and corporations, including:

• Trans-Israel pipeline - metro crossing in the Highway 40 area.

• Petroleum & Energy Infrastructures Ltd (PEI). - metro line crosses the PEI pipeline three times.

• Igudan - current Igudan lines cross the metro four times.

• Water Authority - Coordination with the existing Dan line in a crossing with Highway 40 and Highway 483. In addition, there was coordination with the western Yarkon line on Highway 4.

• Israel Electric Company - overhead power lines of 161 kV and 400 kV cross the metro routes in several places.

**Noise and vibration**

Noise during the construction phase:

Line M2 passes through dense urban areas and the project includes construction of station buildings using the cut and cover (C&C) method, and delivery sites near sensitive locations such as residential buildings and public buildings. Noise calculations were conducted at such places located in the area of the stations and delivery sites for the construction station. The noise was measured from the top and bottom floors. Results of the test were analyzed against accepted noise criteria, such as recommendations of the Environmental Protection Ministry and Abatement of Nuisances Regulations (Prevention of Noise) 1992. Noise calculations were made for every stage of work according to the appropriate equipment and the guidelines received from NTA: A - infrastructure upgrade, B1 - box, B2 - entrances, C - digging and casting. According to the results of the calculations, there are several buildings around most of the stations and delivery shafts in which the level of noise during at least one of the construction stages exceeds the noise criteria. Therefore, the ideal solution for lowering noise levels near the stations is implementing acoustic protection on a per apartment basis. If the excessive noise is to last only for a few days, residents can be provided alternate housing instead.

Vibrations and secondary noise during construction:

This section presents a forecast of vibrations during station construction, and from digging tunnels using a TBM. In order to determine the expected range of the vibration impact, calculations were made based on FTA documents that show the vibration levels for equipment to be used for construction. The calculations indicate that the distances that comply with the vibration criteria (72 VdB) are 38 meters from the station entrances, and 41 meters from the station boundary. Regarding the vibrations to be obtained due to the TBM, no deviations were found from the criteria in any of the locations tested.

There are a number of ways to minimize the impact of vibrations during station construction:

• Design considerations and project outline.

• Working only a limited amount of time consecutively in any one place.

• Using quiet work tools.

• Leaving a message for residents.

• Setting work regulations.

Noise and vibrations from the depot complex:

**Noise during construction** - Since these are routine building works that are essentially no different from other urban works carried out daily, and since the boundary of the project is at least 60 meters away from the nearest residential buildings, excessive noise is not expected to be a problem during construction.

**Noise during operation** - Noise calculations carried out from the depot take into account noise sources within the complex (mechanical systems, generators, light and heavy maintenance structures, train rides within the complex and rinsing facilities), and railway tracks surrounding the complex on the street-level route.

• Noise from train travel on street level -- Noise levels were calculated for one location typical of the three buildings adjacent to the depot complex, on Shimon Wiesenthal St in Petach Tikva. The calculations showed that the noise levels predicted during the day and night do not exceed the criteria.

• Noise from an above ground station (Segula Industrial Zone) - the station is located next to the depot complex at a distance of over 350 meters from the nearest residential building. At such a distance, no excessive noise is expected.

• Noise from the depot complex - Accumulated levels of noise calculated from noise sources operated in the depot do not exceed requirements during daytime (50 dBA) or nighttime (40 dBA) hours.

• Noise from test tracks

**Vibrations during construction** - Since the project is located more than 70 meters from the nearest houses, vibrations are not expected to exceed the criteria -- neither from travel in the depot complex nor from travel on the track that surrounds the complex.

**Vibrations during operation** - Since the project is at a distance of at least 60 meters from the nearest buildings, and the trains travel at low speed, vibrations are not expected to exceed the criteria.

**Air quality**

As stated in the previous section, the Metro line is located for the most part in a crowded urban area, and thus station construction work and activity at logistical sites have the potential to create dust hazards - from digging and loading, transport of dirt, storage of building materials, and digging / positioning works of concrete elements.

Means to keep dust from the works is determined for all potential emissions sources in environmental appendices to be prepared at the detailed design stages, and they include: fencing off the work area, wetting roads dirt piles, spraying and misting, covering trucks and piles, limiting travel speed and more.

**Electromagnetic fields**

Electromagnetic fields from the railway route: This section presents a theoretical specification of electromagnetic field safety for humans and its effects on land use and designations along the metro line. The safety ranges and exposure levels are adapted to the Environmental Protection Ministry guidelines and to the European standard, in accordance with the types of currents - direct current and alternating current:

• Magnetic field flux density in direct current:

o Maximum exposure to the general public - 600 Gauss.

o Maximum exposure to people with pacemakers - 5 Gauss.

• Magnetic field flux density at alternating frequency:

o Maximum exposure to the general public (frequency of 50 Hz ) - 4 mG average per day.

Electromagnetic field flux - Influence on humans: electromagnetic radiation field calculations are performed according to data of the “recipient” and based on the minimum depth of the railway from the surface -- at a depth of 16 meters. The calculations are performed for both direct and alternating current for a 3-rail system and a 4-rail system, and according to common currents (1500 ampere) and peak current (5145 ampere):

• Direct current (1500 ampere):

o 3-rail system - on the surface, flux of 40 mG was obtained, and within the train cars, flux of 500 mG was obtained. In both cases, the flux was in compliance with the criterion of 5 G.

o 4-rail system - on the surface, flux of 90 mG was obtained, and within the train cars, flux of 200 mG was obtained. In both cases, the flux was in compliance with the criterion of 5 G.

• Peak direct current (5145 ampere):

o 3-rail system - exposure threshold does not exceed 3 mG, thus meeting the 5 G criterion.

o 4-rail system - exposure threshold around the track and within the train stands at about 7000 mG, and is thus higher than the threshold exposure for pacemakers of 5000 mG. Outside the tunnel, the flux is not higher than 300 mG.

• Alternating current -

o 3-rail system -

• On street level - the range in which the electromagnetic field flow is obtained is higher than the criterion (4 mG) on the roof of the tunnel (8 meters from the track). There are thus no conflicts along the route (from street level to a depth of 8 meters) as the flux is lower than this criterion.

• Inside the train - the maximum flux obtained is 10 mG. Considering the short time of the ride, the daily average flux is smaller than the 4 mG criteria.

o 4-rail system -

• On street level - the range in which the electromagnetic field flow is obtained is higher than the criterion (4 mG) on the roof of the tunnel (8 meters from the track). There are thus no conflicts along the route (from street level to a depth of 8 meters) as the flux is lower than this criterion.

• Inside the train - the maximum flux obtained is 20 mG. Considering the short time of the ride, the daily average flux is smaller than the 4 mG criteria.

Electromagnetic field flux - impact on the system: based on European standard requirements, an electromagnetic field that complies with the standard must be ensured in a range of 10 meters from the rail. In accordance with the forecast results, the intensity of the electromagnetic field does not exceed the recommended threshold values, and therefore there is no concern that there be interference with sensitive equipment or life-support systems at a distance exceeding 10 meters.

Testing of electromagnetic impact in the depot complex revealed that deviations from Environmental Protection Ministry criteria were not expected outside the depot complex. The impact of the sources was expected to be just patchy, and they are also remote from manned areas of the complex.

Stray currents: these are currents caused when the electric power source leaks to the ground and nearby metal installations, instead of returning to the source transformer through the railroad tracks. These currents are liable to create corrosion in adjacent infrastructures. Stray currents can be prevented by a potential equalization network layer - installed under the train tracks to absorb currents before they reach a nearby metallic infrastructure. At the detailed design stage, there is testing and measurement of stray currents, and accordingly, the scope of required protections is decided.

Substations - Two substations are planned on Metro Line M2 - Hashalom Substation and Kfar Ganim Substation. In order to comply with threshold criteria for electromagnetic radiation, the substations must be a minimum of 35 meters from sensitive environments/locations. Kfar Ganim Substation is located a long way away (85 meters) from sensitive environments, and thus the impact of electromagnetic radiation on them is in compliance with the threshold criteria described above. On the other hand, the Hashalom Substation is a short distance (10 meters) from populated buildings (Max Fein vocational school), and therefore deviation from the threshold criteria is expected. In view of this, as part of the detailed design, the magnetic flux is estimated, and if necessary, means are determined to prevent deviations from the Environmental Protection Ministry criteria, and the electromagnetic radiation is measured to ensure compliance with the ministry's criteria.

**Geology**

The metro route is underground and crosses four geological layers along the coastal plain: alluvial clay soils (AI), hamra soils (Qh), kurkar (Qk) and sand dunes (Qs). This breakdown is based on the 1:50,000 geological map, several boreholes drilled near the NTA red line project, and several boreholes drilled by the Hydrological Service. Following is a description of the geological conditions in the area of the program, and their engineering significance:

• The route of the Metro Line M2 project crosses brittle rock units (clay, sand and kurkar) - excavation in this type of rock requires massive bracing along most of the cut.

• Stability of the rock is greatly impacted by the presence of water, and therefore careful attention should be paid to the groundwater level in relation to the levels at which the tunnels and stations are excavated along the route.

**Seismic Risks**

The metro route is located in an area described as aseismic (there are no active faults in the area), based on the model obtained from the Seismogenic Sources the main lines in Israel - the Arava fault, the Carmel fault, and more. However, this definition does not rule out the possible future occurrence of destructive earthquakes in the route area.

Seismic Acceleration: In accordance with the PGA coefficent (horizontal ground acceleration) at the surface, low accelerations are expected to be obtained in the plan area, and therefore, no complex engineering solutions are expected to be needed in this regard. During the detailed design stage, this subject is to be examined by a foundation and tunneling consultant.

Seismic Site Effect: This is a local condition where the geological structure causes increased earthquakes. Along the route there is an area with suspicion of excessive amplification - in the area of the Carmelit Station and Magen David Square, and also eastward from the Bar Ilan Station. A decision on the location of specific site surveys is to be made after completing drilling and in consultation with foundation/tunneling consultants.

Liquefaction: a phenomenon where the soil behaves like a liquid during an earthquake. The metro route is classified as having low to negligible sensitivity along its entire length.

**Impact of the plan on the hydraulic and geohydraulic system**

The metro project is being built for the most part underground, except for the stations and switches (cut and cover) and the depot and portal areas. Thus, the flooding areas and surface drainage systems are relevant only for the depot complex, as in the area of the stations, the hydrology is based on existing municipal drainage systems.

The underground metro route: the western portion of Metro Line M2 passes along the coastal plain, and advances east toward the Shfela. Most of the route is under the groundwater level, and the water level needs to be lowered at 13 stations, requiring pumping of about 150 million cubic waters of water from the aquifer. The estimate of the volume of water that can be injected in the entire metro, given that the water is of high enough quality for this purpose, is about 82% of the volume of what is pumped.

Prevention of the flow of leachate to groundwater: In general, at the time of detailed design, a plan is to be drafted for the management of excess water, to ensure that the groundwater and streams are not damaged during construction work. The plan is to include fencing and sealing work areas near the streams, particularly the depot complex.

Impact of the project on the hydrogeological system: the entire length of the metro tunnel is dug underground, with part of it being under the ground water level, and part above. Such excavation may constitute a violation of the underground flow system, and accordingly a qualitative and quantitative test was carried out to check for potential damage. The possible damage was ruled out.

Excavation, mining, and construction under the groundwater level:

• **Mining using TBM** - This system does not require lowering the groundwater, as the excavation is performed while pushing water from the ground.

• **Mining and excavation of the stations** - Station shafts are excavated using methods that require work in dry conditions, requiring lowering of the groundwater level - use of C&C and NATM. It is recommended that adjacent stations not be excavated in consecutive order, and to start with deep stations, to avoid wave interference of hydrological depressions created when lowering the water.

• **Mining cross passages** - In Line M2 there are seven switches under the groundwater level. The switches are dug similarly to the stations, and have a similar effect on the groundwater.

Effect of the project on water boreholes:

• **Current situation** - According to Hydrological Service records, along the metro line and its edges (range of 25 meters) there are 33 boreholes. In the Health Ministry database, there are 12 boreholes to produce drinking water, whose protective radius passes near the route.

• **Potential effect of the excavation work on the boreholes** - There are three main potential effects:

o Physical - an initial examination indicates that boreholes at a distance of two or more meters from the route are not expected to be harmed. On the route there are 18 boreholes at a distance less than two meters from the route. Fifteen of them are used for industry and research, and therefore they can be canceled or moved, and three of them are production boreholes, only one of which is active (Andromeda 1), and activity must be coordinated with the borehole owners.

o Constant damage to production potential of the well due to lowering the path of the flow - The tunnel is not expected to cause continuous potential damage to water production, except at borehole Andromedia1, which is in danger of physical damage.

o Temporary damage to production potential of the well due to lowering the flow path - The metro route passes within the protective radii of 10 active boreholes. In areas in which the route is located in the area of protective radii B and C, special guidelines are devised to prevent contamination of the water.For non-active boreholes, a request is submitted to the Health Ministry to cancel the protective radii and the relevant restrictions.

Means to minimize/avoid undesirable consequences on the aquifer:

• Pumping volumes and timing of the lowering works to be coordinated with the water authority.

• Required pumping pace and the geometric array of the boreholes to be carefully planned at each station.

• Removal solution is coordinated with the water authority and relevant bodies.

• In the area where the route passes through the protective radii, the works are performed according to authority guidelines.

• The project includes detailed instructions to prevent water contamination due to damage to the coastal aquifer.

• Spill containment pallets are installed underneath containers of diesel, fuel, oil, and dangerous materials.

• If necessary, work sites to be drained using perimeter channels.

**Soil and groundwater contamination**

A historical survey was made to locate places suspected of soil contamination (attached in the appendices) according to databases, tours in the area and more. The check included areas in a range of about 100 meters from the route. Sixteen points were found to be suspected of contamination; the main ones being Ta'as Magen and Camp Sirkin.

The contamination found is to be treated according to the contaminant content - biological treatment (for the fuels) or removal to a toxic waste landfill (highly metallic contamination).

**Archaeology and heritage**

**Archaeology** - Archaeological sites were examined in a radius of about 50 meters from the railway route according to the map of declared antiquities sites of the antiquities authority (from 2016), and it was found that there are eight archaeological sites overlapping the metro route. An opinion was obtained from the Israel Antiquities Authority (Appendix 7) that it would not object to submitting the plan according to the accepted criteria and with attention to the following points:

• Hashmonaim Station - The authority requests performing a test excavation up to the natural rock layer.

• Sirkin Stations - The authority requests performing a test in the preliminary design stage, in view of the identification of archaeological findings in the areas.

• At the other stations - the authority does not object to the project, subject to testing and supervision of the plan by the authority at the time of construction.

**Historic buildings** - a survey was made of historic buildings designated for preservation in the area of the metro route, in the various municipalities. From the findings, it turns out that one such building would need to be demolished to build the Magen David Square Station.

**Appearance and Landscape**

**Station buildings** - were designed in accordance with architectural design and development principles, which are mainly expressed in an emphasis on continuity of movement in the station, streamlining of processes for reaching the platforms, connectivity between different rooms, uniform distribution of passengers in the station in order to avoid overcrowding, and a balance of quantities of passengers throughout the station.

Regarding the depot complex and the substations, the landscape design is to be performed according to several principles designed to reduce visual-landscape obstructions to a minimum:

**Depot:**

• Moderation and concealment using suitable large trees and vegetation.

• Adapting large trees to the areas within the depot and between the buildings/installations in order to soften and "break up" the complex area from an aerial view.

• Treatment of building roofs (Fifth Facade) using intensive and useful green roofs or extensive- ecological roofs. As an engineering installation, the depot complex has no urban value.

• Maintenance of as moderate slopes as possible to arrive at maximum integration in the open field landscape, and planting trees along it.

• Thickening vegetation along banks and planting trees along the stream to emphasize a natural appearance for the natural stream channel.

**Substations:**

▪ Vegetation - for the purpose of recession and concealment of the facility and the perimeter fence, suitable large trees and vegetation appropriate to the area are used.

▪ Access ways to the facility - use of existing and \_\_\_ roads as much as possible. Keeping the slopes as moderate as possible on the access roads to the facility for maximum integration into the landscape.

▪ Preservation of surface runoff - For the purpose of preserving surface runoff water, the runoff water is directed to water-permeable areas in landscaping strips within the lot area and/or permeability installations are installed in the area of the lot.

▪ Mature trees - the planning addresses preserving mature trees on the field.

▪ Wall development - walls if required are offered in bare concrete finish or stone cladding.

▪ Treatment of the roofs of buildings and concealment of various technical installations on technical balconies and roofs as much as possible as part of the general architectural design.