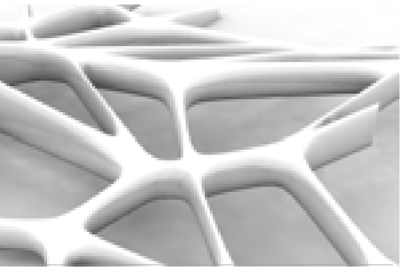
KARTAL MASTERPLAN, ISTANBUL

FINAL REPORT 02/2009



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CONTENTS

References :
Land Use Allocation report – dqdx London
Infrastructure report_ ARUP London
Technical report (Geothechnical, mitigation) _ ARUP London
Environmental report _ Bogaziçi University, Istanbul / ARUP

PROJECT BACKGROUND

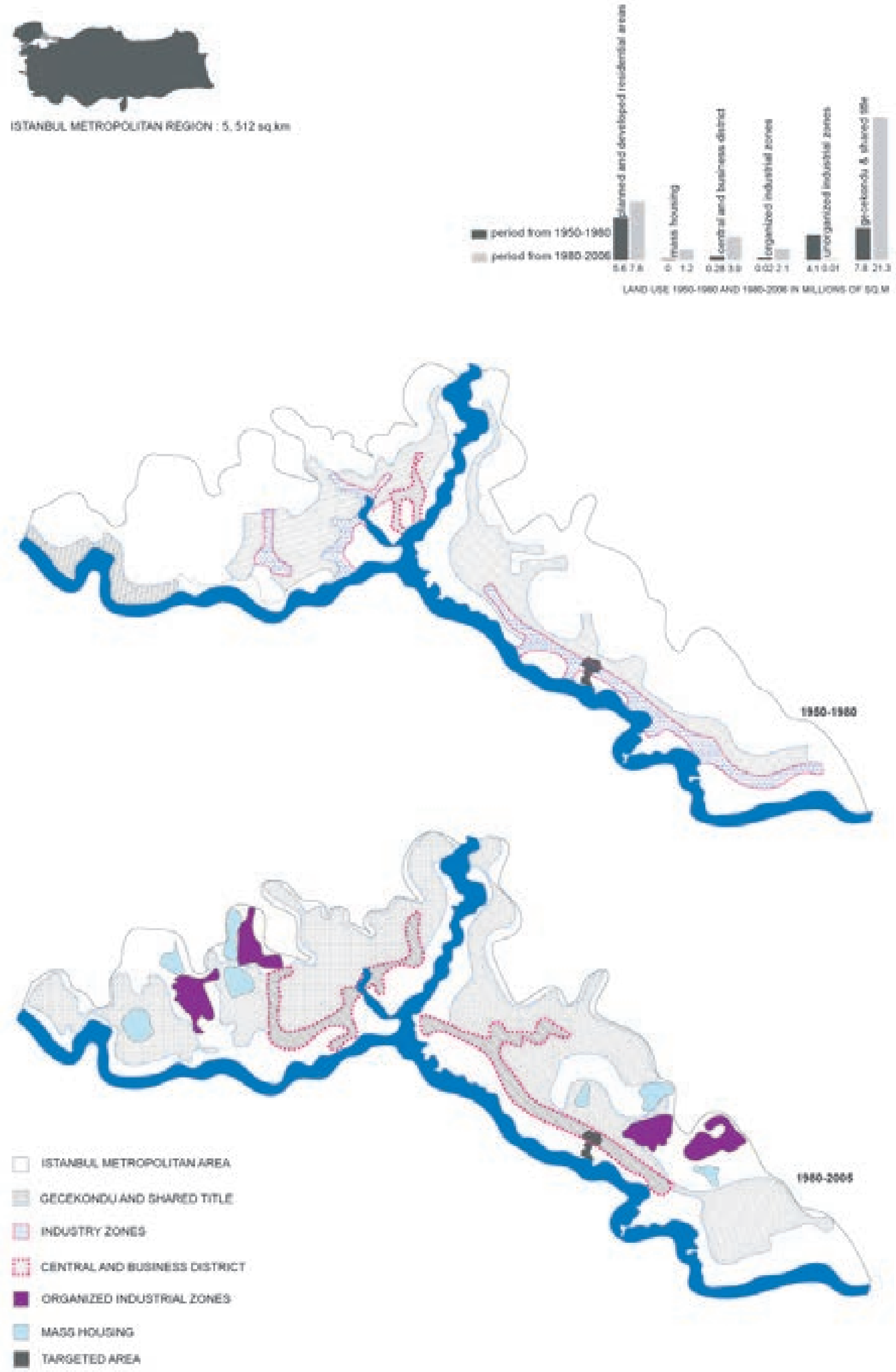
Opportunity for structured development
The city of Istanbul is located on two major peninsulas separated by the Bosphorus, at the point where two continents, Europe and Asia, meet.
It has been the country's commercial and cultural capital for over 3000 years and is one of the fastest growing metropolitan areas in the world.
With an official population of 14 million inhabitants and 95% of the city area urbanised, it is still growing rapidly with approximately 300 000 new inhabitants settling in every year, most coming from the undeveloped areas of Turkey.

As the industry grew, the city expanded rapidly in the East-West direction without a clear urban strategy or planning restrictions. With further industrial development, the eastern, Asian, part of Istanbul has expanded followed by the extension of main transport lines creating a linear urban sprawl. The central historic area in the European part still retains its importance as a central commercial and business nucleus.

Until recently the industry has been the main economic force in Istanbul with one third of Turkey's manufacturing plants located in the Istanbul region. Although the industry is still employing a third of the city's population, it has given way to the service sector. With this shift in economy combined with an increasing philanthropic interest of the city's elite there has been a very strong trend on the relocation of the industry to Istanbul's' outskirts, also outside Istanbul's Metropolitan Area.

A key strategic area
The area presents a key strategic location for controlling the patterns of growth in Greater Istanbul and achieving balance between the city's western and eastern halves. With the relative proximity of the airport, the city may take advantage of the ever-increasing importance of air travel for business connections. Equally important is the concentration of road, rail, subway and sea transport networks which makes the site ideal for mediating between the forces operating at each scale.

West-East Connectivity to broader Istanbul



Land Use from 1950 to 2006

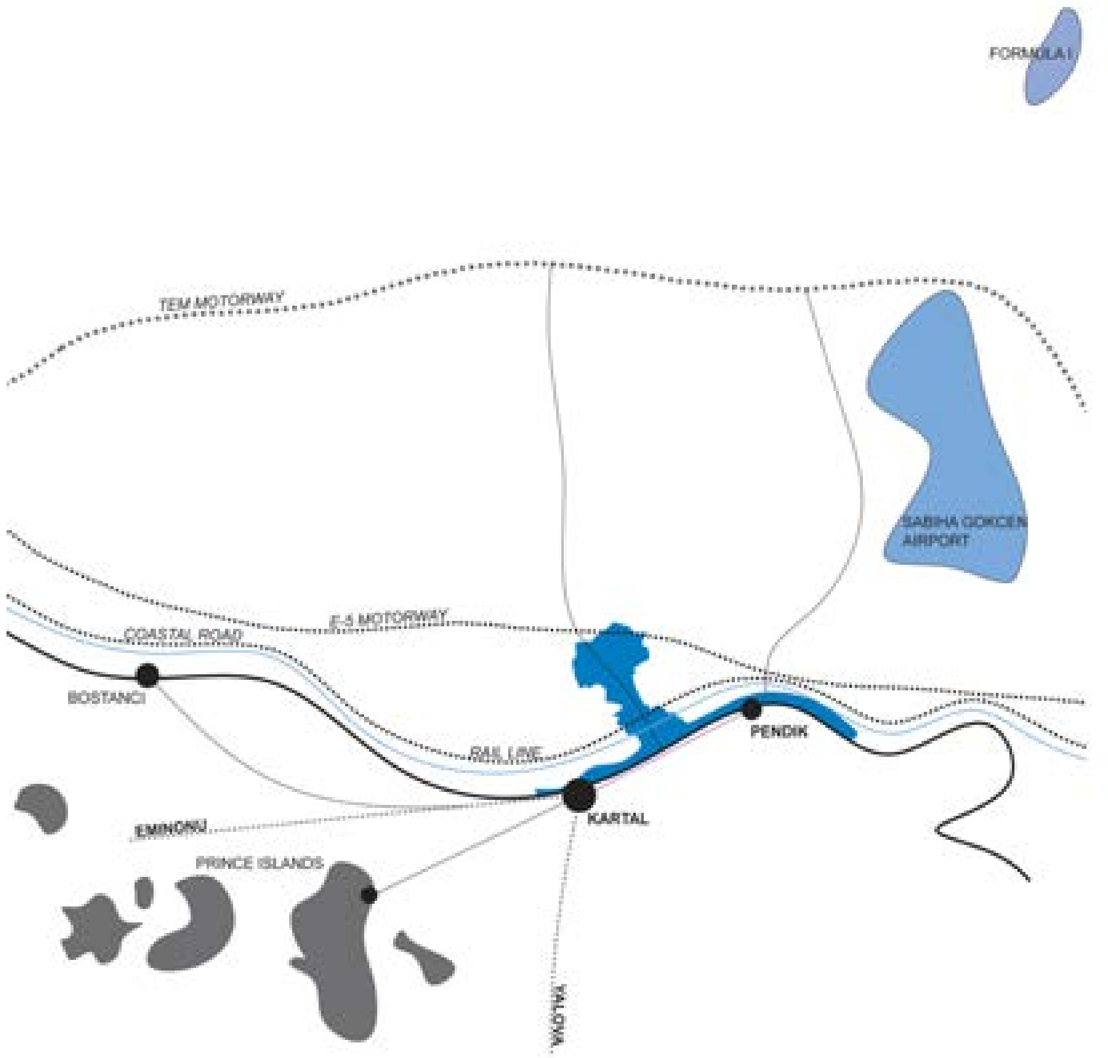
PROJECT BACKGROUND | *definition of the project area*

Location
The project site is located within the boundaries of Istanbul's Metropolitan Area, east of the historical and business centre of Istanbul, on the Asian Continent at a point some 20 kms from the Bosphorus.

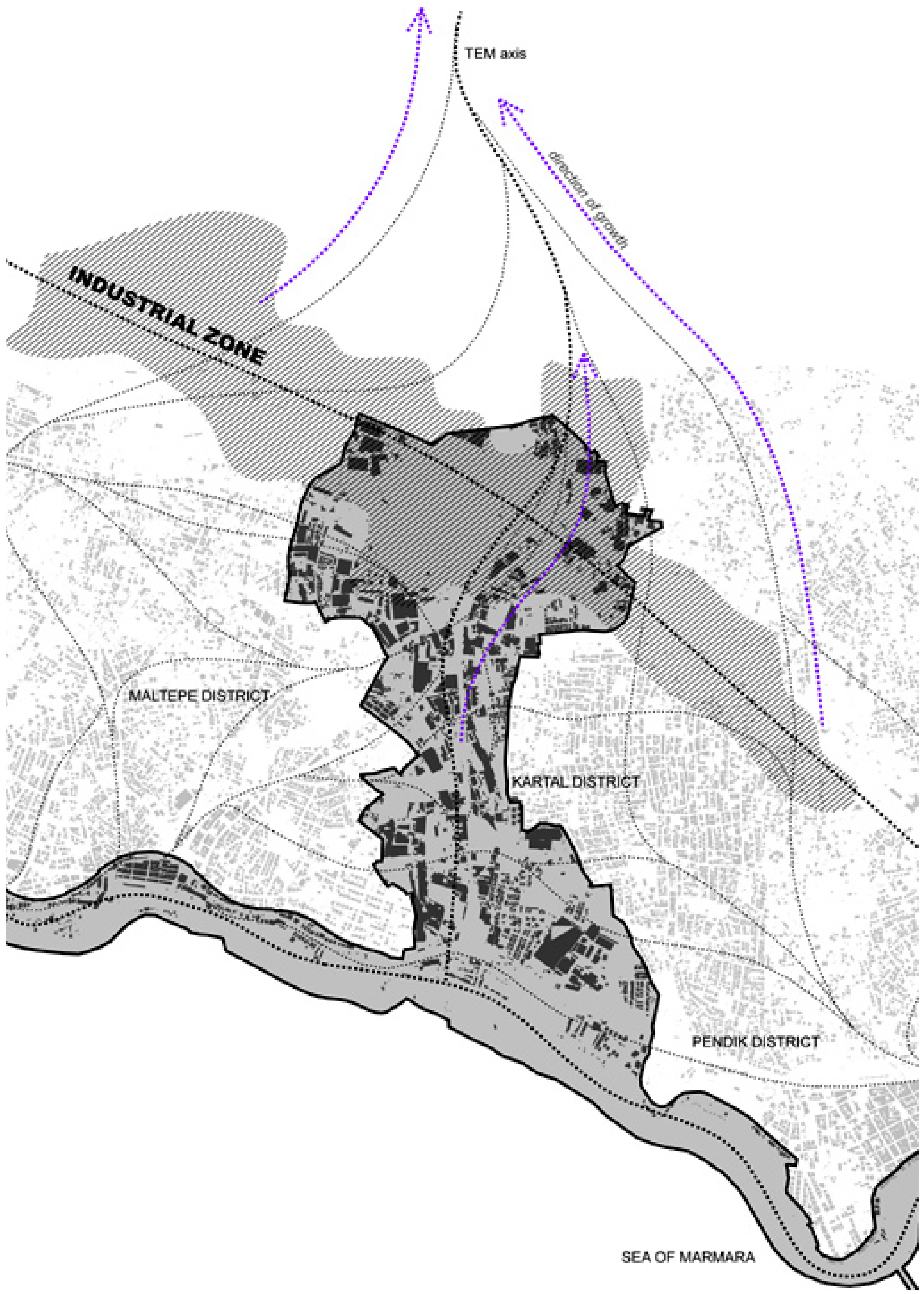
Total project area is 550 hectares which includes 360 hectares development area, the rest continues to the existing green belt.The site is an elongated strip of land typically 600m wide (roughly east to west) and 3km long (roughly south to north).

It is framed by the Marmara Sea, the railway line linking to Ankara and the coastal expressway to the south, the E5 highway to the north and the heavily residential areas districts of Kartal to the west and Pendik to the east.

The site has many advantages in terms of its planned circulation infrastructure, which provides the framework for the emergence of attractive and identified urban districts.



Regional transport system



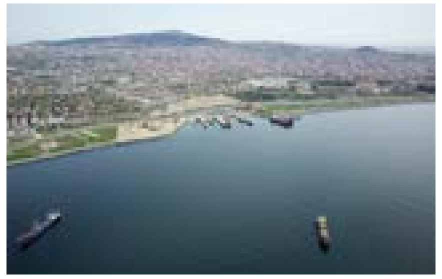
Regional connections and potential growth

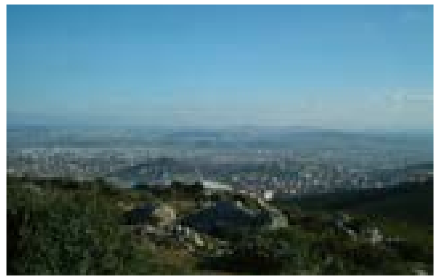
Strong topography with three differentiated areas
The main characteristic ot the area is its sloping site towards the sea with a 120 m height difference in total which creates the opportunity of spectacular views and south facing.

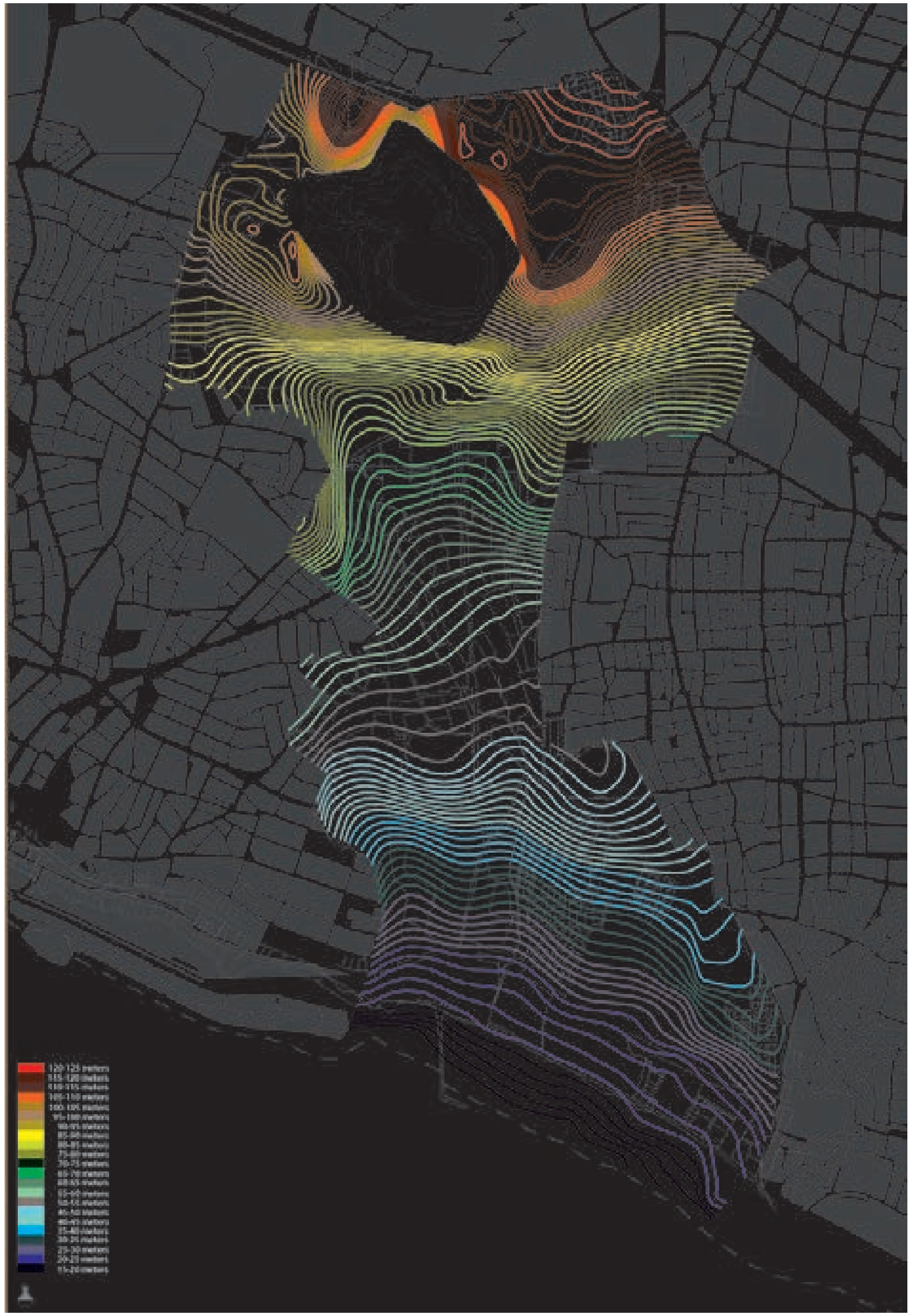
There is a natural differentiation of the site into three broad bands running roughly west to east.
The northernmost offers the potentials both of high ground as well as access and visibility form the E-5 motorway.

Another band traces the sea-coast with its recreational potential and local connections to Kartal and Pendik town centres. Inbetween these two bands, a third offers the suggestion of a civic and residential continuity between the existing housing communities. This natural differantiation of the site is important to the establishment of distinctive urban quarters integrating into urban patterns.

These bands are crossed by a natural axis that extends southward to the sea from E5 exit near the quarry.The coastal stretch and the redundant stone quarry are the two natural strong landmarks of the site.





Existing Topography

PROJECT BACKGROUND | *existing land use*

Predominant land use

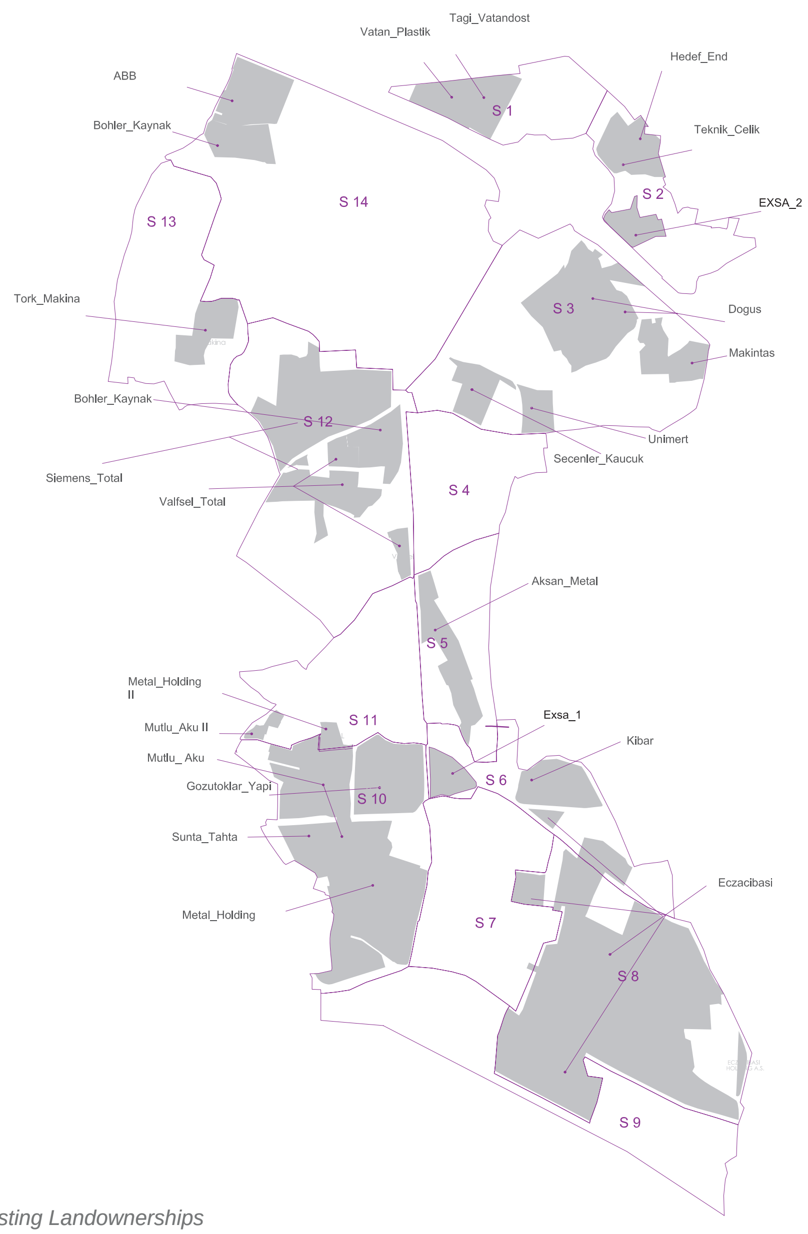
The project area has been developed as an industrial area. Although it still retains predominantly industrial character, the city's economic move from industry to service rendered most of the industrial operations redundant and made technology outdated.

The remaining industries have already started or planned their move outside Istanbul's Metropolitan area. In addition, the operations in the public owned quarry have been stopped and cement plant demolished.

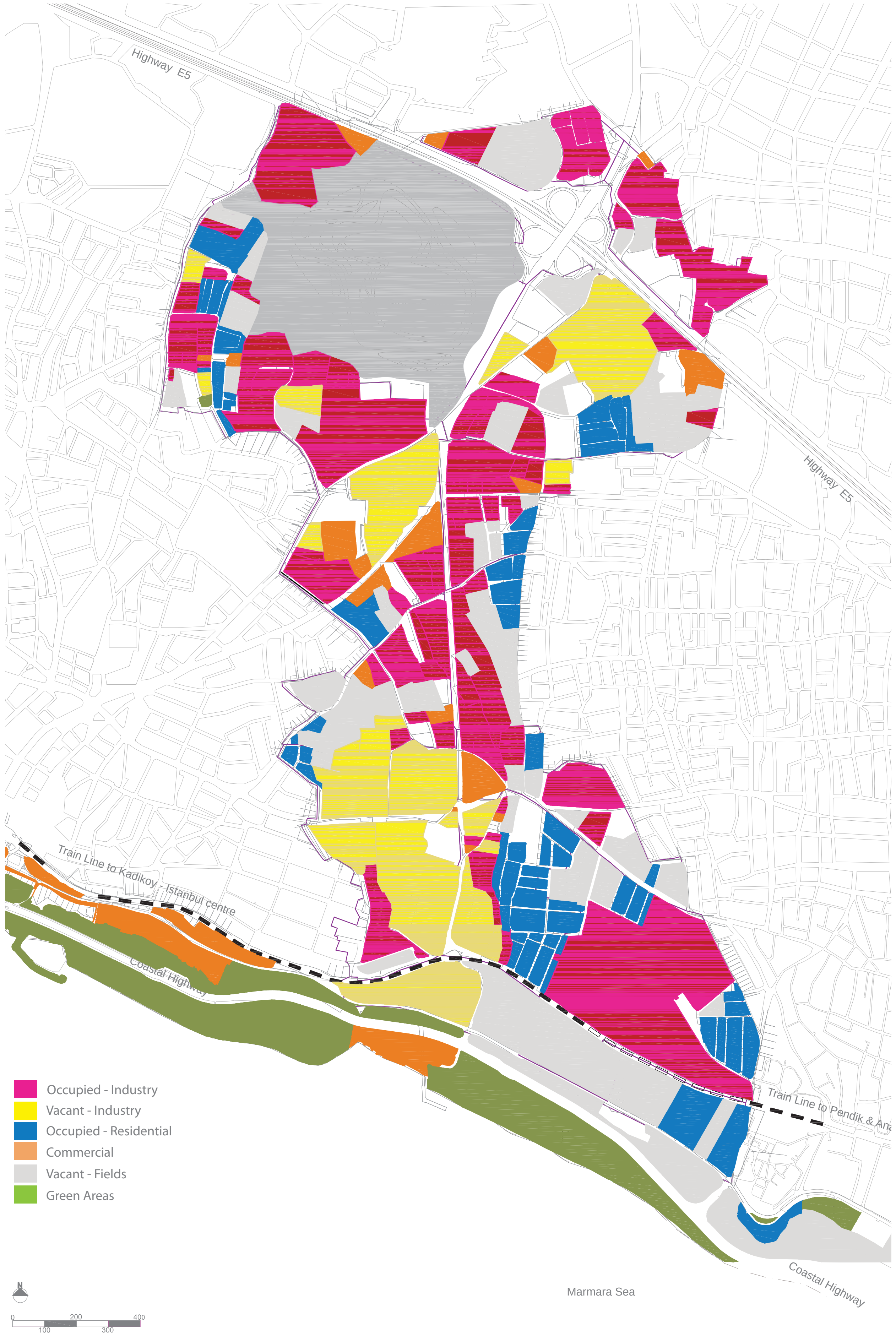
As a result a substantial amount of land has been left vacant and unoccupied, creating a potential for an urban intervention, equal to the development of a whole new city.

Intricate matrix of existing landownership

The current land ownership plan is a patchwork of larger industrial estates, publicly owned land and small residential ownerships.



Existing Landownerships



Existing Land Use

URBAN STRATEGY

URBAN STRATEGY | ***masterplan brief and vision***

Programmatic balancing of Asian part of Istanbul
In the last decades Istanbul has seen a period of tremendous growth and transformation, while still retaining its mono-centric character. New Kartal Masterplan project has been developed as a continuation of the regeneration study following the international competition held in spring 2006.

The purpose of the project is the regeneration of the area through urban and programmatic proposal that will help re-balance the mono-centric nature of the city of Istanbul.

Almost all of the economic activity is centred in the European part of Istanbul creating pressure on historical areas of the Bosphorus coast and creating high commuter traffic movement. Currently there is only one primary centre on the east bank and the aim of the regeneration in Kartal area is to emerge as the alternative economic and service centre eradicating this misbalance between the two banks of Istanbul Metropolitan Area.

The emphasis of the project is on the urban solution for transformation from industry to service sector which will provide between 80 000 and 100 000 new jobs for the area over the period of 25 years.

The programmatic vision for Kartal-Pendik is for a modern mixed-use centre offering jobs, homes, culture and entertainment with supporting social infra-structures. Essential to its success is an integrated transport strategy which provide good accessibility, safety and convenience without environmental degradation. This implies that public tranport and walking be given priority over private transport.

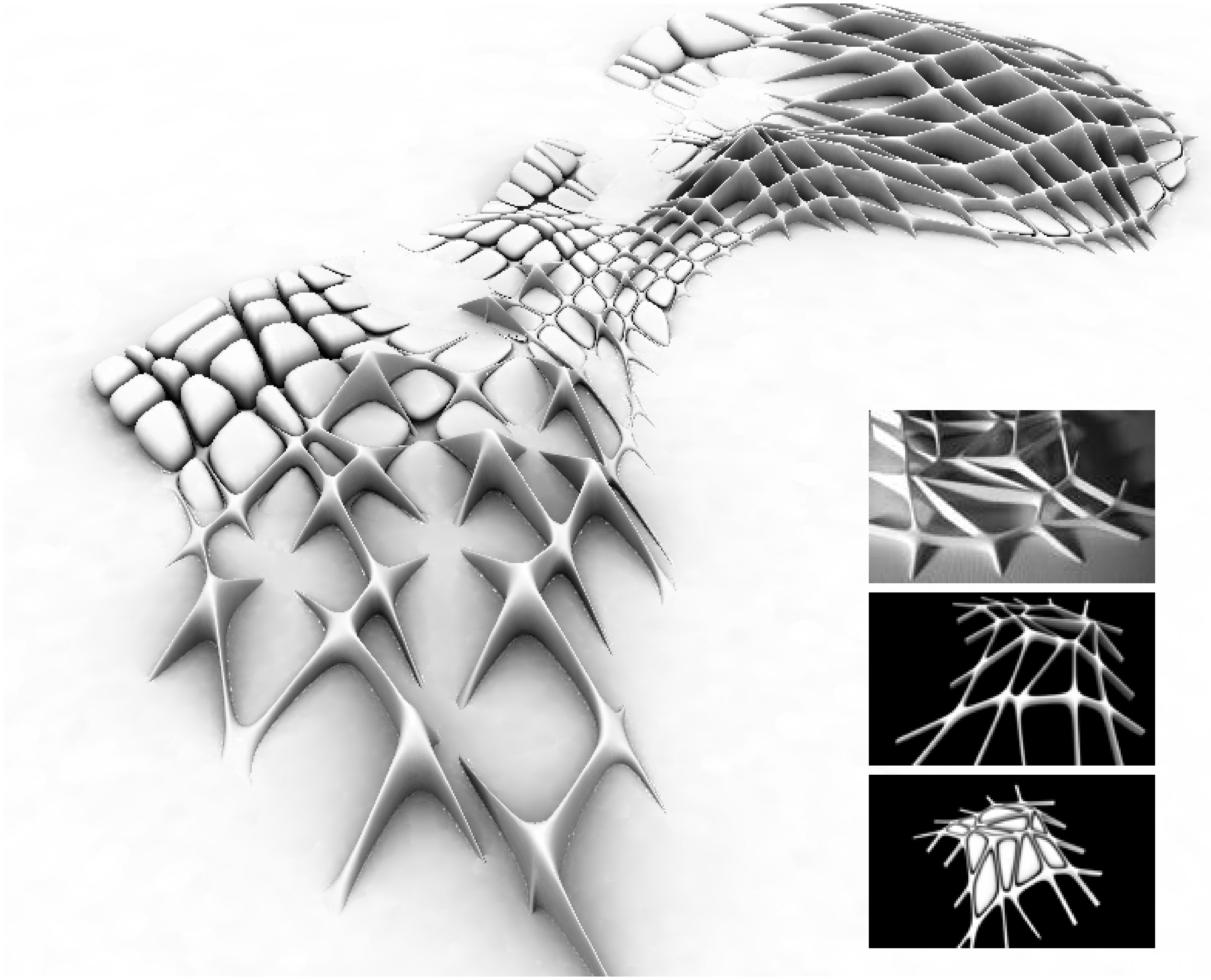
However, the challenge is not simply that of ensuring infrastructure capacity, but of envisioning a distinctive landscape and urban identity that will draw people and resources here in a sustained way over time.

Creating a distinctive cultural landscape
The world's great cities are known by their distinctive cultural landscapes, and this project for Greater Istanbul is driven by the wish to preserve the one at its historic centre and cultivate another in its eastern hinterland. Our aim is to generate a robust vision of a future landscape whose inner principles will structure and sustain the decision making and negotiation and development process, involving all the stakeholders and representatives of different com-munity groups.

Our distinctly three-dimensional approach to the planning and implementa-tion process is adding complexity, visibility and necessary ambition to a more traditional approach of simple density and land-use plan.

Existing condition

Proposed condition



Distinctive cultural landscape and urban singularities - Competition stage - 2006

URBAN STRATEGY | *balanced land use allocation*

To become one of the new centers in the polycentered Ustanbul, New Kartal needs to deliver balanced land use. To provide this blanced live-work model as well as to meet the objectives of both Istanbul Municipality and the stakeholders of the Istanbul Kartal Development Corporation, we have worked with Dqdx and Ove Arup Consultants to propose optimal assumptions.

2.5 million m2 developable land area
Final agreement between the Municipality and the private landowners defined that each landowner had to donate 40% of the property for public use within the same administrative sub-region; each landowner was given the option to choose which part of the property they will give away.
Land use ratios of Public Amenities were defined by the Municipality per each-sub-region for the purpose of integration within the land parcelation strategy. Streets and urban blocks were defined through the continuous negotiation process whilst keeping the overall urban strategy consistency. The project developable land area (parcels) of 2.54 million m2 is divided into 31.5 % public space and 68.5% private space including 12.5% of existing housing areas.

3 plot ratios options
Plot ratios have been defined in 2008 by the Municipality and offered to developers as 3 developable options:
Option A : 31-50 % of the land use is allocated to residential use, maximum plot ratio is to be 2.5
Option B : 0-30% of the land use is allocated to residential use, maximum plot ratio is to be 3.
Option C : 100 % of the land use is allocated to hotel, leisure, cultural facilities, maximum plot ration is to be 3.
Existing housing areas (0.3 million m2) a treated as special areas exempt from the above options. Municipality estimates that residential ratio is about 2 in these areas and wants to revise this ratio in the future.

4.5 million m2 of mixed development
Given the above figures, approximate total GFA assumption is 4.5 million m2 which is split into public and private GFA.
private GFA: 3 500 000 m2 = 78 %
Options for land-use mix and modal split were modelled. A critical factor was the relationship between inhabitants and jobs. Almost 60% of the private land use need to be residential otherwise either vehicular accessibility is not tenable or car use is too low to insure the commercial viability of the project.
Sub-allocations should be as followed :
60% residential = 2 100 000 m2 (including existing housing areas)
15% office = 525 000 m2
15% retail = 525 000 m2
10% other commercial (hotel/convention center, leisure, private education or health etc) = 350 000 m2
public GFA : 1,000,000 m2 = 22 %
The configuration of the public space is vital to ensure a sustainable and dynamic regeneration enterprise. There are certain mandatory sector allocations within this space which are mandatory to provide functionality of the urban environment. These include roads, green spaces, key workers amenities (schools, healthcare etc), public administration and public worship.

50 000 inhabitants - 14 000 housing units / 100,000 workers
New Kartal development will serve the catchment area of Greater Kartal with it's population of 2 million.

We forecast a very high New Kartal resident population working in the area, in consonance with the design brief which indicates an "autonomous community".

Given the current socio-economic profile of Old Kartal, this assumes a high number of residents coming to New Kartal as "first timers", working in a professional/service-oriented CBD. Age would be relatively young and appartments mainly for mid to high income professional and management people.

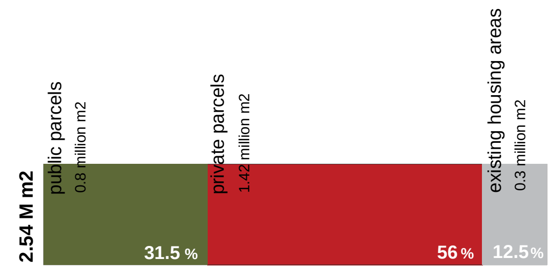
The proportion of residential build (both private and social) is a matter for public policy but will be a key factor in determining the social mix of the project and the complexion of the final regeneration.

Given below Kartal's Municipality ratios, demographic profile assumption is 50 000 resident population and 100 000 working population over the period of 25 years.

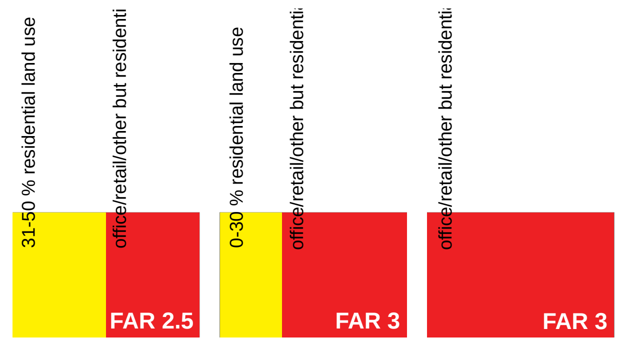
average dwelling unit size	165 m2
average household size	3.5
average office/commercial area per worker	25 m2

This optimal space allocation can only be considered an estimate, the actual construction will be phased over 15 to 20 years. This mix should be continually assess in accordance with the future economic environment to ensure properly planned urban regeneration.

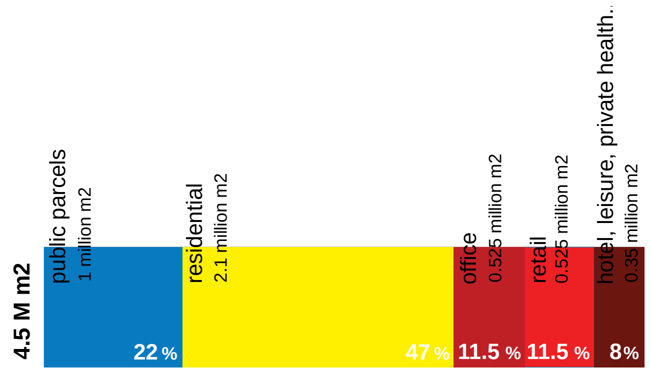
Source : ARUP & Dqdx



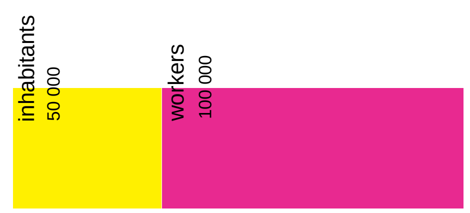
Public space 31.5 % Private space 68.5 %
Public / Private land use mix - parcels only



Option A Option B Option C
3 Plot ratio options



Public GFA Private GFA 3.5 million m2
GFA breakdown



Demographic profile

Source : ARUP & Dqdx

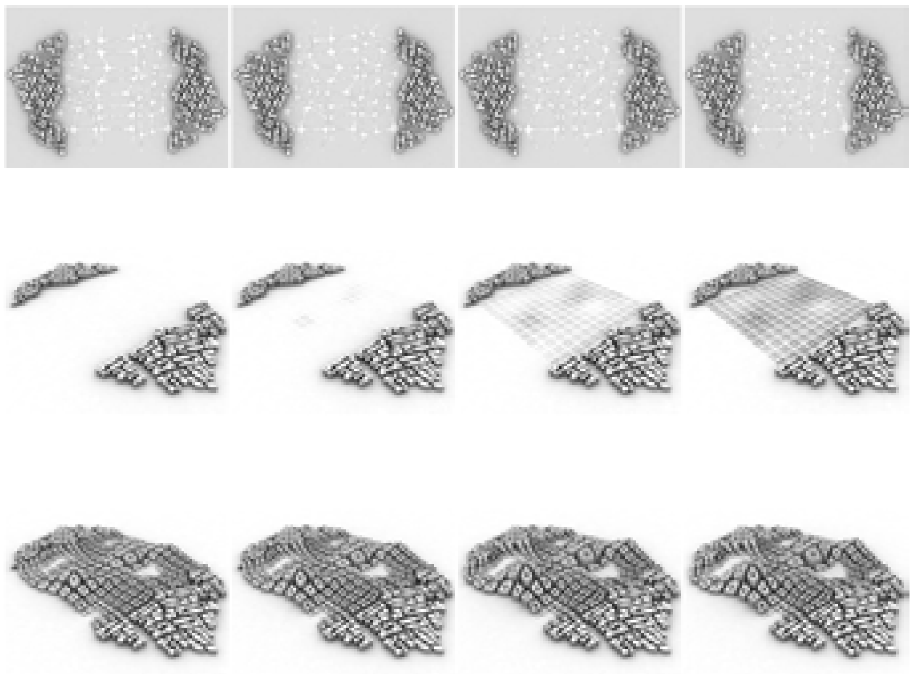
URBAN STRATEGY | ***winning competition concept***

Dynamic Stitching is the main conceptual idea from the competition stage designed to connect the Masterplan site to the surrounding context, creating the potential for the emergence of an overall distinctive cultural landscape.

Existing, loosely configured net of streets, shools, gaps and houses stretches across the neighbouring towns. The purpose was to incorporate and elaborate this net into our exploration for potential landscapes. The idea of the net has proven a compelling metaphor across time, in our work, the graphic medium of the net becomes the calligraphy of an urban landscape. It provides a unifying structure for the pursuite of patterns of complexity and differentiation.

It begins by tying in together the basic infrastructural and urban context of the surrounding site. The integration of the lateral connections with the main longitudinal axis creates a soft street grid that forms the underlying framework for the project.

The concept is flexible and adaptable to the existing context and focuses on the idea to control the un-built rather than the built.



Stitching across the site - Competition stage - 2006

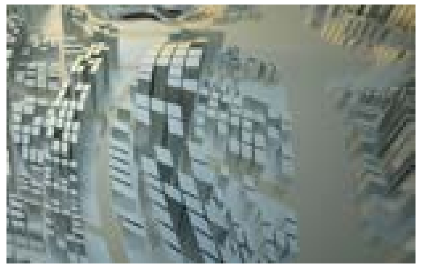
URBAN STRATEGY | *singular sub-systems*

Subgrids and movement
Early stages of graphic production and modellin reveal site strengths, values and constraints. Series of lines respond to the landscape in a variety of scales. Those lines have developped and evolved continuously through the process of the project. They form sub-grids of the main overall street grid that may suggest the trace of potential flow of people, a height zone boundary, a building line, a line of sight. Together they generate a framework against which a flexible volumetric landscape can take shape.

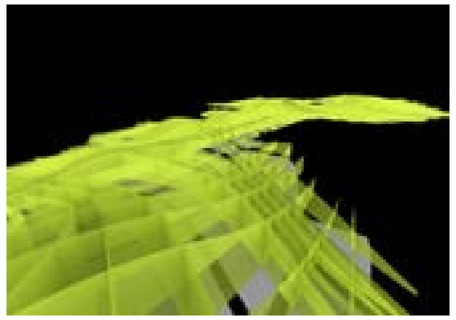
These sub-systems are essential to overall dynamic of the stitching , both at a smaller scale as well as complex city scale. Attentive to economic flexibility they allow the emergence of singularities in the neighborhoods.

Locally, these sub-sytems can be intensified to form areas of higher programmatic density, open spaces, parcelation, vertical buildup of the city fabric...

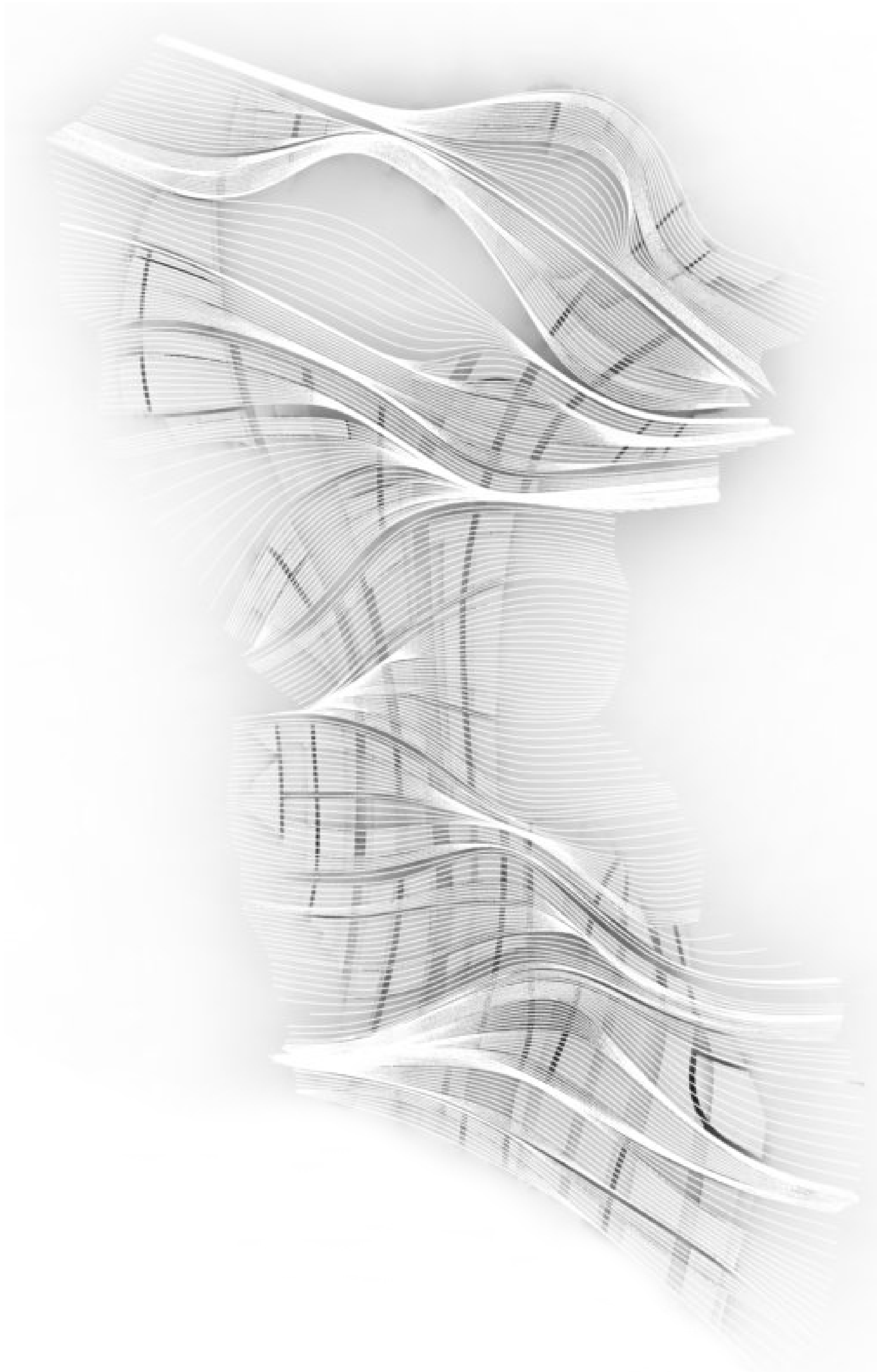

Competition stage - 2006



Massing singularities tests

sub-grids tests



Subgridi simulation

URBAN STRATEGY | *dynamic stitching*

Dynamic stitching describes the overall concept and is developped in the following strategies.

Street connectivity
Lateral lines stitch together the major road connections emerging from the west and east surroundings. Since the Masterplan site accomodates many landowners, a flexible curved grid system has strong advantages for the transformation process from existing ownership to the new land parcelation.

Network of Public Open Spaces
East - West public generous promenades are part of the open space and landscape strategy.
Apart from linking the existing housing districts to the new Kartal development area, they also create distinctive entrances from the surrounding neigbourhood into the Masterplan site.
The public promenades develop a distinct identity for the new urban area as part of the overall new landscape and integrate the local public amenity clusters to the main public spaces network.

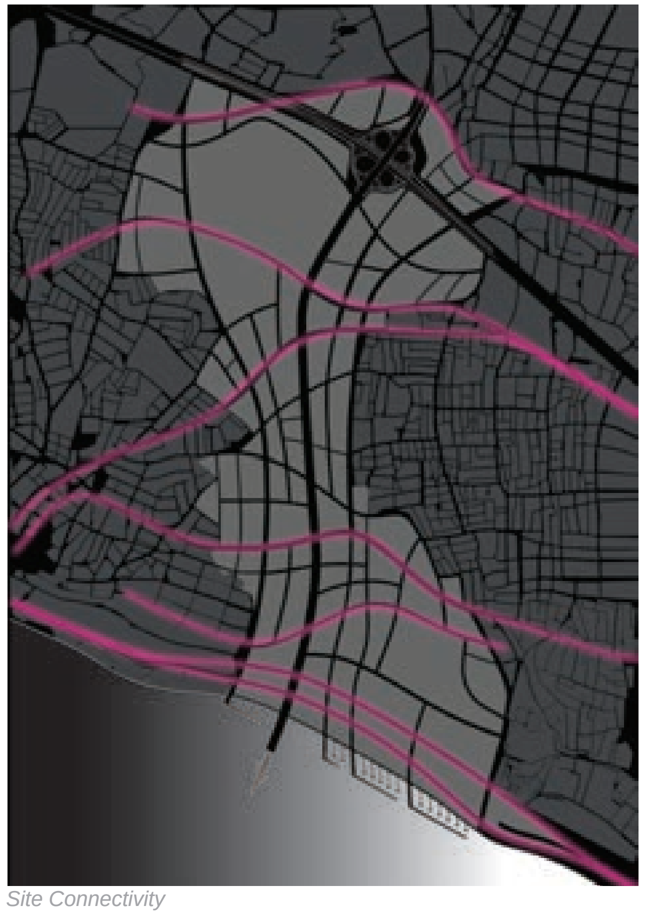
Programmatic Continuities
Commercial routes take advantage of the public promenades and clear routing. We propose to locate commercial and retail facilities at their most visible - adjacent to the pedestrian movement.

New commercial routs connect into the existing commercial land use strips along the main roads outside the Masterplan boundary. They respond to and interpretate local patterns of commerce to clearly define retail activity within the Masterplan context.

Urban massing
The aim is to create an overall distinctive landscape growing from the surrounding sites to rise peaks and higher densities in the middle of the site. This supports the stitchining strategiy.

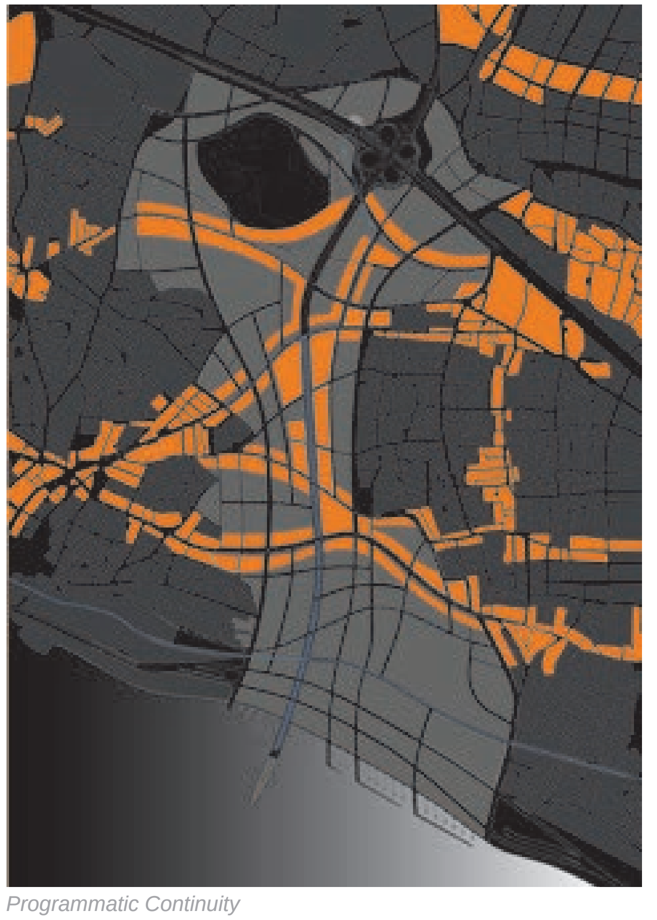
East - West zones of allowed height proliferation provide an exciting urban experience with change of pace, scale and offer varied speeds according to the character and singularity of the urban quarters.

The heighest buildings are regulated in those bands stretching from East to West thus supporting the public promenades and public and retail programmes.

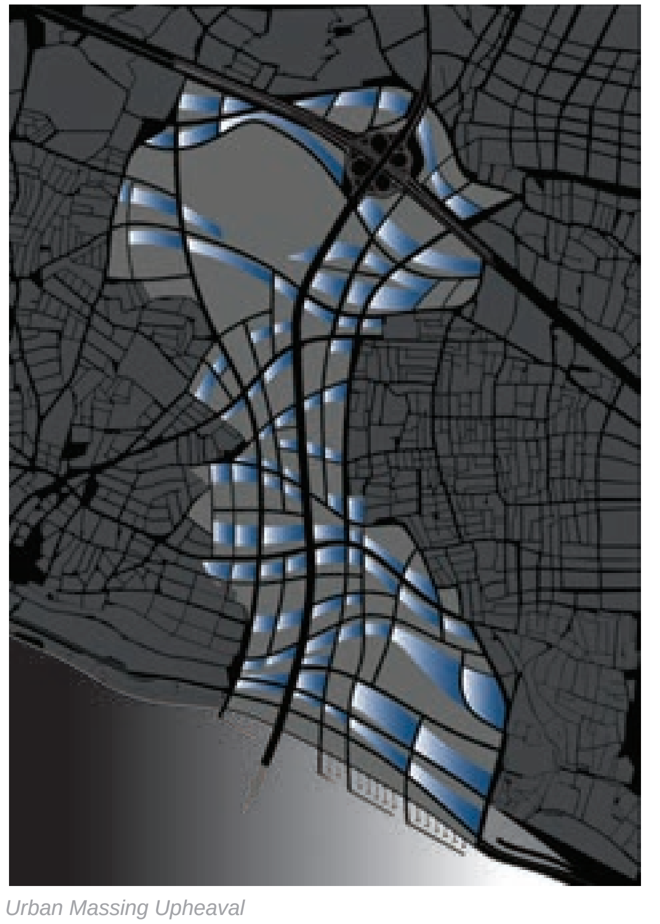


Site Connectivity

Public Open Spaces network



Programmatic Continuity



Urban Massing Upheaval

URBAN STRATEGY | *concentrated uses*

Three attractive Focal areas
The three main distinctive urban quarters are identified by the natural differentiation of the site into three broad bands running West to East. Two strong urban landmarks, the former stone Quarry area and the Seafront are linked by the North-South main public axis, supporting the tramway line.

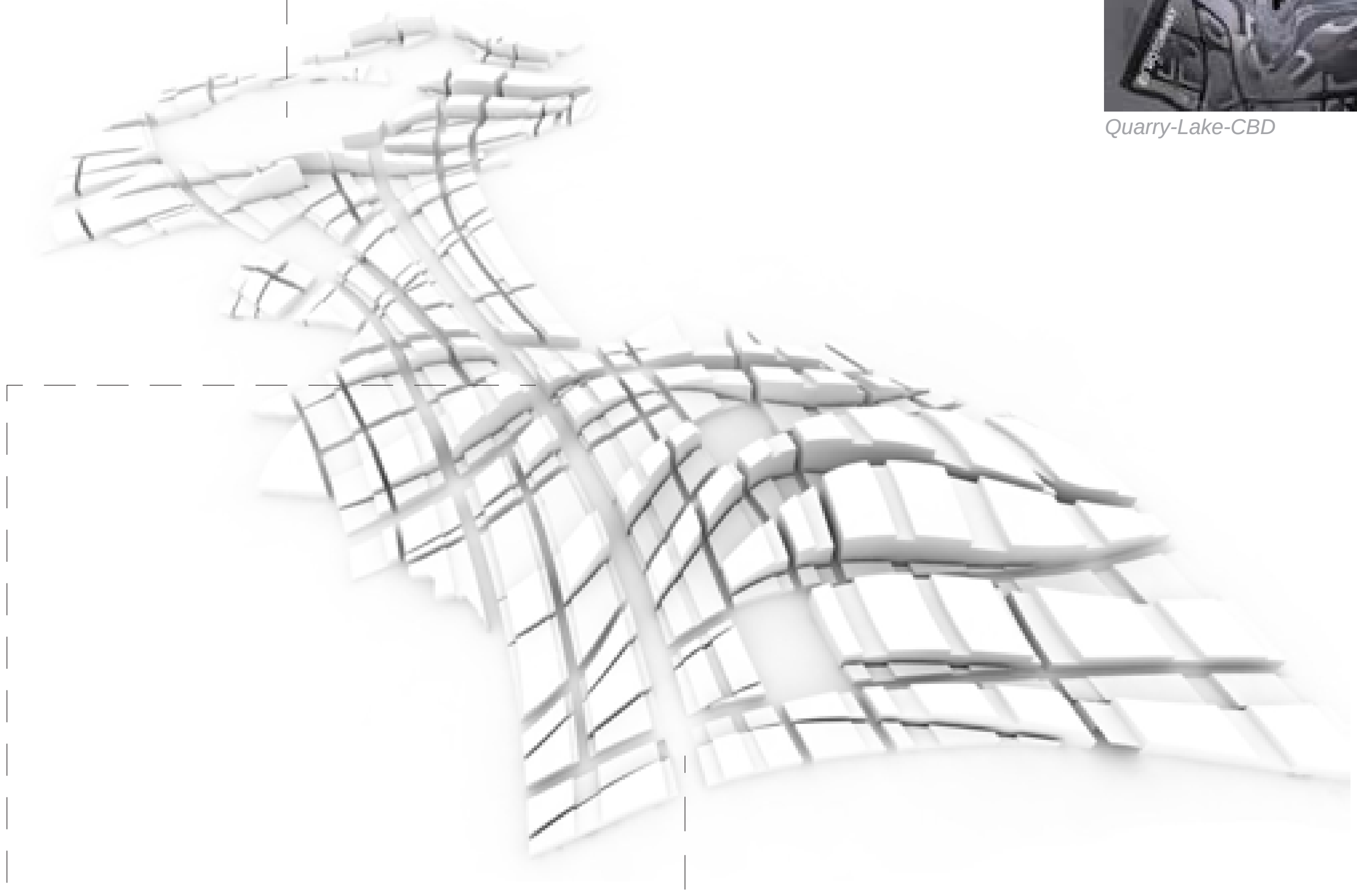
1- North Hub and Public recreation area linked to CBD (office park)
Former stone Quarry will be transformed into an attractive public recreation area. Leisure and office functions are surrounding a central public plaza, connecting the North Hub (subway station interchange and tram north terminus) to the CBD which is one of the height peaks in the skyline.

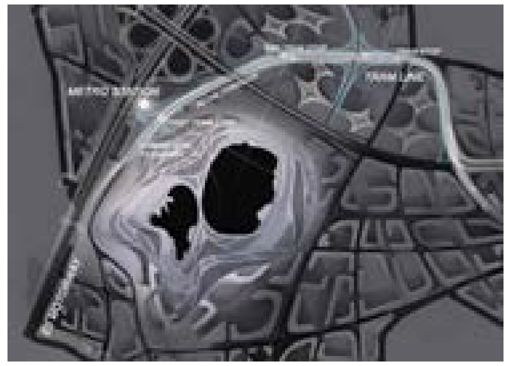
2- Seafront-Marina and South Hub
The Seafront is connected to the South hub tram/train/ferry and is the vitrine of Kartal Pendik new district from the Marmara Sea. It serves as a leisure and recreation quarter. Inland, a new cultural and civic center emerges near the transportation hub linking light and heavy railway infrastructure.

3-These two focal areas are linked by the central spine of the Boulevard.
The tram and the central median public space create a strong urban element supporting more traditional european ground floor commercial continuity and small scale city blocks.

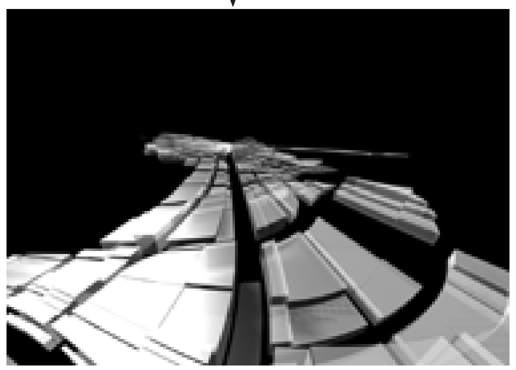
These three landmarks are strong urban generators and form the main polarities and landscape events in the Masterplan.

Public Amenities and Local Nodes
We propose to concentrate the public amenities needed in each sub-region in order to form readable community scale public nodes. These nodes form lively urban hearts for each neighbourhood, with higher density of uses and continuous activity throughout the day. These zones of urban intensification are tightly connected to the general open spaces network and green spaces.

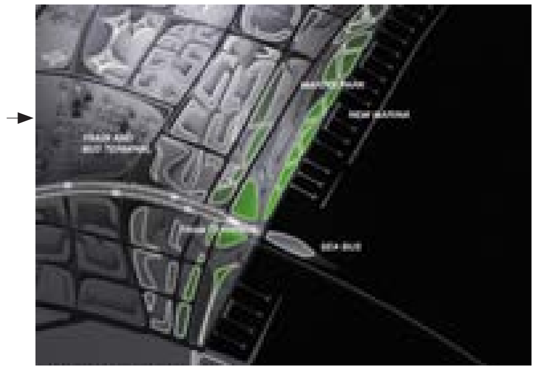




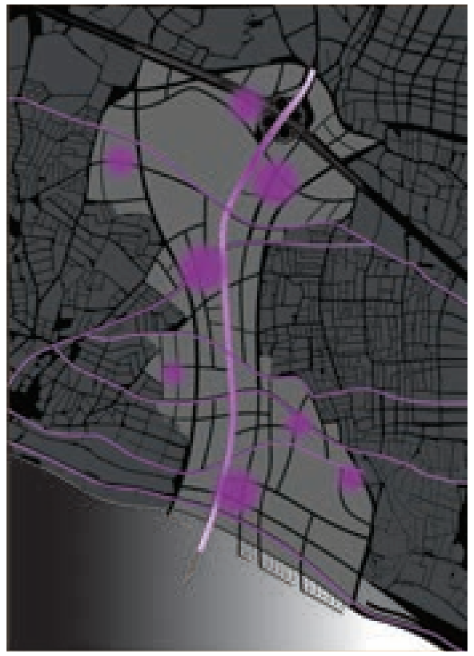
Quarry-Lake-CBD



Boulevard



Seafront - Ferry terminal - Marina



Community scale Public Nodes

PLANNING CODE

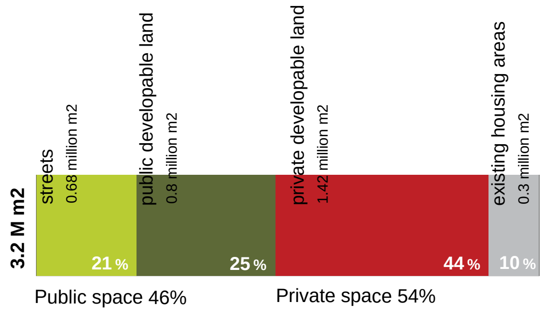
PLANNING CODE | *street grid and urban blocks*

Continuous interactive process of land negotiation between public and private
Part of the regeneration efforts of today are in partnership with the industrial communities they are succeeding.
Due to its industrial background, the site is characterized by an intricate network of land ownership.
The planning challenge was found in the search for a sympathetic transition, supporting the short-term interlacing of industrial and service-based sector. Dealing with existing large industrial estates, publicly owned land and built residential ownerships was a main part of the working process, as maintaining existing roads as often as possible.

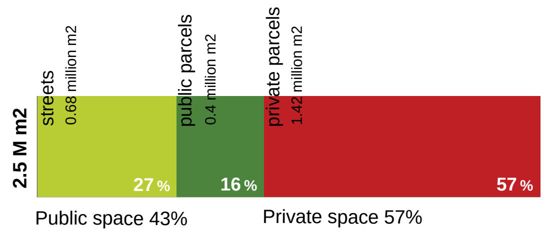
According to the agreement between Municipality and landowners 40% of each private land had to be given to the public use, and 60% of each land kept as a main developable landownership. Existing housing ownership is excluded from principle maintaining its current shape and organisation.

In addition, the area is divided in fourteen existing administrative sub-regions and all landownership issues, shifts and exchanges had to be solved within their original sub-region.

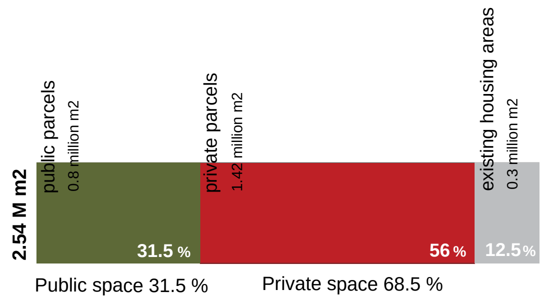
The land division between streets, public and private ownership as well as the parcelation into main urban blocks have developped and evolved continuously through the negotiation process, resulting in a land use mix of 21% for streets, 25% for public parcels, 44% for private parcels and 10% for existing housing areas.



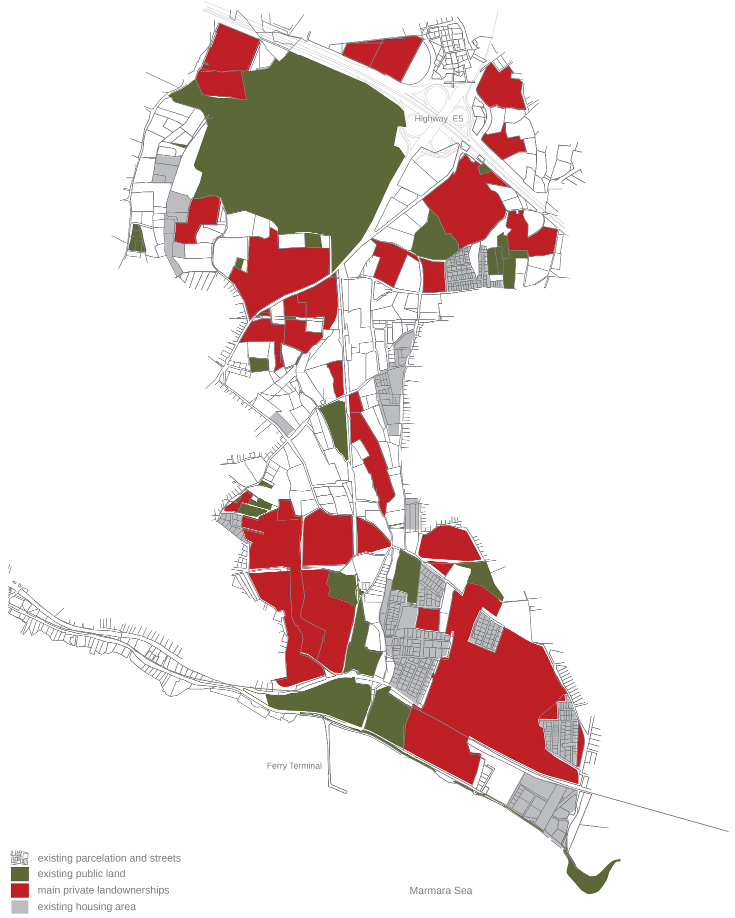
Public / Private land use mix - total sub-regions area



Public / Private land use -
sub-regions without exist. housing & Quarry area



Public / Private land use mix - parcels only



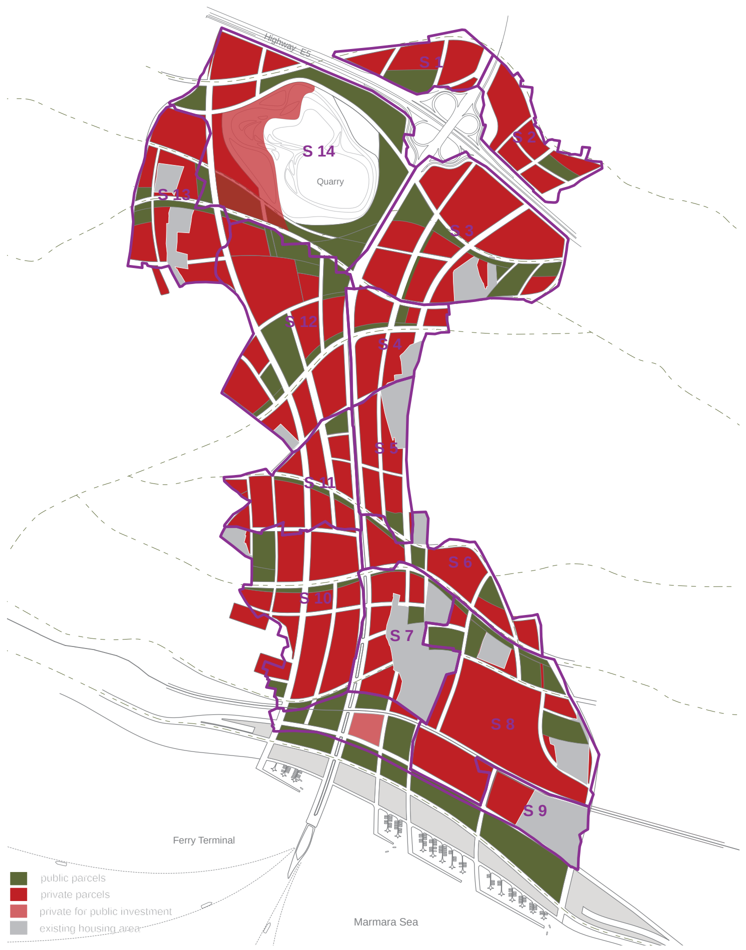
Existing Public/Private Land Use mix

total masterplan area (including green belt)	5 500 000 m2
masterplan "development"	3 600 000 m2
total sub-regions area	3 200 000 m2
existing housing area	300 000 m2
total area used for land appropriation calculations (excluding ex.housing and quarry)	2 500 000 m2
total parcels area (public & private together)	2 540 000 m2

Masterplan general areas

Land Use /Sub-regions	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	Total
Private developable land	50796	65648	176206	64292	49384	69561	51943	185626	36818	152983	95270	189841	80341	155833	1424543
Streets	27166	34074	88268	39409	32222	39953	27353	56441	43351	63259	46276	72316	23120	85019	678228
Total Public Land	43255	54116	154990	45915	43768	54001	38044	142631	104057	115249	65838	148387	57887	406794	1474931
Public land without streets	16089	20042	66722	6506	11546	14048	10691	86189	60706	51990	19562	76071	34767	321775	796704
Public land without streets & Quarry															402044
Existing Housing	0	0	25849	9696	23805	7808	94494	40448	51343	8289	0	4536	52362	0	318630
Total sub-region area	94051	119764	357045	119903	116958	131371	184481	368705	192218	276521	161108	342764	190590	562627	3218106
Total Parcels Public & Private	66885	85690	268777	80494	84735	91417	157128	312264	148867	213262	114832	270448	167470	477608	2539876

Land Use public/private breakdown per sub-region - after 40% appropriation



Public/Private Land Use mix after 40% appropriation

PLANNING CODE | *street grid and urban blocks*

Soft Grid and Flexibility
Urban plans have to keep a balance between an overall guiding structure and the flexibility to respond emerging differences.

European-type cities mostly have a grid or hierarchal system of streets and often a mixture of the two. The grid offers both a strong overall urban image with a generally even distribution of traffic and the most equal and flexible urban fabric for future evolution in terms of density, sub-parcelation, land-use etc.

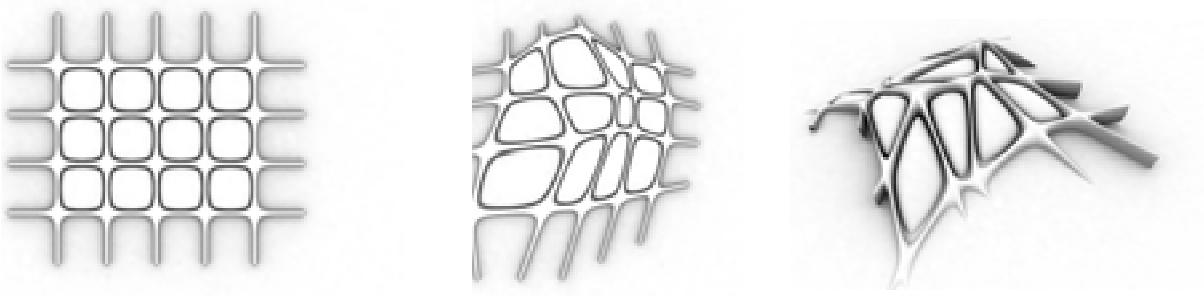
The proposed landscape is supple enough to respond to the seaside disposition and topography, the motorway and the rail line as well as the existing industrial character discreet blocks of housing. Curved street grid allows flexibility in the process of land distribution and parcelation and presents a robust framework for unifying a differentiated landscape of future urban quarters.

As a soft grid, with varied sizes of stitches, it supports and unifies tight clustering of business-centred environments in some quarters, as well as the more open fabric associated with recreational use of the ground in other quarters.

The original stitching idea and soft curved grid concept from the competition stage, have developped and evolved continuously through the negotiation process of land use parcelation. Main existing roads are maintained and upgraded in the new street grid.

The softgrid incorporates possibilities of growth, as in the case where a network of high-rise towers might emerge from an area that was previously allocated to low-rise fabric buildings or faded into open park space.

The plan is thus a dynamic system that generates an adaptable framework for urban form, balancing the need for a recognizable image and a new environment with a sensitive integration of the new city with the existing surrounds.



Netpull - Competition stage - 2006

PLANNING CODE | *open spaces strategy*

Public open spaces network
The stitching strategy embodies urban positioning and an operational reality to shape and control the un-built rather than the built.

Since open spaces do not carry economic value, often tend to be marginalised if there is a space contsraint. However, a well connected network of varied scales of such areas has been shown to both enhance the welfare and social utility of green spaces and increase land value in the proximate build environment.

The soft-grid framework and its division into many sub-grids creates open conditions to support a porous, interconnected network of open spaces that meanders throughout the city. In Kartal, the public land area is currently constrained and to meet the demand for space, important focus areas such as the quarry or the recreational seabelt must be integrated as main public polarities in the open spaces network and tightly mixed with work or residence land use.

We defined three main scales, constituents of the network :
1- Large North-South spine linking the main focus areas on the whole site as such: quarry park/ CBD, commercial areas, sea front and marina.
This spine is supported by the tram line which is a very strong urban element in the Masterplan and has a great opportunity to form public spaces and distinctive urban sequences across the site.

2- Public promenades crossing the whole site from west to east :
they participate to the comprehensive stitching strategy as a part of the programmatic bands stretching from West to East connecting the local public amenity nodes to the larger public spaces and polarities.

These promenades are intended to provide pedestrian access and to support the commercial use along them. Therefore they are mainly finished in hard surfaces and should in no case be unacessible grass bands. These public links are tightly connected to the proposed height zones.

3- Shorter public spaces in every neighbourhood, integrated to the community hearts, such as green vertical paths, parks and plazas.

PLANNING CODE | *open spaces strategy*

Three Sequences along the Boulevard
Stretching from North to South the boulevard acts like a main link between the two focal areas.

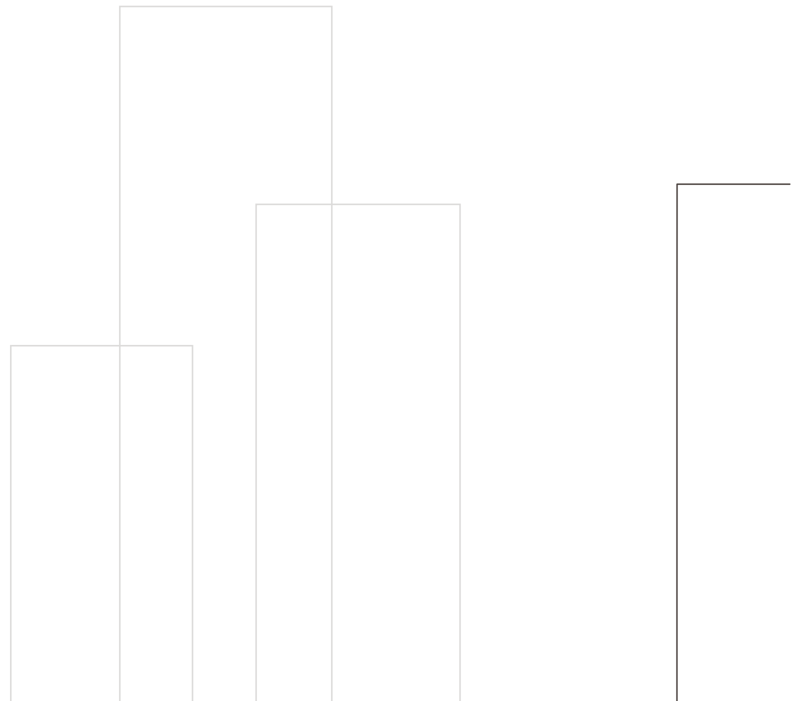
It irepresents the main element of the open spaces network and it crosses the site connecting areas of three different urban identities and scales.

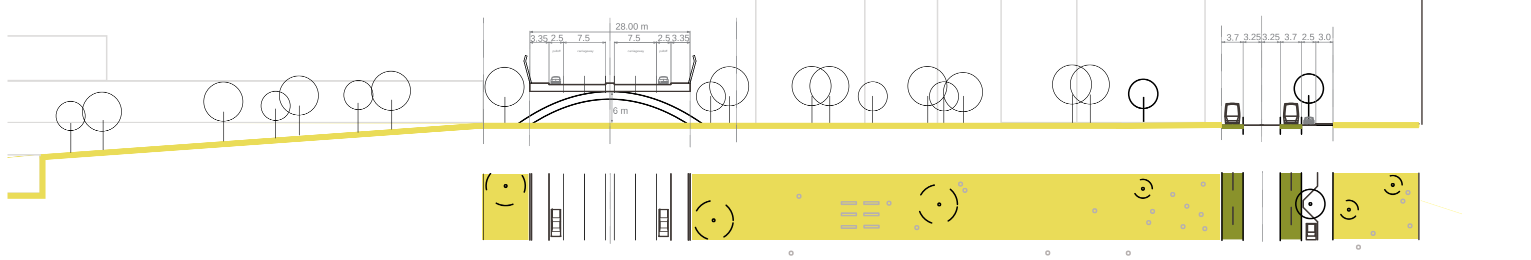
At North it emerges from the clover roundabout in a form of a bridge road. creating the opportunity for a large scale, multi-level city quarter, with high speed, transport connectivity, high rise and large public and private amenities, materializing the contemporary metropolitan urban life.

The ground floor level is mainly pedestrian supported by the tramway line and a green vertical band which insure a smooth transition from a large scale to the more traditional city scale of the boulevard.

The central boulevard area has a "main street" character tree lines on either side,typical to many European cities. Supporting strong retail programme and pedestrian movemement it gives the opportunity to 24 hour activities such as daily market, small shops, cafe, playgrounds, local amenities, cultural events .

The south part of the boulevard is a landscaped sequence, with less retail and plazas and more open air playgrounds and sport facilities. Random tree planting, varied sizes of green, and softer surfaces create a more autonomous entity sloping towards the seafront.

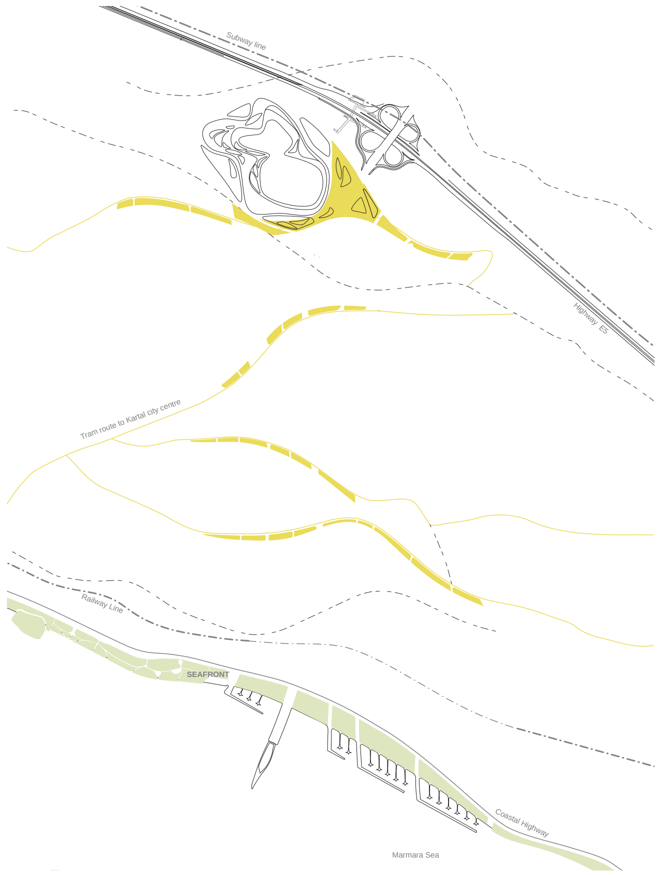




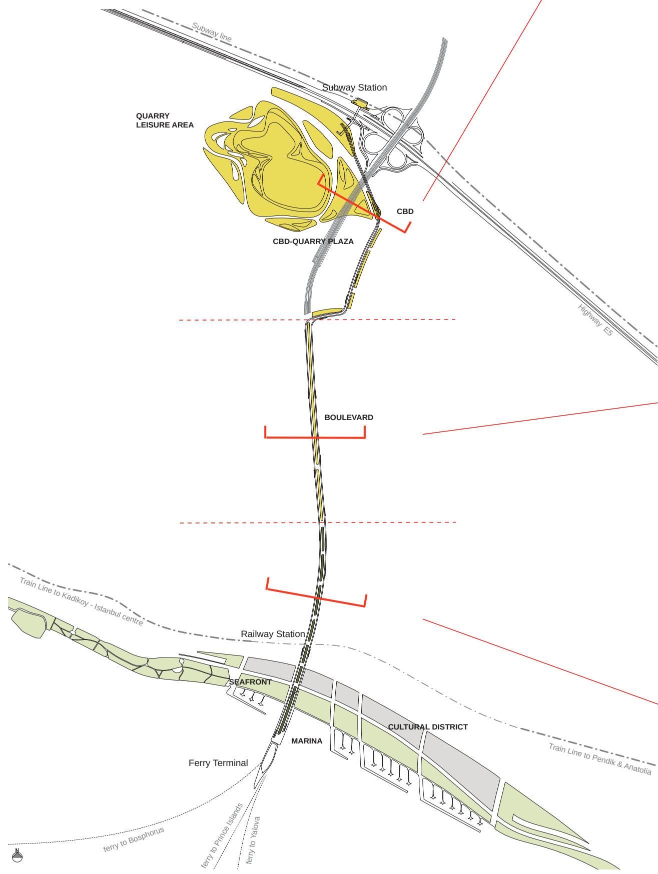
1. CBD - Quarry Plaza

Three main scales of connected public open spaces

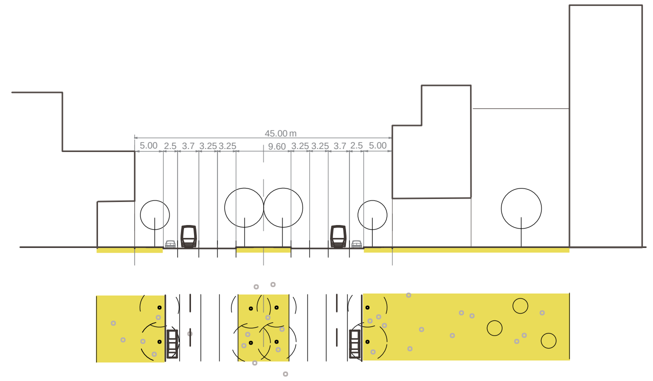
Community scale : Parks



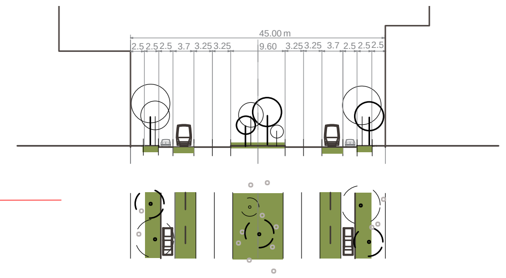
District scale : West-East Promenades



City scale : Boulevard North-South Spine



2. Central Part of the Boulevard - Hard Surface



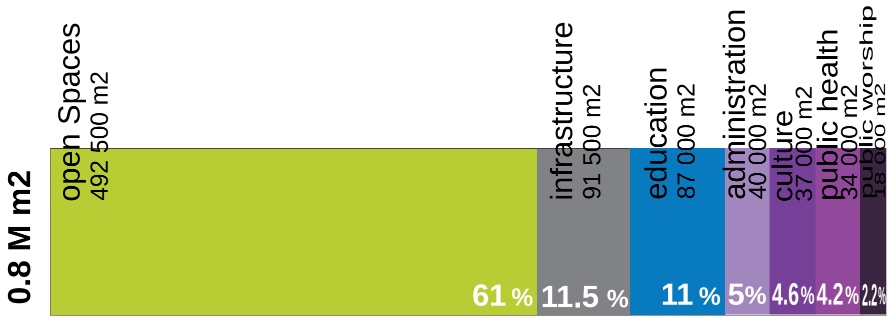
3. South Part of the Boulevard - Soft Green Surface

PLANNING CODE | *public land use breakdown*

Concentrated Nodes of Public Amenities
We proposed to concentrate public amenities needed in each sub-region in order to form readable community scale public nodes connected to the general open spaces network and green spaces.
Each node incorporates schools, social facilities and small scale green spaces into lively attractive hearts of the neighborhood /subregion.

Public Land Use breakdown
The land allocated to the public area is fluid since it doesn t have to obey the three plot ratio options. It constitutes a flexible reservation to face the programmatic and economic evolutions of the area.

Split of public land, as given by the Municipality is:



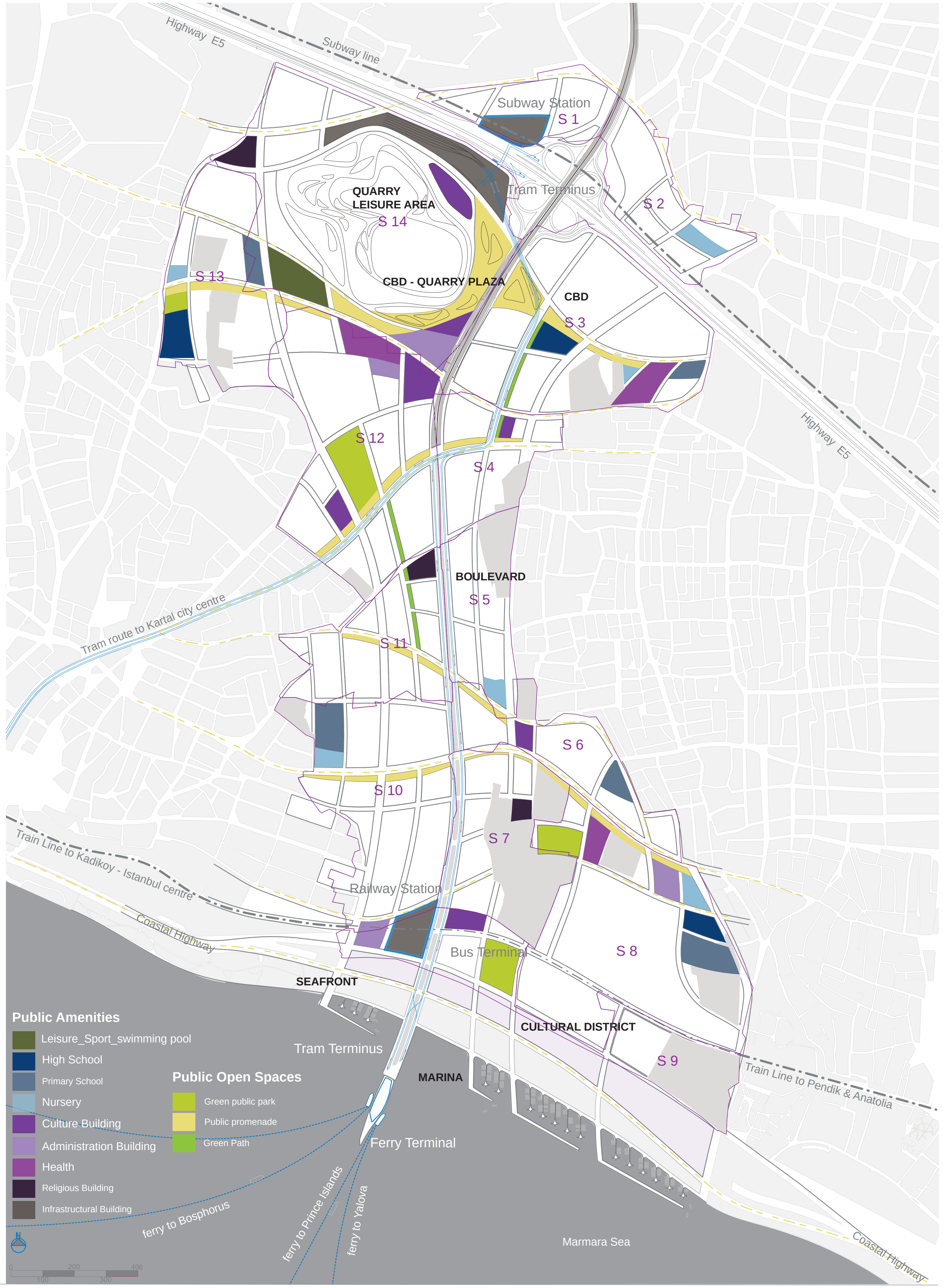
Public Land Use breakdown

Land Use/Sub-region	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	Total
Streets	27166	34074	88268	39409	32222	39953	27353	56441	43351	63259	46276	72316	23120	85019	678231
Public Amenities	16089	20042	66722	6506	11546	14048	10691	86189	60706	51990	19562	76071	34767	321775	796706
Total Public Land	43255	54116	154990	45915	43768	54001	38044	142631	104057	115249	65838	148387	57887	406794	1474937
Sub-region area	94051	119764	357045	119903	116958	131371	184481	368705	192218	276521	161108	342764	190590	562627	3218106

Public Land Use breakdown per subregion

reminder : the space allocated for a possible Convention Centre dovetails with demand for hotel space (in the private space) since both correlate in the market for business tourism.
Education relates to state (public) schools/colleges to serve the needs of the New Kartal resident population only. All areas are considered to be well served already.
If the initially planned Law Courts for Kartal which were planned to have a GFA of 360 000 sqm are still to be located in New Kartal, it will affect the land area required in the public space significantly.

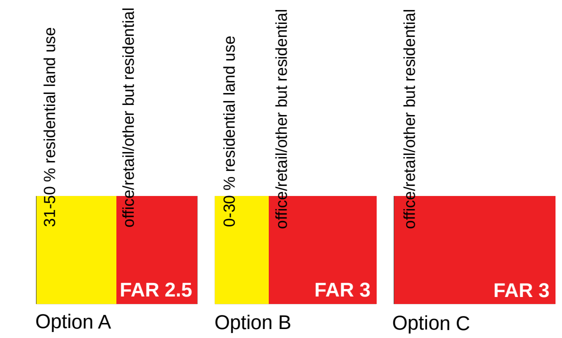
Source : Dqdx



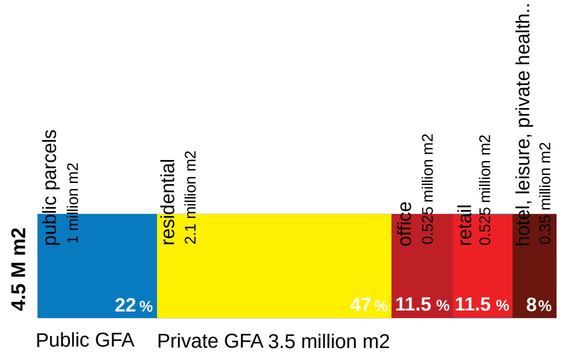
PLANNING CODE | *private land use & GFA breakdown*

Proposed Predominant Private Land Use

In spite of the private developers having been given a free choice of land use for each parcel, we propose a general guidance for the best land use in order to provide overall consistency of the urban project and economic viability.
First principle is to concentrate offices next to the two main focal areas which are connected to transportation hubs and include main public spaces polarities. This context is necessary to provide an optimum environment for business an cultural development.
A second principle is to take advantage of the tramway lines and tram stops by proposing a dominant retail programmes along the route. A mix of retail and housing is proposed along the boulevard to match the suggested small city scale density, as a pedestrian european scale sequence supported by the generous public space and the tram line.
Varied heights and land use is promoted along the seafront to provide day-night activity and a dynamic and lively vitrine from the sea.
Quiet clusters of residential neighborhoods are developped next to the surrounding existing areas.
Takin into account the transportation requirements, the total buildable land use (3 million m2), three available options for FAR, international benchmarking comparison and our consultants analysis and forecasting, we made assumptions for the public/private GFA mix and we propose to split the private land use into 9 categories.

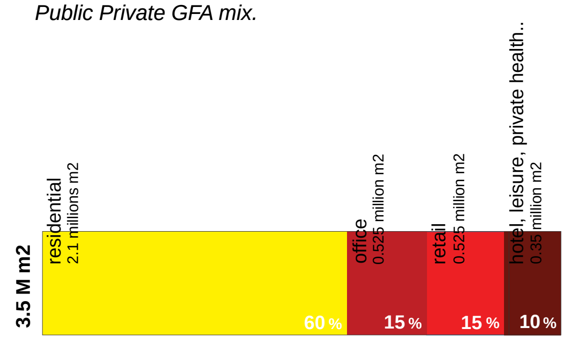


3 Plot ratio options



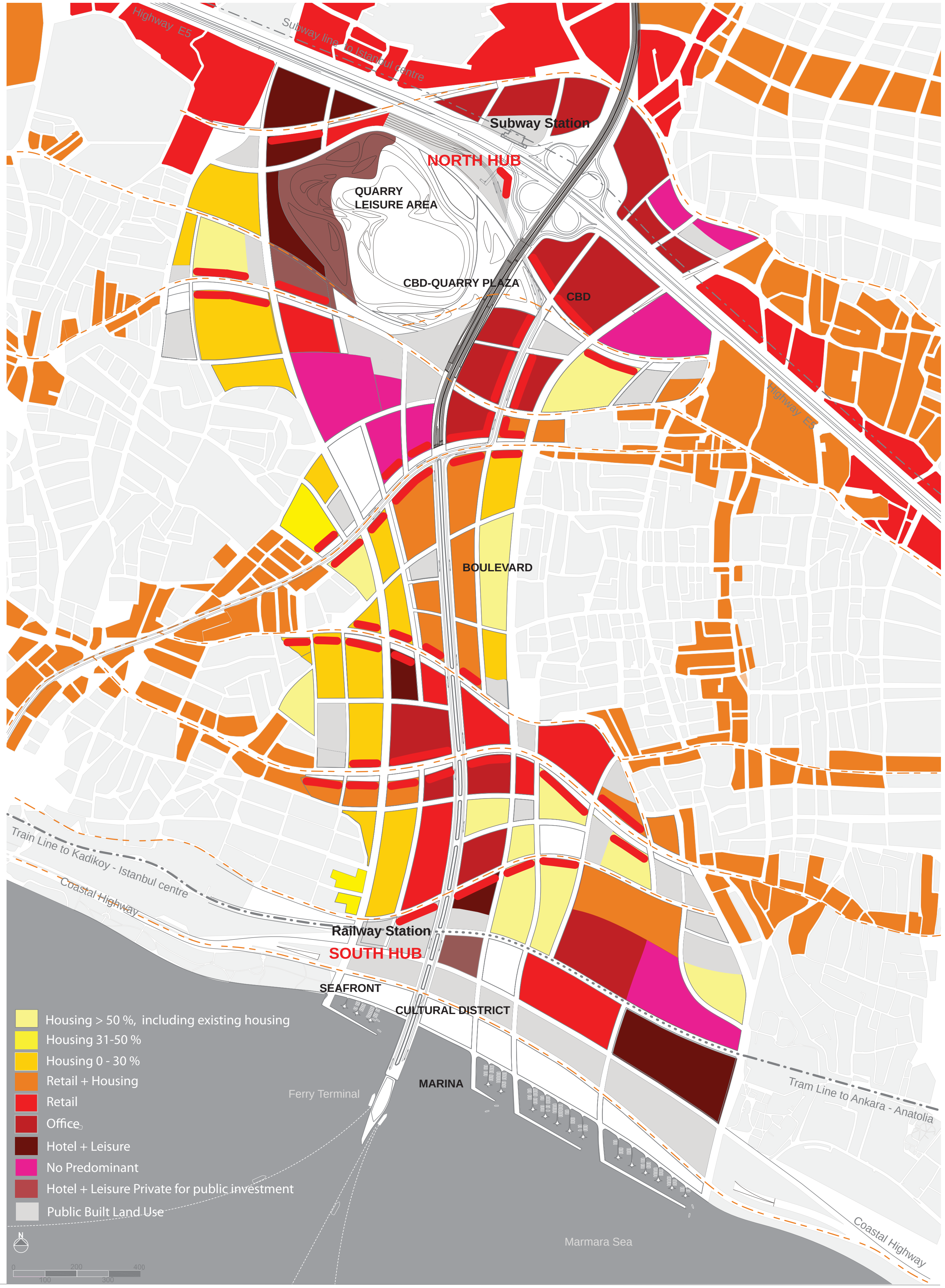
Public Private GFA mix.

Source : Dqdx & ARUP



Private GFA breakdown

Source : Dqdx & ARUP



PLANNING CODE | *transport system*

Efficient Integrated Public Transport alternative
A transport model was established with the main objectives of predicting public tranport and vehicular demand both to and from the site and within it. In addition, parking demand was assessed for weekdays and weekends. The model was used to test combinations of land use mix and modal splits.

The development must rely extensively on public transport, especially for journeys to and from work.

It is clear that car use would need to be restrained or built area reduced. Hence the tests were carried out using the lower spectrum of car usewhich might prove acceptable to residents, employers and visitors.

Public tranport of rail, ferry and bus will furnish capacity to meet the demands of the site. Extensive works are required on the E5 motorway and, in particular, the site interchange, to achieve even the moderate level of vehicular accessibility proposed.

An integrated public transport system consists of two focus hubs : the metro station in the north, the suburban rail, bus and ferry public tranport node in the south linked by a structuring tramway route.

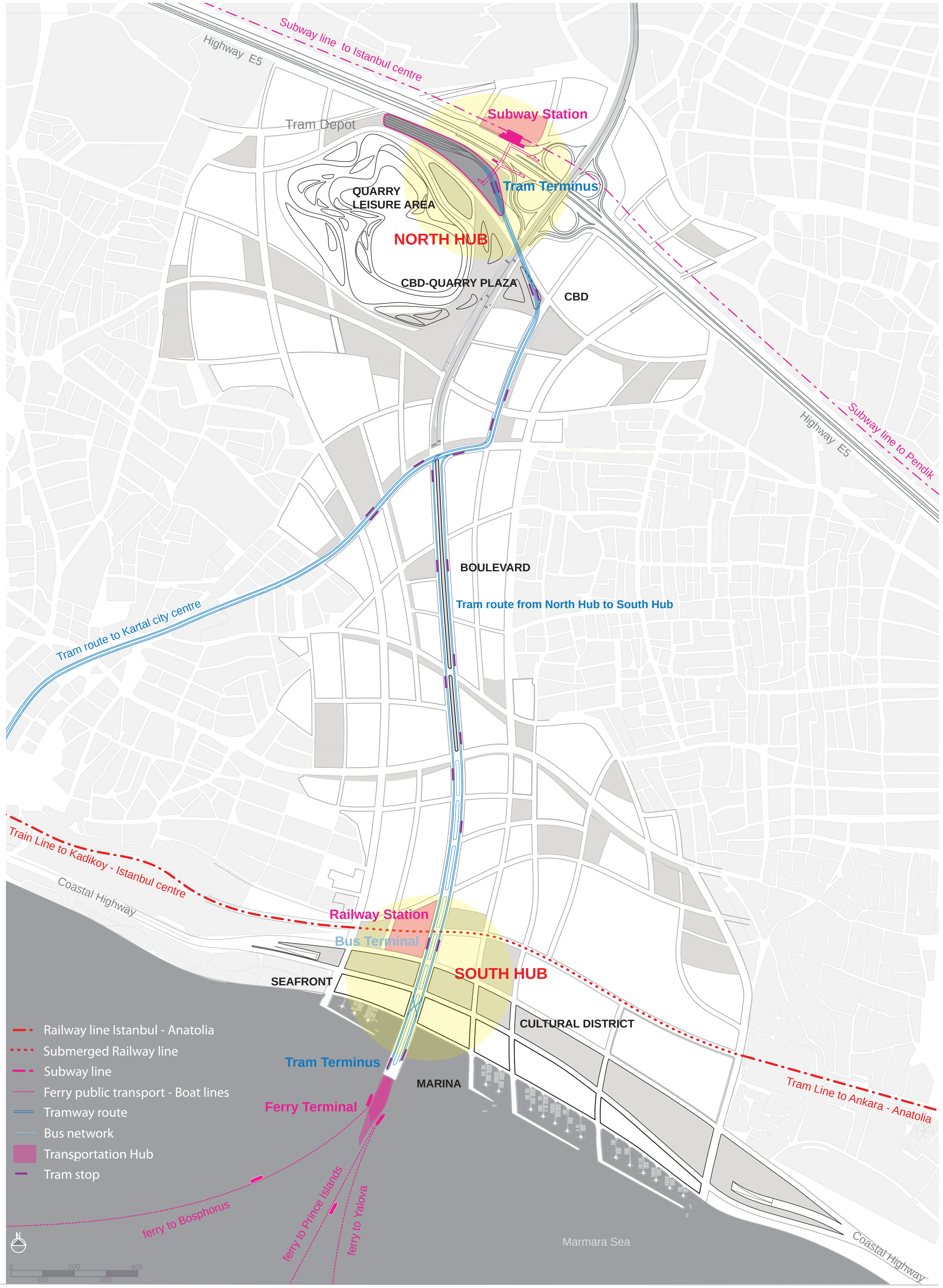
Public rail transport will be very important to provide the degree of accessibility necessary for the development to flourish.
The suburban railway is placed in a tunnel.
The tram, with stops every 300 to 350 meters apart, has a potential branch into Kartal.

To achieve accessibility, the capacity of the railway lines needs to be matched by bus sytems serving the site and surrounding areas, together with strong internal transit to and from the railway stations.
An extensive bus network has a main bus station at the southern public transport node and a secondary one at the metro.
A passenger ferry lies at the terminus of the tram.

Public road tranport must not be overlook as it provides coverage and flexibility which rail systems, by their nature, cannot.
The site and its junctions with the Coastal Highway and E5 motorway will be used extensively by through traffic.

This infrastructure provides the framework for the emergence of new urban districts. Not only does the transportation system generates the essential linkages with the wider metropolis, but the streets, tram, and train stations also are the starting point to define the identity of their immediate urban surroundings. Transport nodes and interchanges define not only the points of concentration in a pattern of movement, but ultimately become keys to the architecture of urban intensification.

Source : ARUP



PLANNING CODE | *transport system*

Street Hierarchy and Profile
Road Access opportunities are restricted to the E5 interchange in the north and the Coastal Highway in the south. To the east and west numerous but mainly low capacity streets offer access.

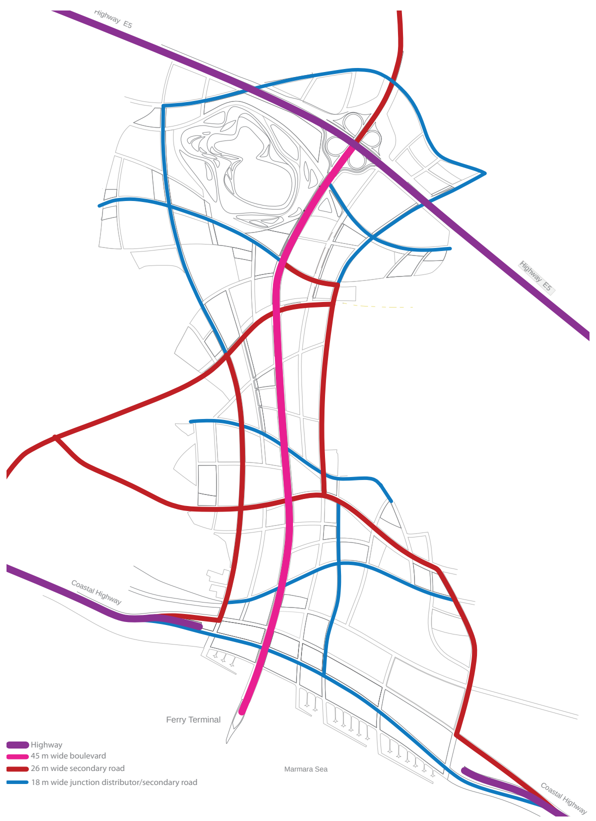
The E5 has reduced to 2 lanes by the time it reaches the site from Istanbul and capacity is further threatened by some not too well defined partial junctions. The interchange on the E5 has circular ramps of a capacity in the order of 1,500 vehicles per hour (vph).
The capacity of the system is further compromised by the junction design on the E5 where entering and exiting traffic conflicts and will have to be enhanced in the future to support New Kartal development.
The Coastal Highway offers more opportunities for access. However, its role is more local than the E5.

A four-level hierarchy of streets, each with a defined role is proposed. (cf. sections next page) The boulevard, with its tram route, is in a special category being the symbolic heart of the Center with a limited vehicle capacity. To achieve this objective, two norrth-south routes, one either side of the boulevard, distribute traffic to the Site as well as leading traffic from Kartal and Pendik to the E5 interchange.

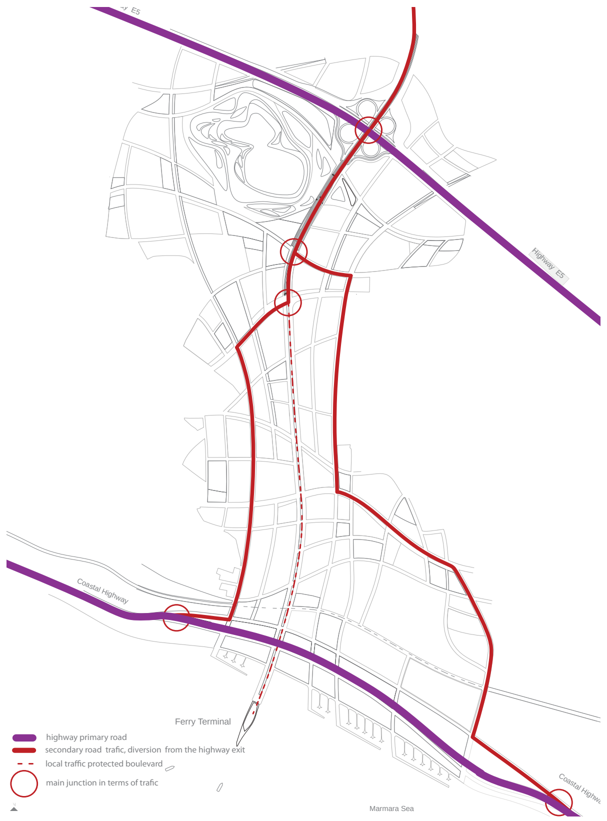
The Coastal Highway is placed in a tunnel.

Pedestrian connectivity is assured by a dense network of generous sidewalks.

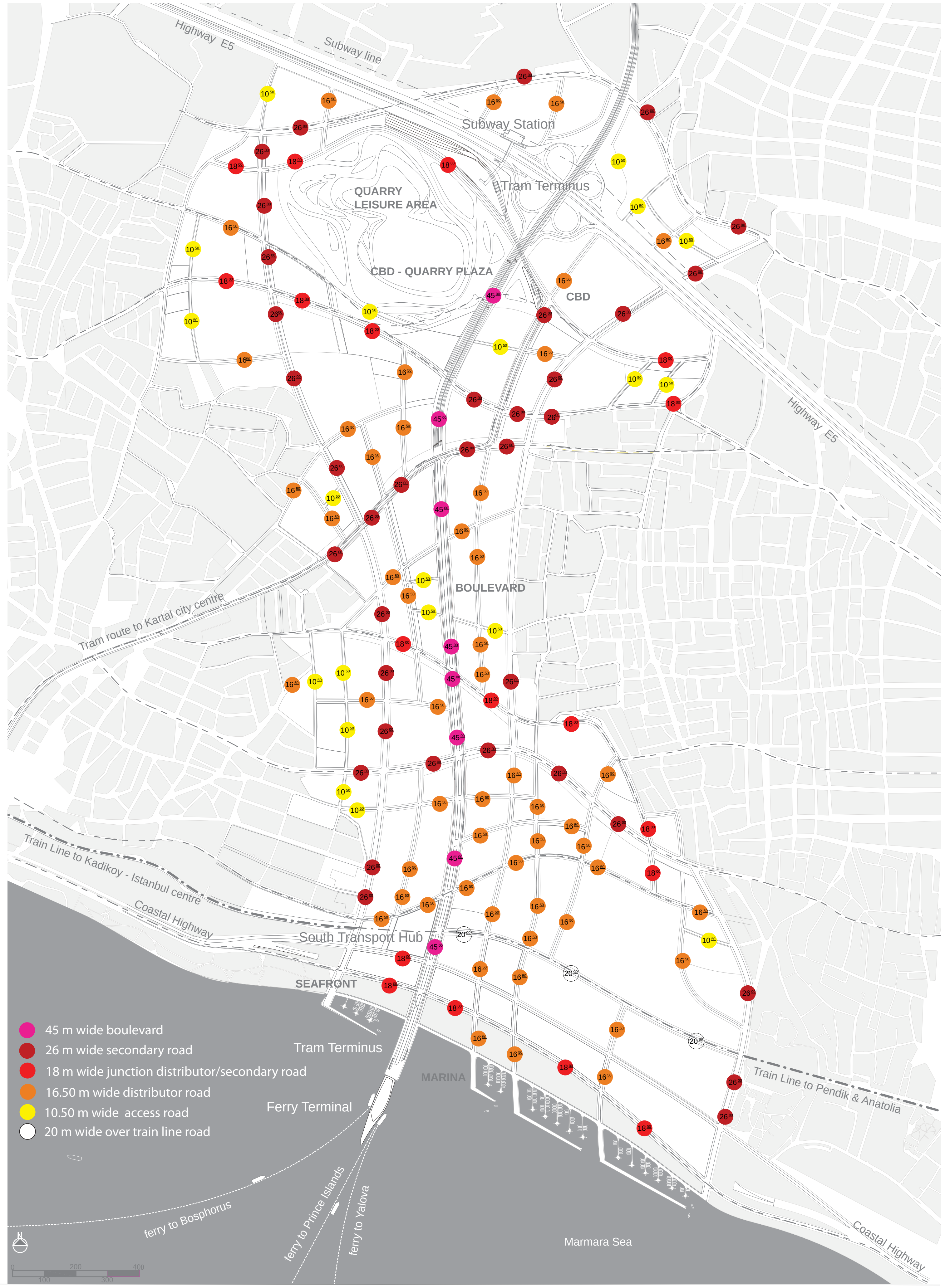
Source : ARUP



Main Streets network



Boulevard trafic diversion



Parking policy
A car parking policy, embracing provision and management, is vital to the success and accessibility of the center. Car parking standards, below those prescribed currently and sharing of non-residential spaces are advocated together with a variable tarif and permit system to regulate usage of parks.

Basement parking is promoted, since Istanbul Metropolitan Area is in the first degree earthquake zone, most of the foundations of the buildings should go at least one basement deep into the soil in order to be able to resist the horizontal movements originated by earthquakes.

On street parking
In general on street parking (in line) on both sides of the streets has to be the rule. (cf. street sections). Large parking plots on an entire parcel should be forbidden and not any green or park should be transfer into a parking. This is necessary to protect the city scape and provide comfortable and lively sidewalks.

Exceptions can happen for big or special public facility or infrastructure.
Private parking needs to be solved within each private parcel, either at the back of the parcel or in a basement.

By no means public promenades, parks or setbacks should be used as parking, not even temporary parking. Parking lines have to start 10m away from a junction between two distributors and 20m away from a junction between a secondary road and a distributor or another secondary road.

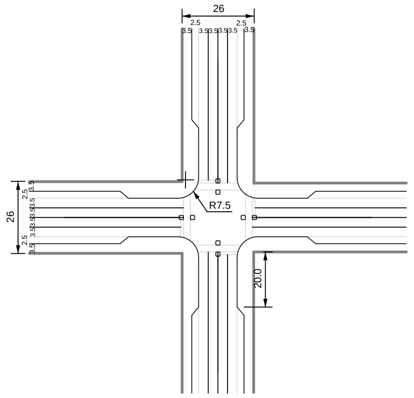
Strict parking regulations in terms of supply, use and management are also essential.

Source : ARUP

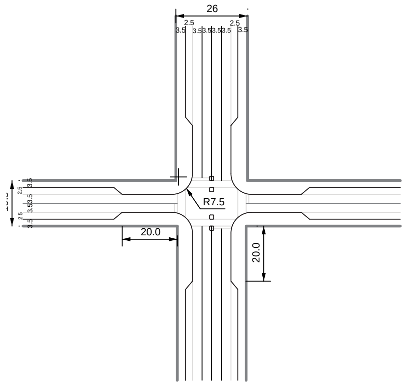
	Land use		Parking needs		
	GFA	%	non resi		residential
	m2		m2 /p		1/ dwelling unit (165 m2)
Residential	2,300,000	51.11%			13,939
Office	525,000	11.67%	100	5,250	
Retail	525,000	11.67%	115	4,565	
Hotel	145,000	3.22%	200	725	
Entertainment	110,000	2.44%	35	3,143	
Private Health	95,000	2.11%	100	950	
Education	185,600	4.12%	150	1,237	
Cultural & Social facilities	288,200	6.40%	50	5,764	
Administration/Infrastr	210,700	4.68%	125	1,686	
Public health	80,000	1.78%	100	800	
Public worship	35,500	0.79%	225	158	
		0.00%			
Total	4,500,000	100.00%			
				38,217	

Parking needs

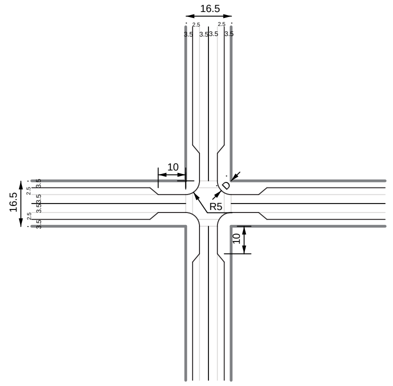
Street main junctions



junction between 2 secondary roads



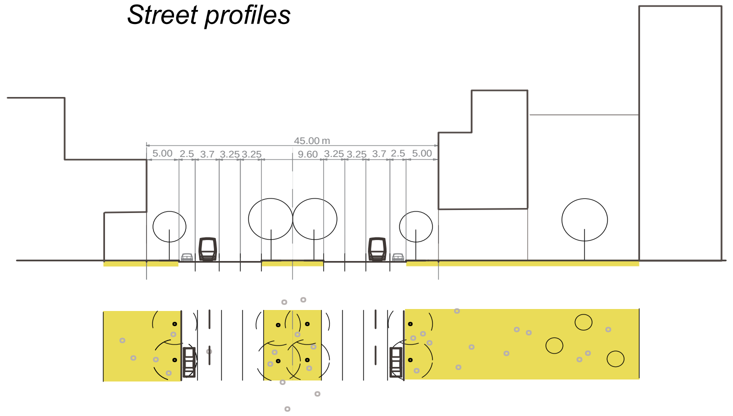
junction between secondary and distributor



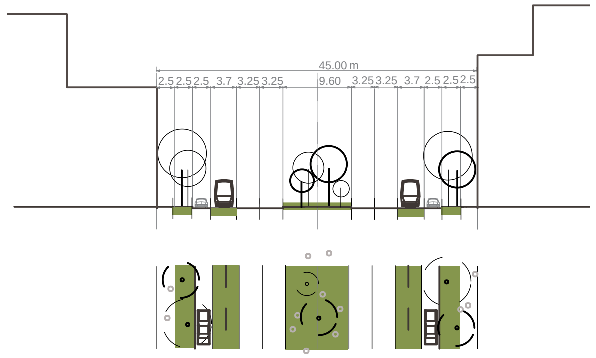
junction between 2 distributors

Source : ARUP

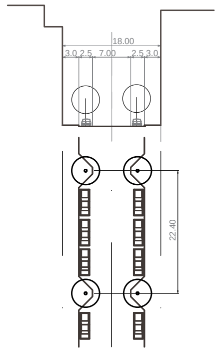
Street profiles



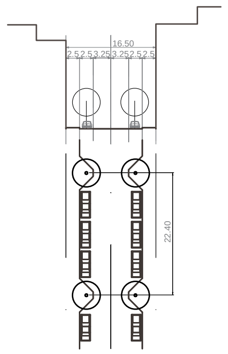
45^{00} *boulevard - center part :*
2 cars lanes + tramway + on street parking each side



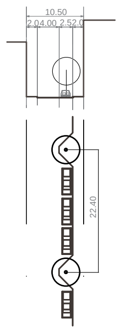
26^{00} *secondary road :*
2 car lanes + on street parking each side



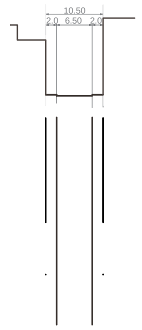
18^{00} *distributor road (transition from 26 to 16.50 m):*
1 car lane + on street parking each side



16^{50} *distributor road*
1 car lane + on street parking each side



10^{50} *local road one way*
1 car lane + on street parking



10^{50} *local road*
1 car lane each side

PLANNING CODE | *urban massing and height strategy*

If the urban soft grid, the open spaces network, the concentration of usages and the transport sytem provide a guiding structure for differentiation, our project-based experience with the three dimensional architecture of movement allows us to define the specific qualities of new urban districts.

The landscape of the future city is based on discovery, nurturing, and radical interpretation of the fragmented and distorted form of the currently existing landscape.

Skyline and Urban “Blanket “
The proposed height strategy aims to apply the original concept of the distinctive dynamic skyline developed in the project’s competition stage.

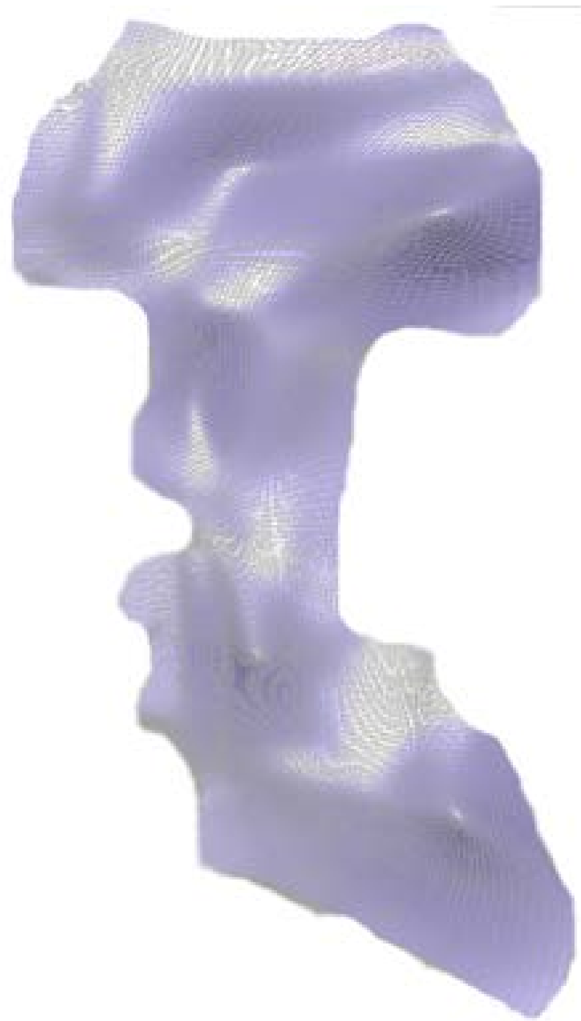
Urban Massing is generated from the three-dimensional model of skyline.

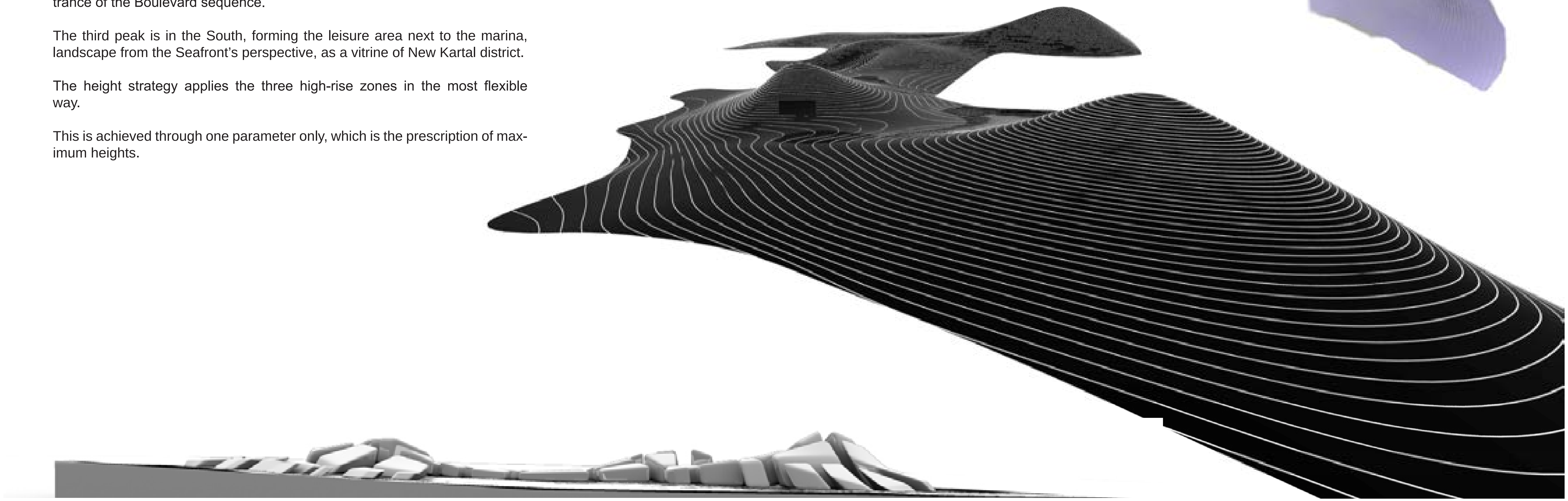
The urban blanket defines three high-rise regions located on strategic points on the site :
The first peak is forming the CBD (office park) on the north side of the Masterplan
The second peak is at the starting point of the Boulevard, forming the entrance of the Boulevard sequence.

The third peak is in the South, forming the leisure area next to the marina, landscape from the Seafront’s perspective, as a vitrine of New Kartal district.

The height strategy applies the three high-rise zones in the most flexible way.

This is achieved through one parameter only, which is the prescription of maximum heights.





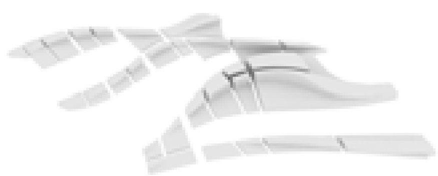
PLANNING CODE | *urban massing and height strategy*

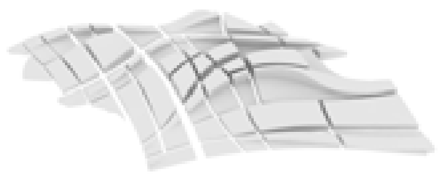
Zones of allowed height proliferation
The height regulation is achieved through identifying and specifying the maximum height on all the urban blocks.

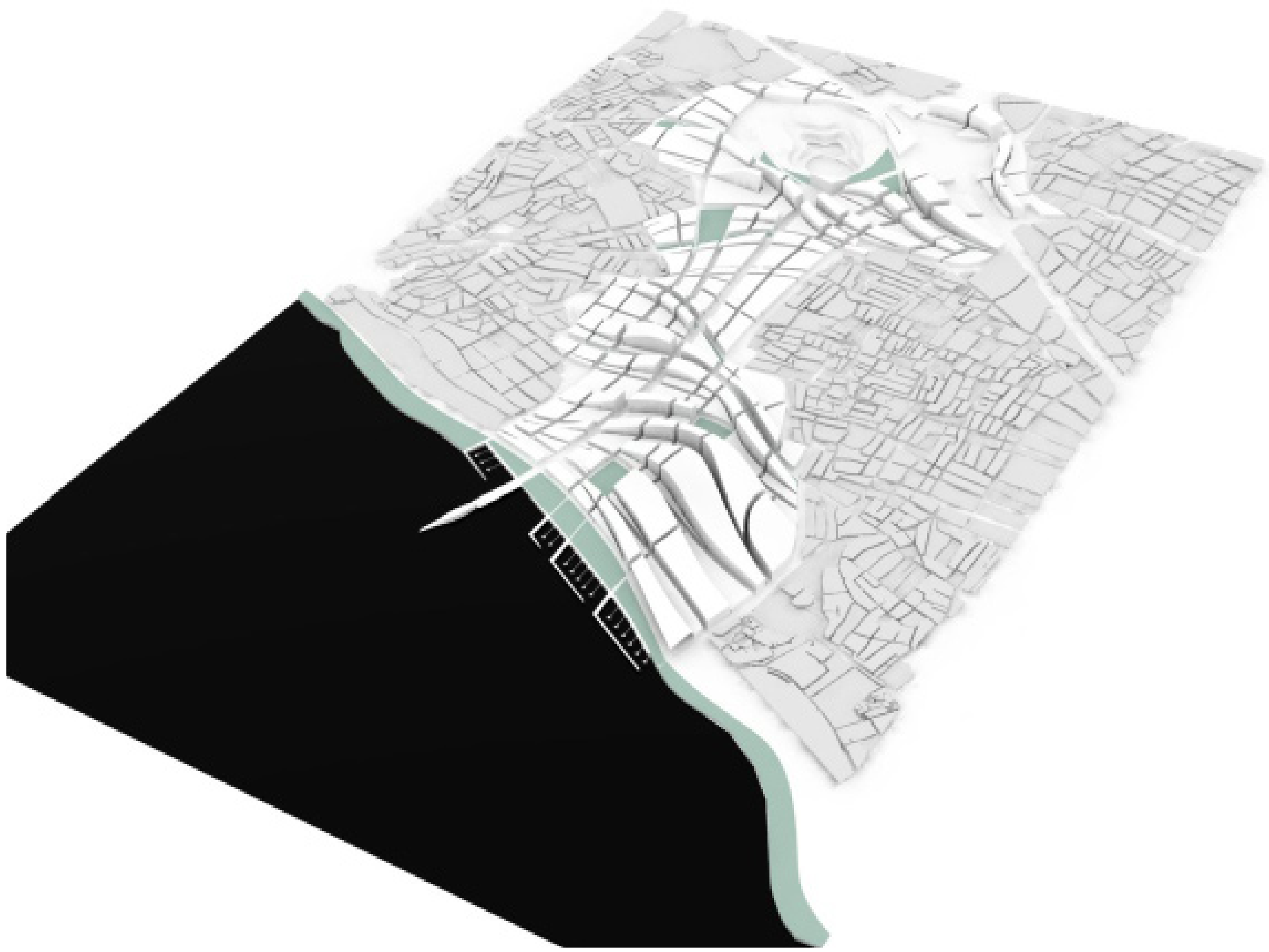
The heights are regulated in bands stretching from East to West thus supporting the idea of “urban stitching” on several levels, spatially as well as programmatically.

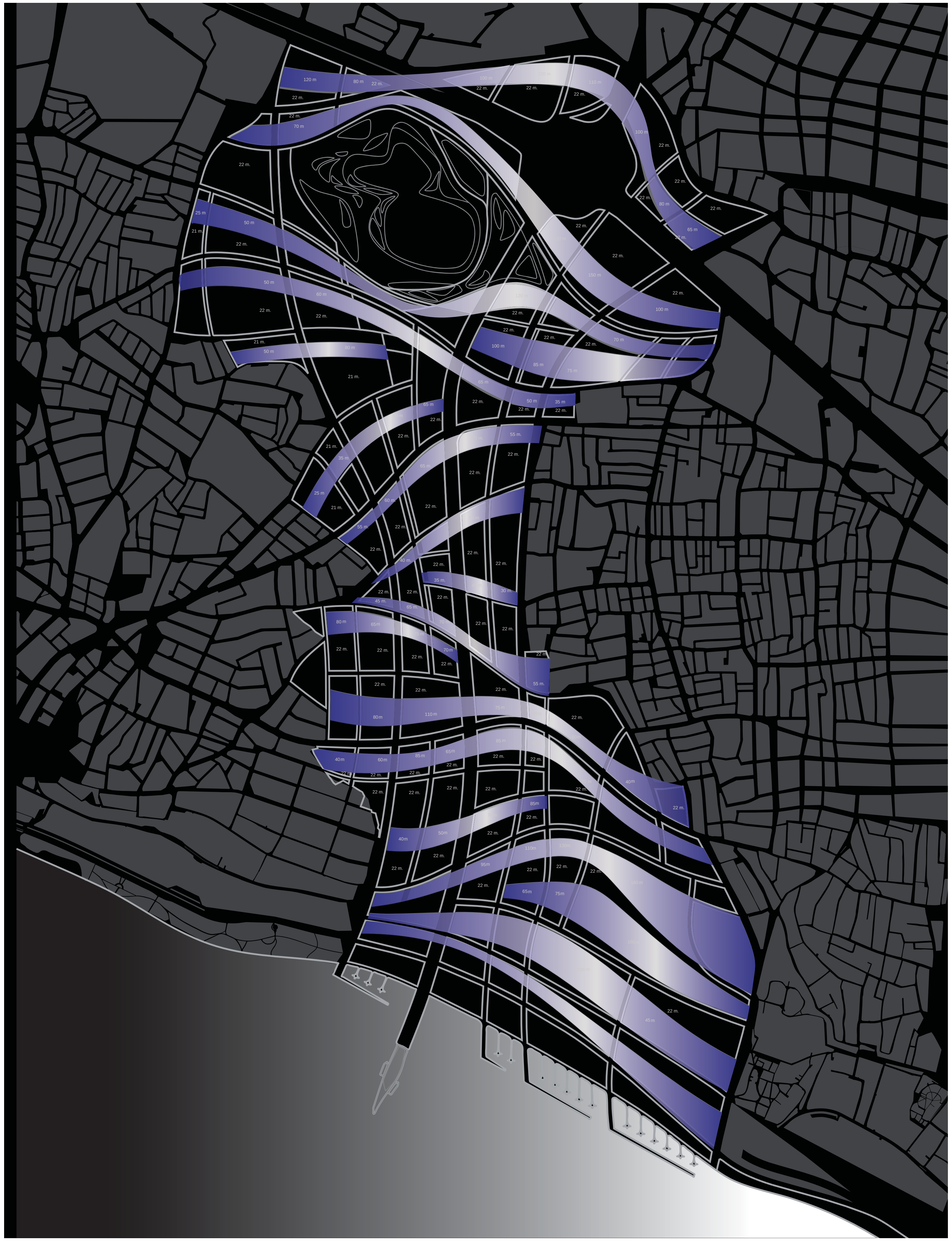
There are two distinctive height zones - one being variable and the other 22 meters:
Purple Height bands show the variable height, generated from the 3d model of skyline dscribed before. General height in between the bands is defined as 22 m. It gives the opportunity to built up to 7 floors (assuming the ground floor to be 4 m high).

On each city block Maximum height is indicated and a physical line marks the height change where it occurs.









PLANNING CODE | *seafront landscape*

The seafront is the unique gateway and arrival point to the site.

Seafront's panorama reflects the moving skyline of different height zones, offering a distinctive and visible "vitrine view" for the New Kartal area from the waterside.

The panorama shows the ascending built-up strips, moving from the seafront towards the quarry.

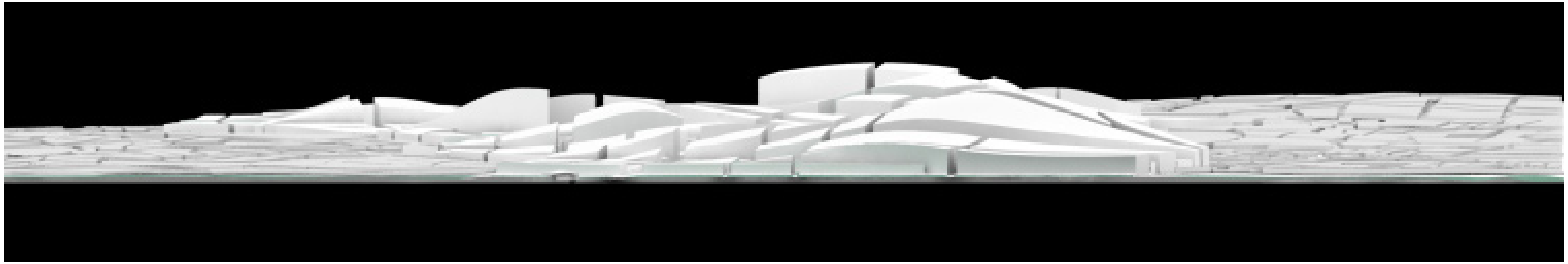
The height strategy defines only maximum heights within height strips due to the very complex ownership and parcelation background of the project. Therefore it is ov great importance to follow particular design recommandation in the front parcels at the seafront.

Buildings along the seafront should not be of the same height in order to avoid the impression of a built wall separating the seafront from the rest of the city. Access to seafront should not be blocked.

The unique location to the seafront shouldn't benefit only to the privileged front parcels - all parcels should benefit from the prosperty of the area.

Cultural district
The public strip next to the marina is defined with a cultural programme. Althugh compliant to height regulations the district also reflects the dynamics of the overall urban landscape.

Seafront future functions should be mixed and vibrant enough both at day and night to ensure the urban intensification role of the water edge.



PLANNING CODE | *city & streetscape*

Human scale bulk along the streets
To achieve the “city scape” from the perspective of the street level, we have set up a sequence or architectural volume rules along the streets. The main issues are to avoid canyon - like streets, to insure a certain maximum light fall on the street surface as well as on the building facades. Public spaces and streets are the most sustainable elements of a city and also the shared reflection of each quarter’s character.

The streetscape guidelines define a buildable envelope in relation to the street width. A line drawn from the centre axis of the street to the top of the maximum alowed facade height of the facade along the parcel boundary defines this buildable envelope on both sides of the street.

We propose two methods of getting the maximum height in accordance to the main building typology.

small/intermediate scale building blocks:
small to intermediate scale buildings which are in an urban city block location forming a continuous building facade along streets
To get the maximum façade height along the parcel boundary the following formula is applied:
max height = total width of the street between two façades + 1 storey

Maximum allowed façade heights according to the street types :

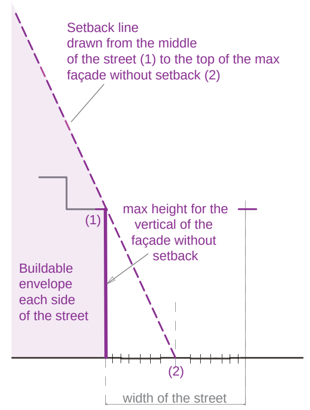
10.5 m wide streets:	H max 14 m
16.5 wide streets:	H max 20 m
18 m wide streets:	H max 21.5 m
26 m wide streets:	H max 29.5 m
45 m wide boulevard:	H max 48.5 m

high rise/ isolated building blocks:
any building which fits in an envelope of average max 50mx50m width and doesn’t build up the whole parcel length and doesn’t form a continuous building facade along streets (distance between two buildings has to be more than 50m).
To get the maximum facade height along the parcel boundary a ratio of 1/1.5 between the street width and the maximum allowed façade height is applied.

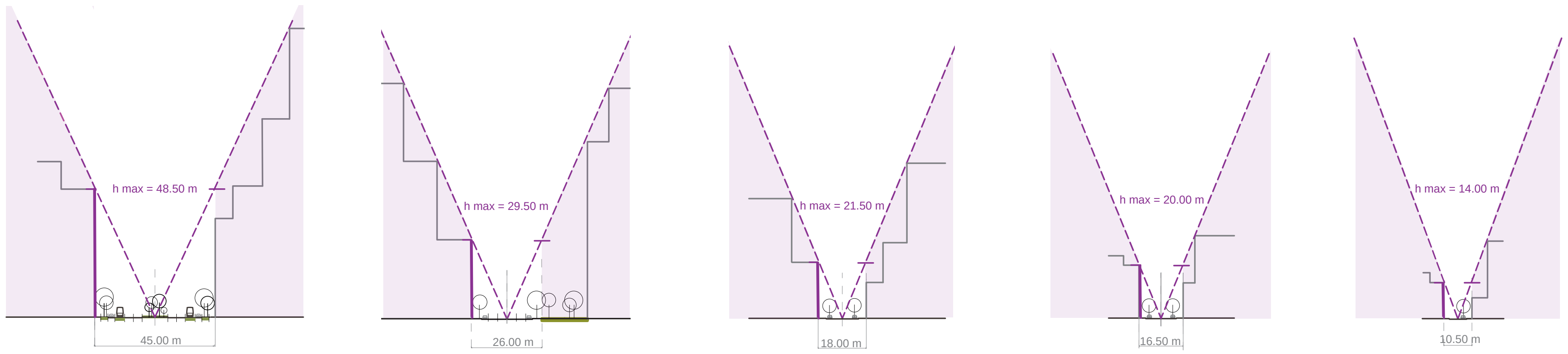
Maximum allowed façade heights according to the street types :

10.5 m wide streets:	H max 16 m
16.5 wide streets:	H max 25 m
18 m wide streets:	H max 27 m
26 m wide street:	H max 39 m
45 m wide boulevard:	H max 67.5 m

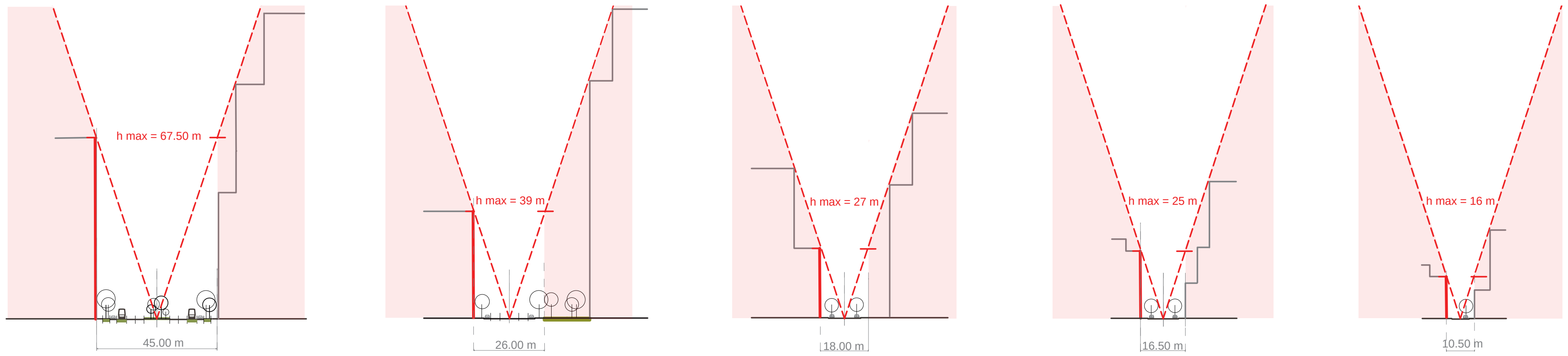
These guidelines are relevant for private parcels only, fixed heights for education buildings have been defined by the Municipality:
nursery = 1 storey (max. 5 m height)
primary school = 3 stories (max. 10.50 m)
high school = 5 stories (max. 17.50 m)



Principle



Buildable envelope for small/intermediate scale buildings



Buildable envelope for high rise/isolated buildings

PLANNING CODE | *building lines & distance between buildings*

Vertical building lines
To protect a continuous groundfloor commercial activity and avoid street volumes becoming to wide, all landowners along the vertical building lines in the central part of the Boulevard are obliged to build their parcel up to 70% along these building lines.

The same principle is applied along the East - West promenades, as 40% to 70% of the building lines need to be observed.

Existing housing zones
In a second phase, if they are demolished, the existing housing zones must also comply to the building lines.

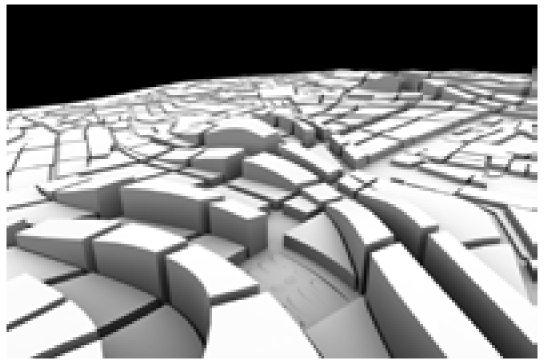
Distance between Buildings
To allow sufficient light and air circulation inside the parcels we propose to regulate the minimum distance between two buildings.

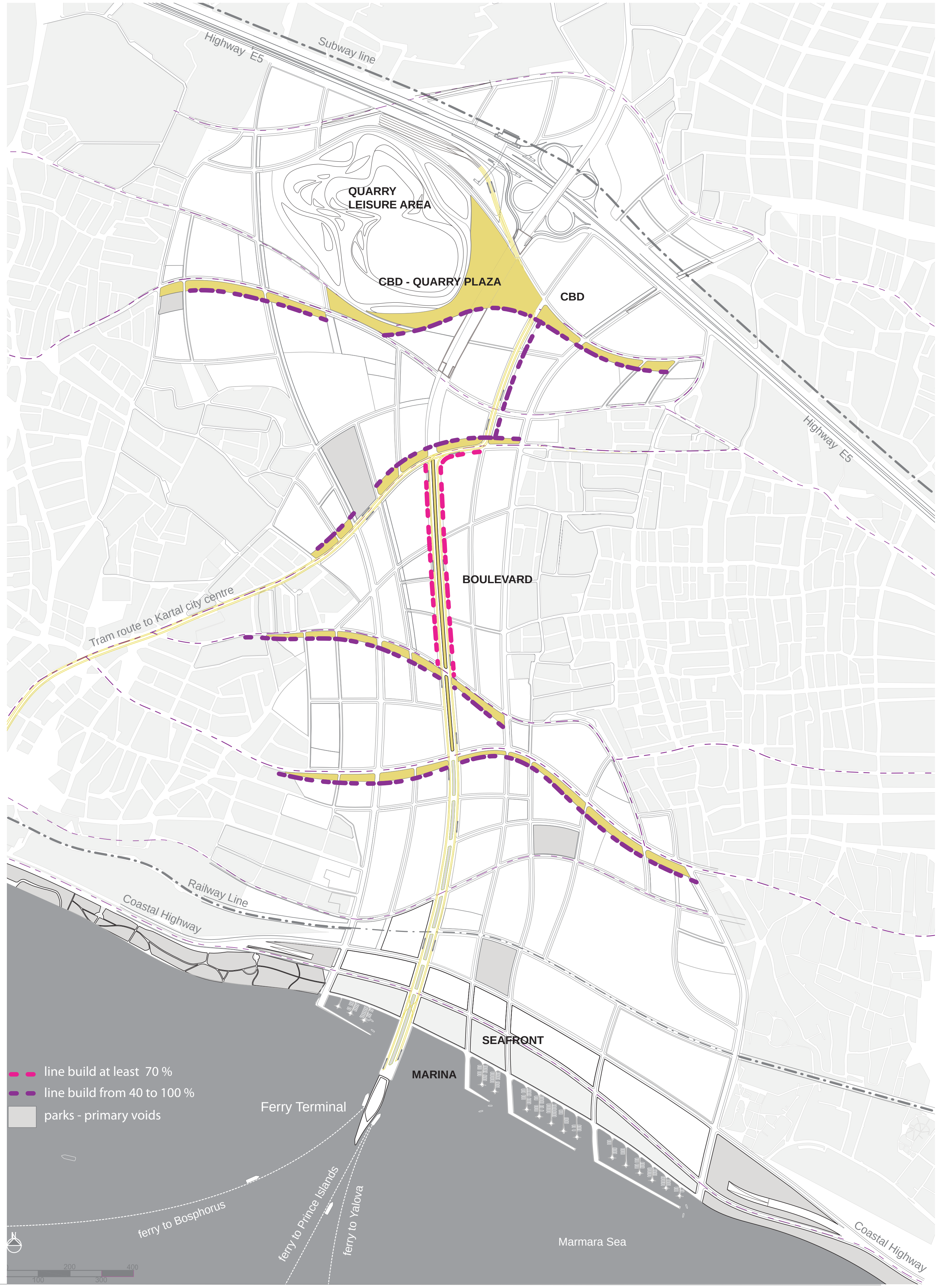
In any parcel, two or more detached buildings shall be permitted on a lot in accordance with minimum interior yard requirements between all buildings. The required minimum depth of such yards shall be determined in relation to the height and length of each building wall, as follows:

Urban city blocks (cf. above definition)
 Min Depth = (H1 + H2) / 2
High Rise/ Isolated building blocks (cf. above definition)
Min Depth = 50 m

The minimum depth of yards shall be measured perpendicular to the building wall at all points. Such distance between buildings shall in no case be less than the sum of the required minimum depth of such adjoining yards. Required yards may overlap, provided that such overlapping does not decrease the above minimum yard distances separating buildings.

After any portion of a lot has been developed under the above provisions such lot may be divided into smaller lots only if each resulting lot and buildings thereon conform to all the regulations of the zone district in which such lot is located.





PLANNING CODE | *phasing principle*

Private and public projects in strategic nodes.
Uncertainties about programmatic and economic situation, private and public investments capacities, imply that urban planning is no longer frozen long term master planning.

The planning must be more strategic and flexible, allowing varied programs, densities and development scales to take place in the future without affecting the spirit and matrix of the project.

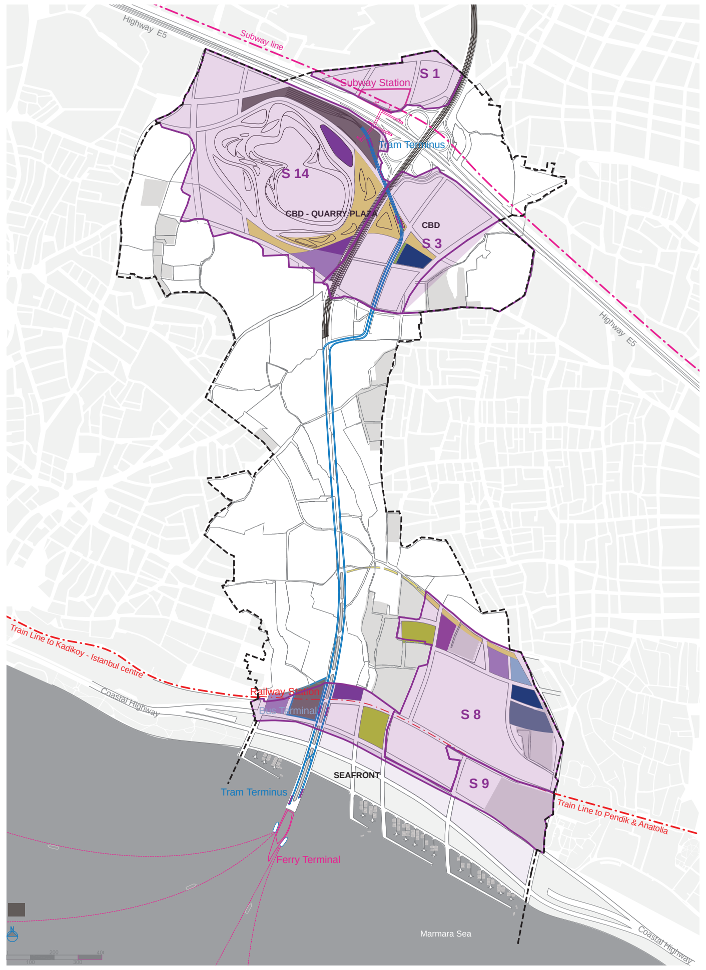
The regeneration of Kartal area will be experienced as an emerging mosaic of new urban quarters each structured around a particular logic of investment appearing in time. Detailed and spread out phasing over 25 years would then be unrealistic and inappropriate. The issue is to insure a good and sustainable start of development for the new Kartal sub-center.

Visibility is also a critical point in such a large and strategic new district for Istanbul City. The sucess of first developments will be critical to the success of the new image and attractivity of the whole area. If strong and continous political support, well-recognised private developpers, outstanding and singular starting actions, and even small but strategic and qualitative public actions are gathered, it will pave the way and give the necessary trust to average developers.

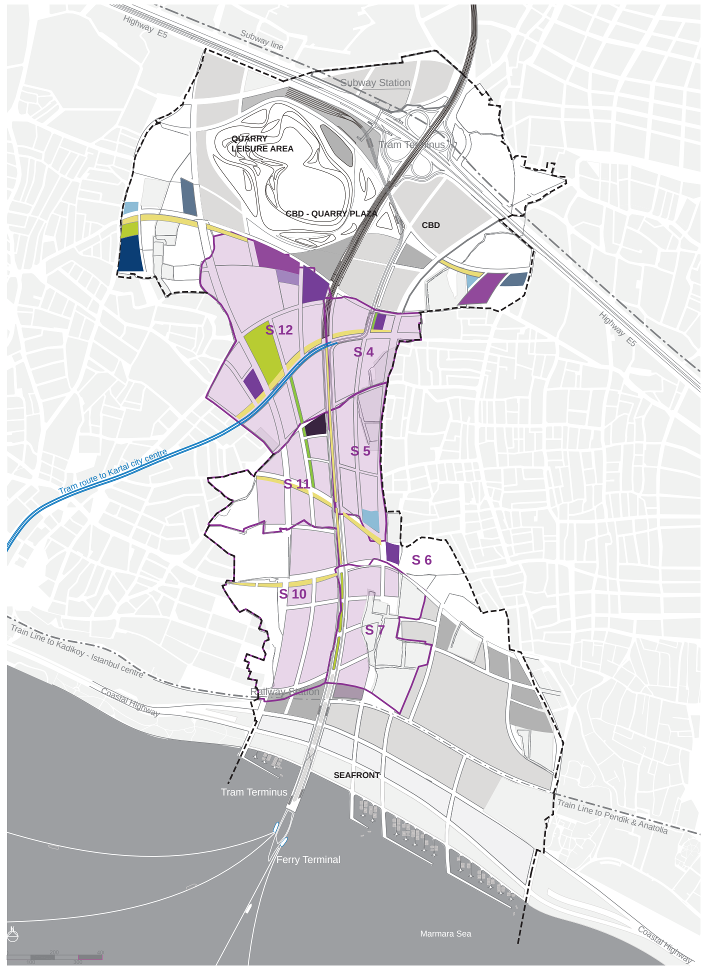
Starting and concentrating first actions to provide sufficient “mass effect” is then an absolute necessity.

Again, good accessibility, early and efficient development of the public transport is also a key element of the attractivity of the new area.

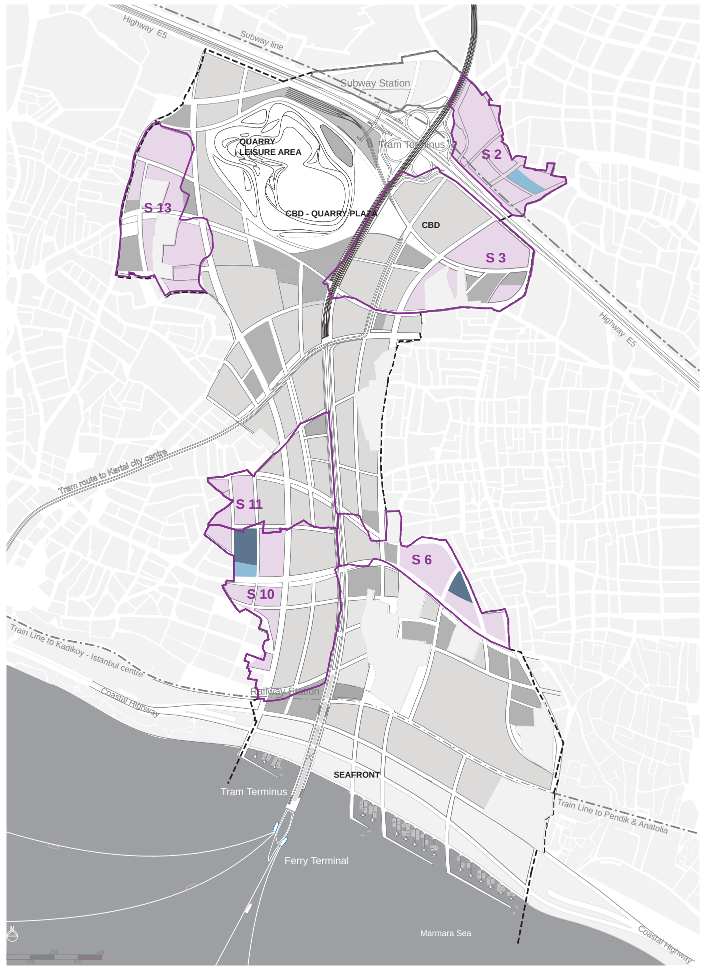
Providing the economic stability is achieved the first phase can be achieved over 5 years and followed by the longer period of 15 years for the completion of the masterplan development.



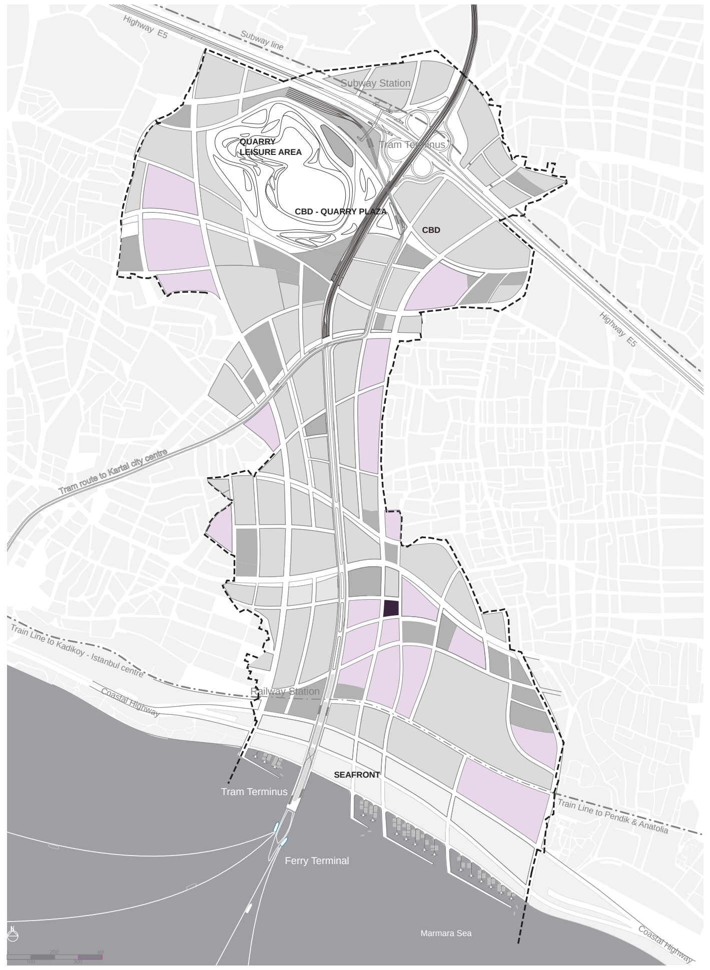
phasing plan over 5 years : focal areas, transport system, main public spaces



phase 2 principle : central area, 2 main N/S roads, W/E promenades

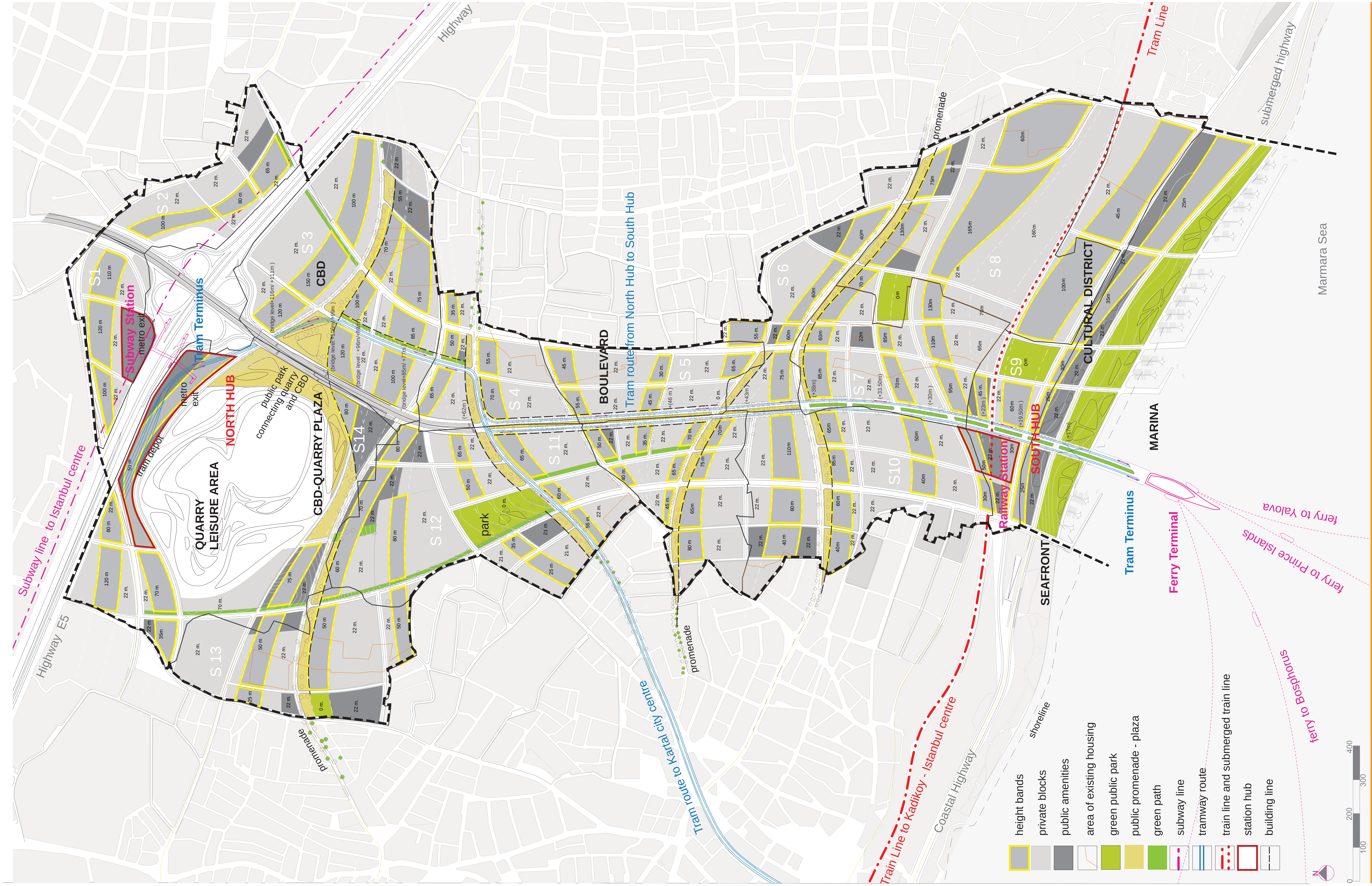


phase 3 principle : junction areas



option with renewed existing housing areas

PLANNING CODE | *reference masterplan 1/1000*



NEIGHBORHOOD, SINGULARITY AND SPEED

NEIGHBOURHOOD, SINGULARITY AND SPEED | *density and ground coverage variations*

Singularities within the overall landscape
Overall dynamic landscape is generated from the three-dimensional model of skyline expressing itself in varied heights, densities and ground coverages.

Sub-grids may further be used to sub-divide as much as needed in each block development to define parcels, perimeter blocks, voids, detached buildings, cuts and setbacks.

It will allow the emergence of distinctive quarters and singularities in the new urban landscape while creating a porous, interconnected network of open spaces that meanders throughout the city. Through subtle transformations and gradations from one part of the site to the other, the resulting fabric will create a smooth transition from the surrounding context to the new, higher density, and more intense urban experience development on the site.

3 identified scales and ground coverages
In certain areas the model rises up to form a network of towers in an open landscape, while in other areas it is inverted to become a denser fabric cut through by streets, at other time may completely fade away to generate voids, parks and openspaces.

The quarry-CBD area and the Seafront are large scale and high rise areas (Peaks), where buildings tend to be tall, isolated, like objects connected to big public spaces. In the center a broad band including the boulevard offers the suggestion of a civic and residential homogeneity at smaller scale with build continuity and high ground coverage. Public and semi-public spaces are smaller and more intimate.

To make a smooth transition between these two opposite scale two intermediate zones forms the third scale of urban fabric, with medium ground coverage and mixed building types. Here the pace slows down or speeds up.

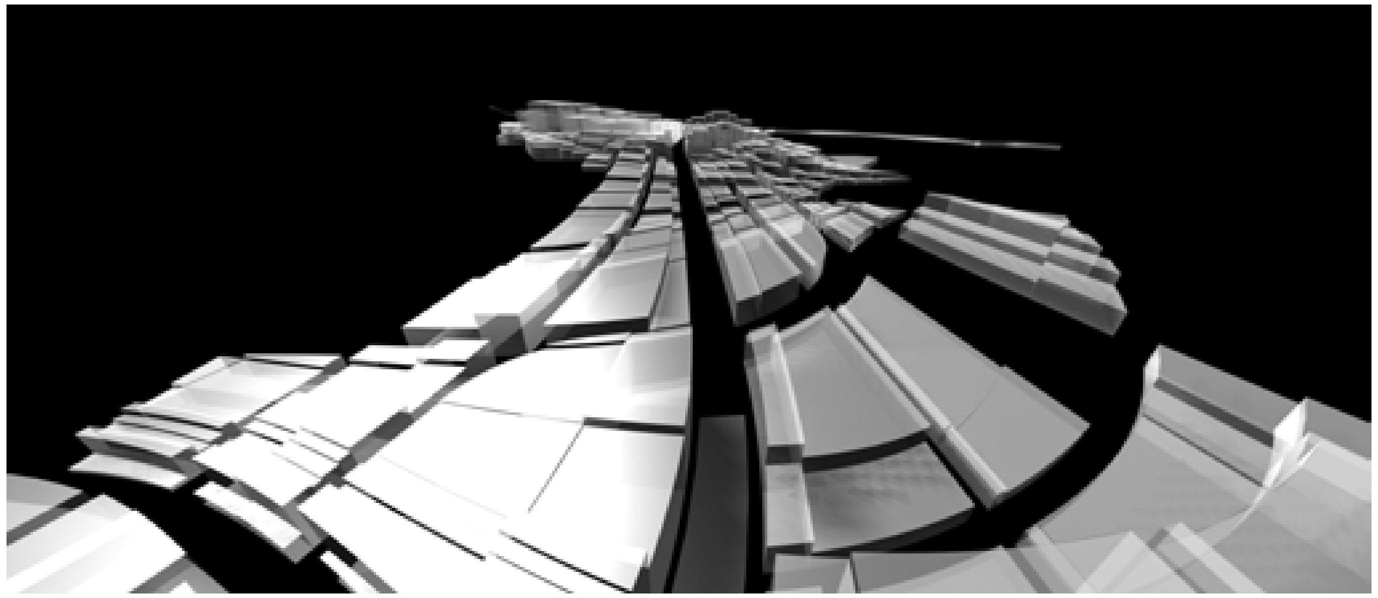
Varied speeds and changes of pace
This differentiation encourages variations in the overall urban landscape but also in speed of vehicular traffic, pedestrian movement, morning and evening rush hour dynamics, as well as difference in building typologies and architecture. It also allows integration of future development into existing urban patterns.

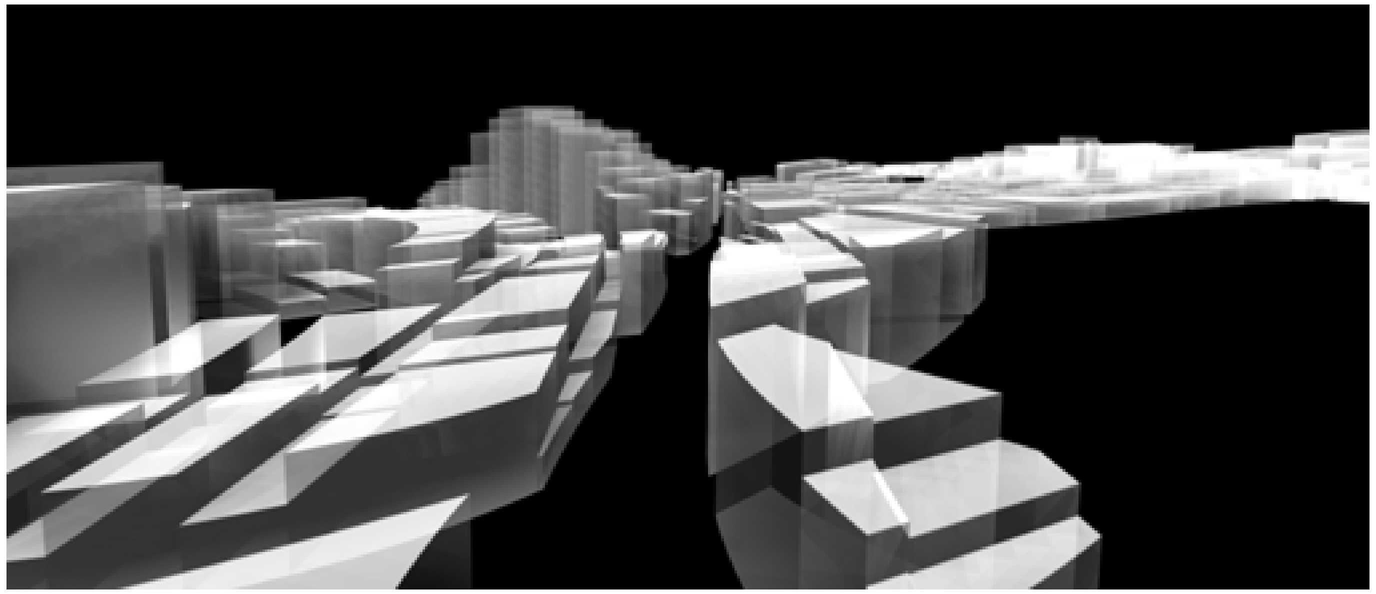
Movement, changes of pace, scale breaks as well as fixed nodes, vertical or horizontal crystallisation, are all sub-scripts of the first soft grid system. They will add more subtlety and singularity to each quarter, creating local accidents and events, “hard points“ of urban definition and intensification, as well as softer zones of slackening and urban breathing.

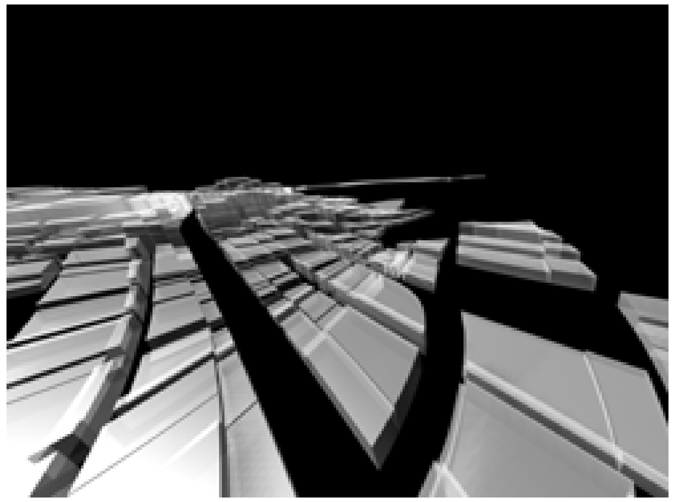
This complexity adds to the quality and variety of spatial perception, creating landmarks and strong identities and is important to the establishment of distinctive urban quarters. The flexibility of this non-systematic sub-division approach can absorb differences in land ownership sizes, styles and typologies of architecture as well as variety of land uses.

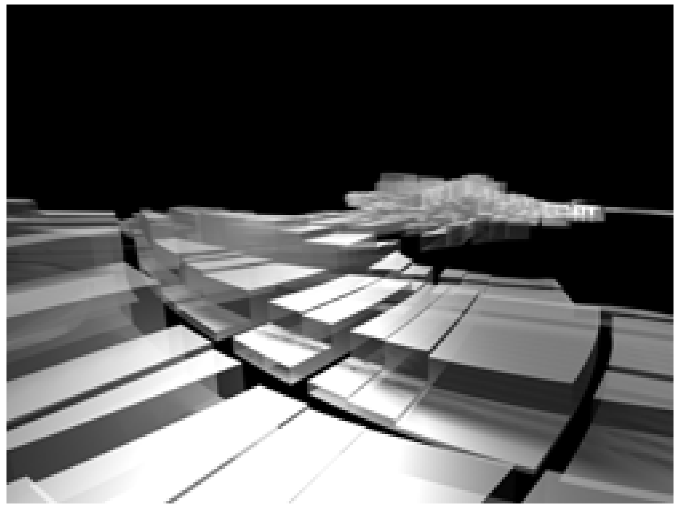
The unity of these distinctive urban quarters is embodied in a new cultural and complex landscape whose hallmark is the embeded balance between the architecture of movement and marked clustering of urban ressources.

NEIGHBOURHOOD, SINGULARITY AND SPEED | *change of pace and scale shifts*

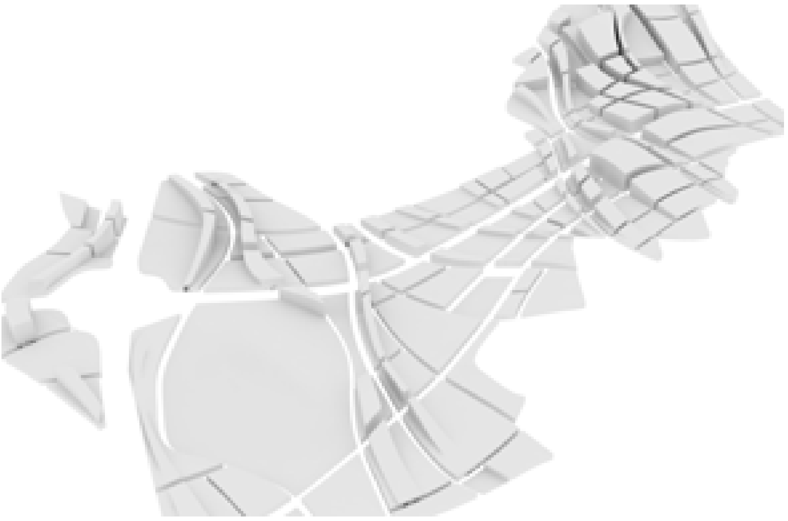
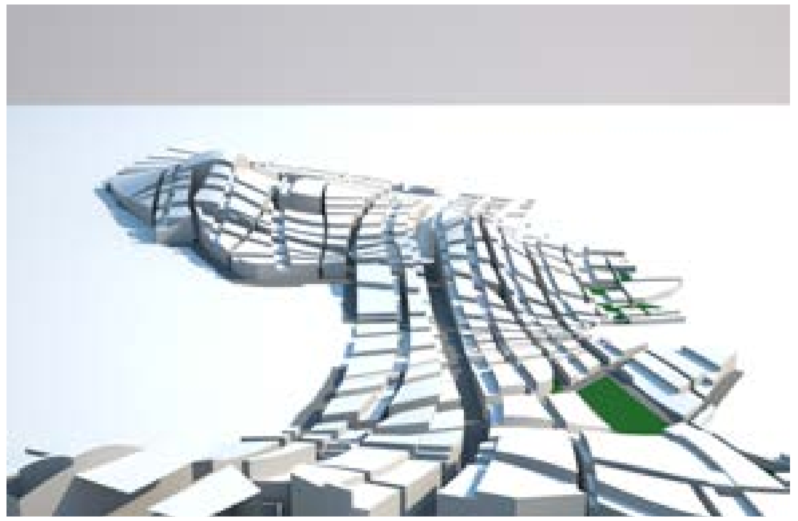
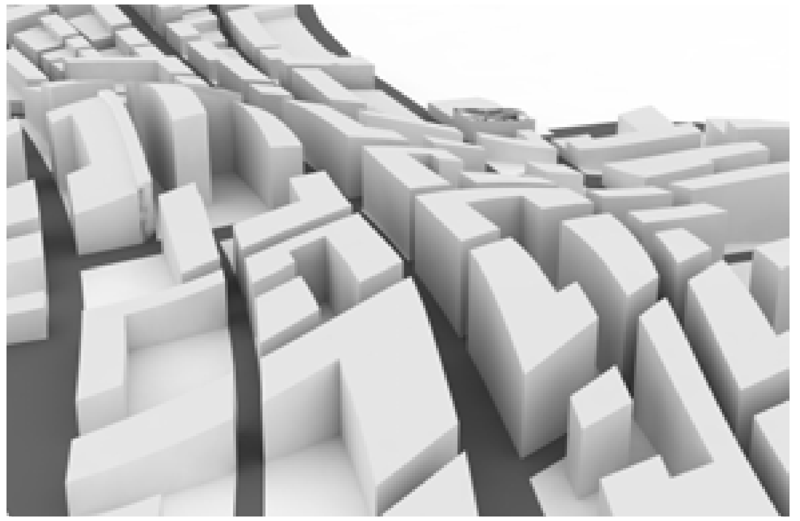
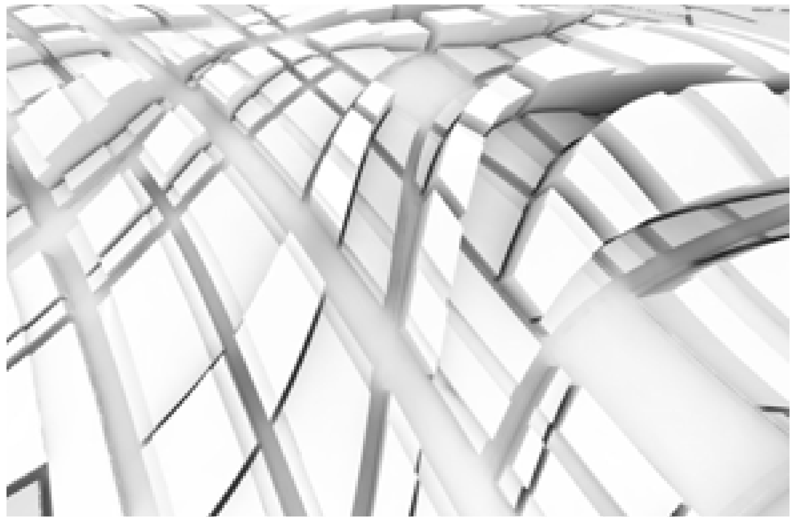
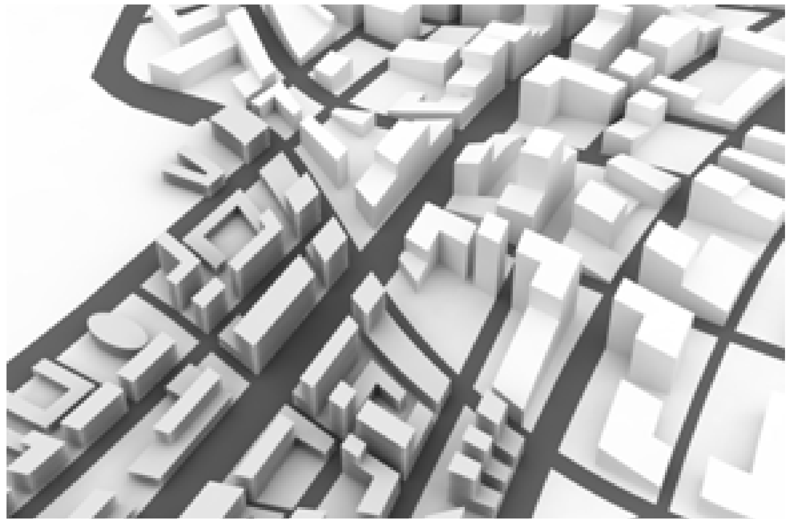




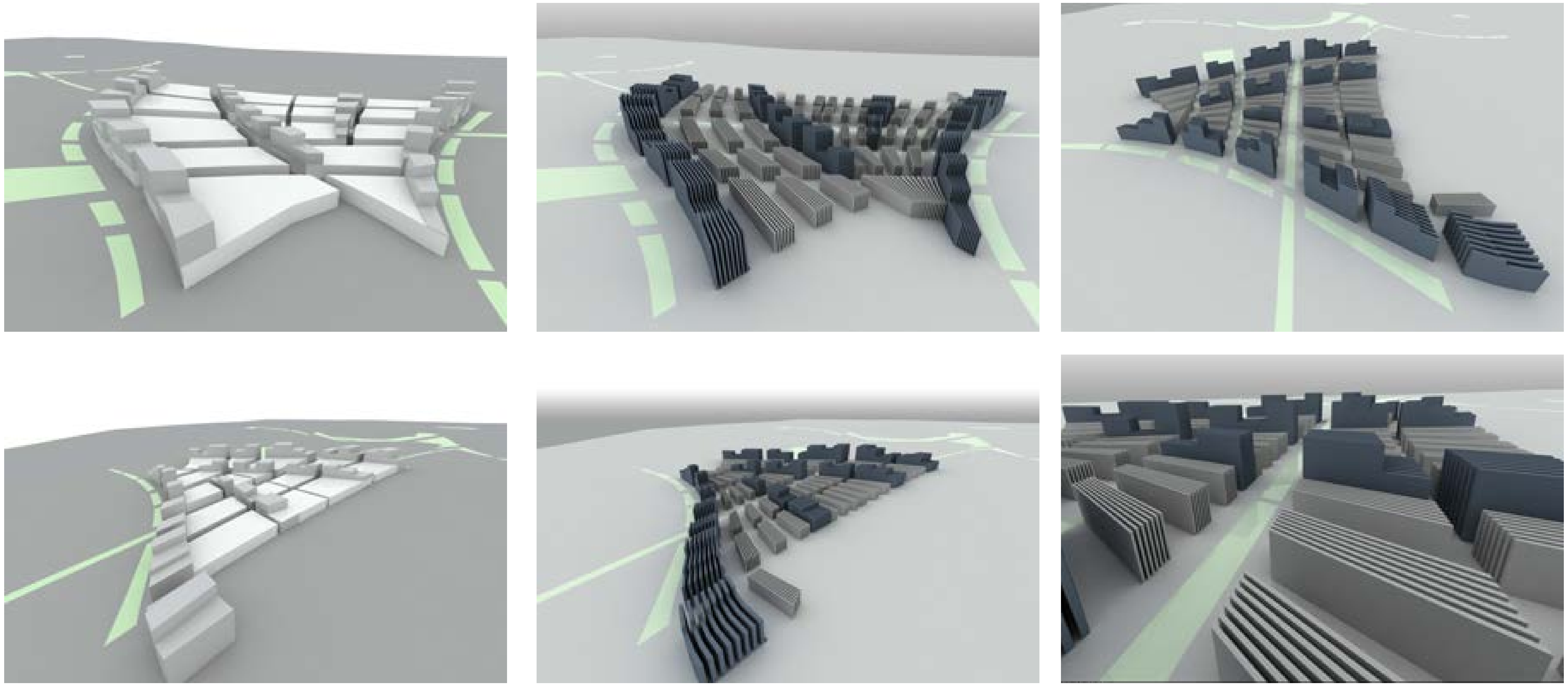




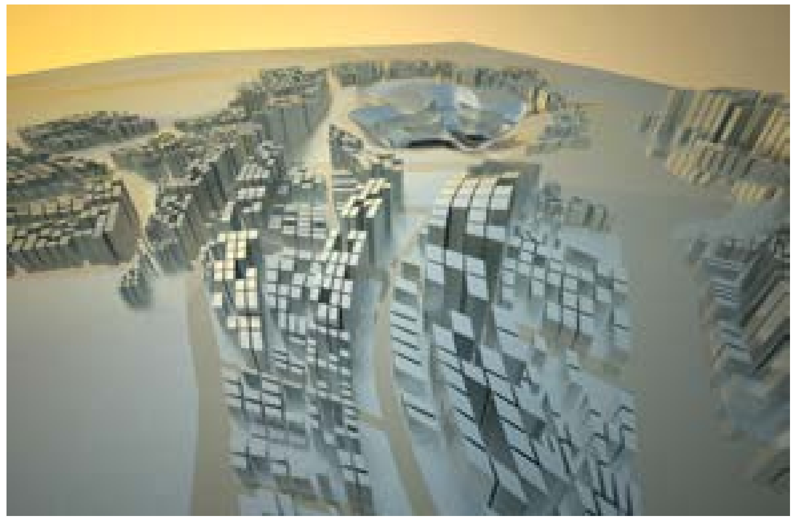
NEIGHBOURHOOD, SINGULARITY AND SPEED | *neighborhood and streetscape studies*

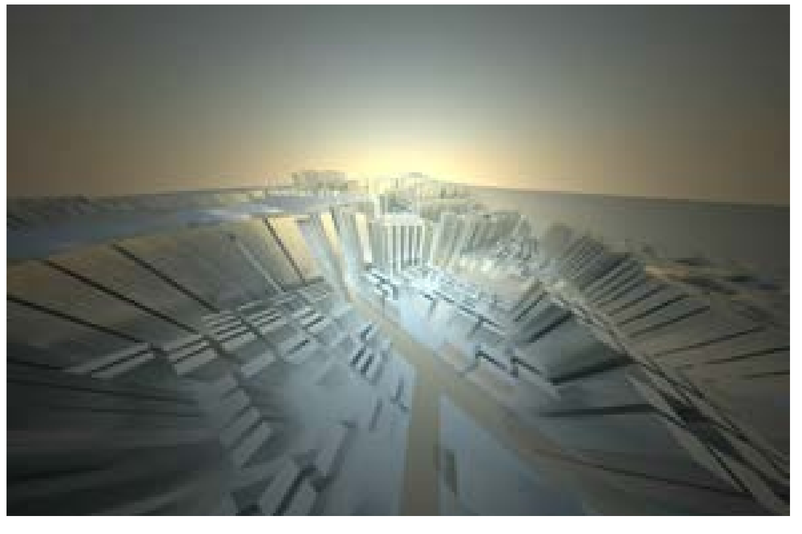
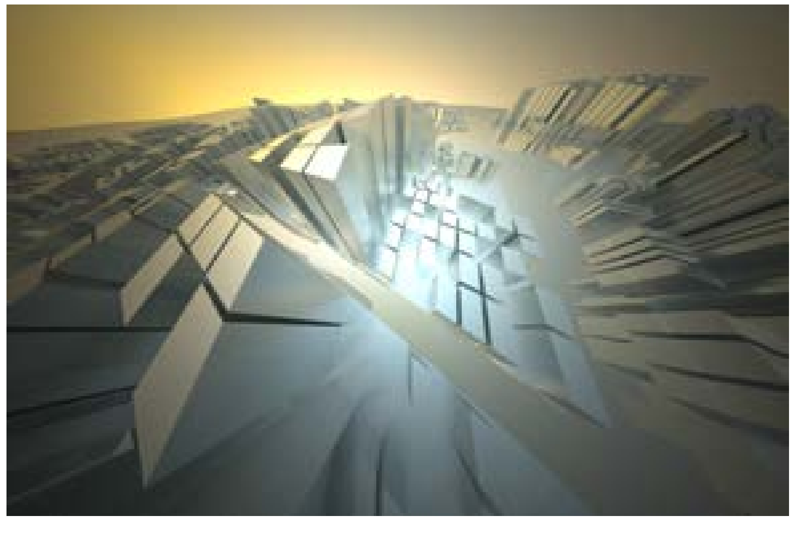
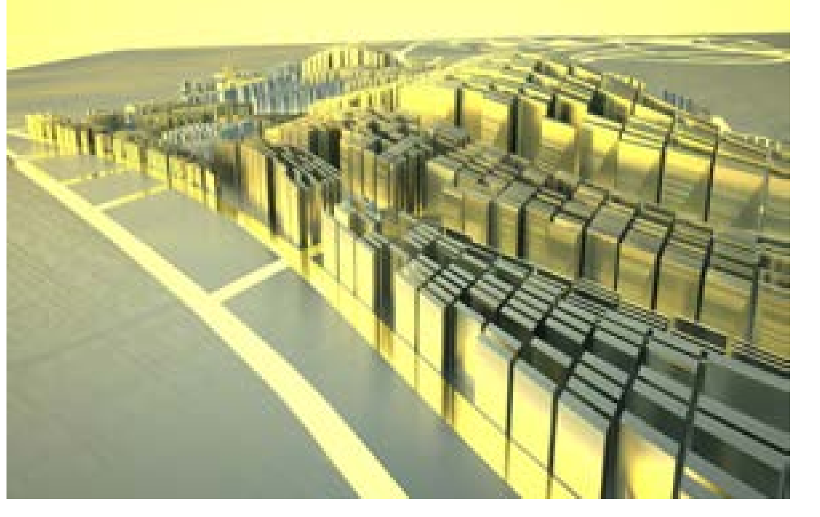







NEIGHBOURHOOD, SINGULARITY AND SPEED | *height proliferation along public promenades*

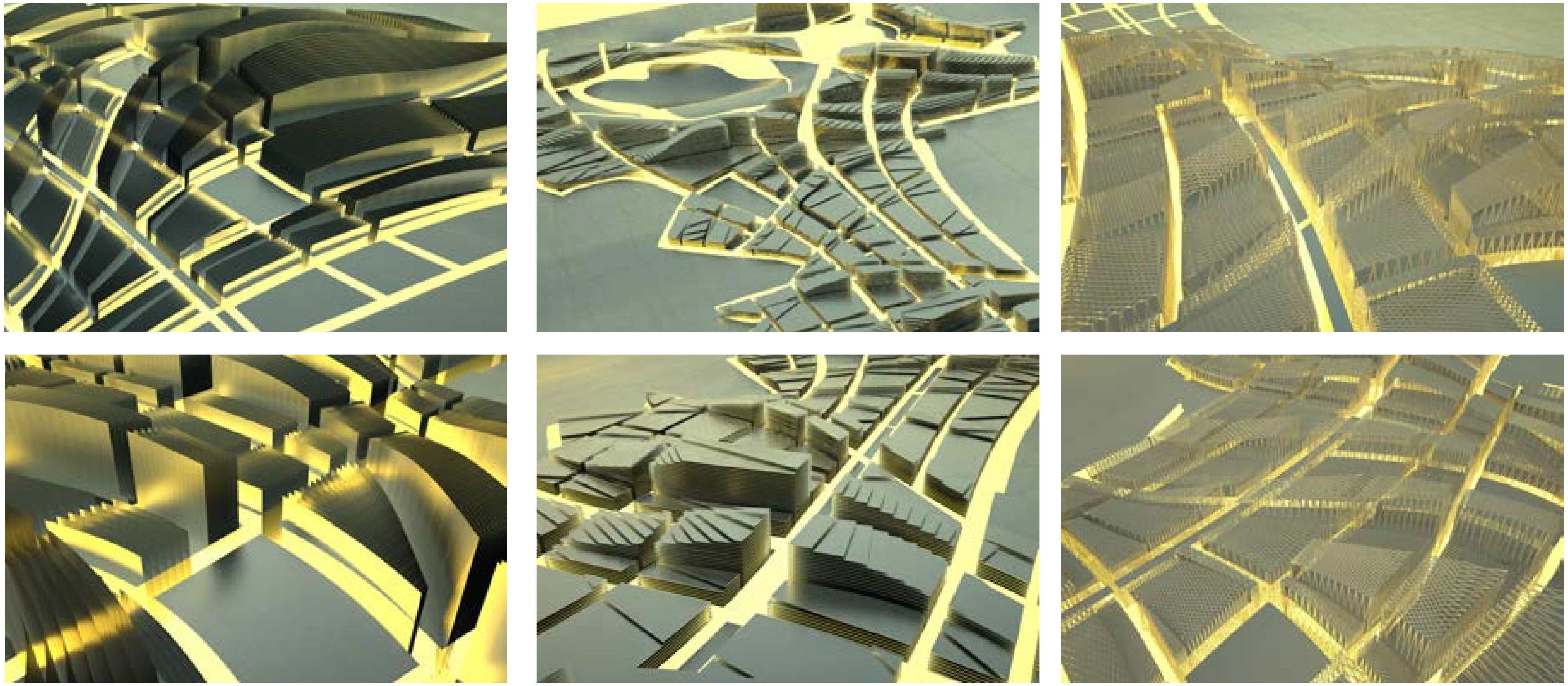


NEIGHBOURHOOD, SINGULARITY AND SPEED | ***tests of vertical urban mass ntensification***



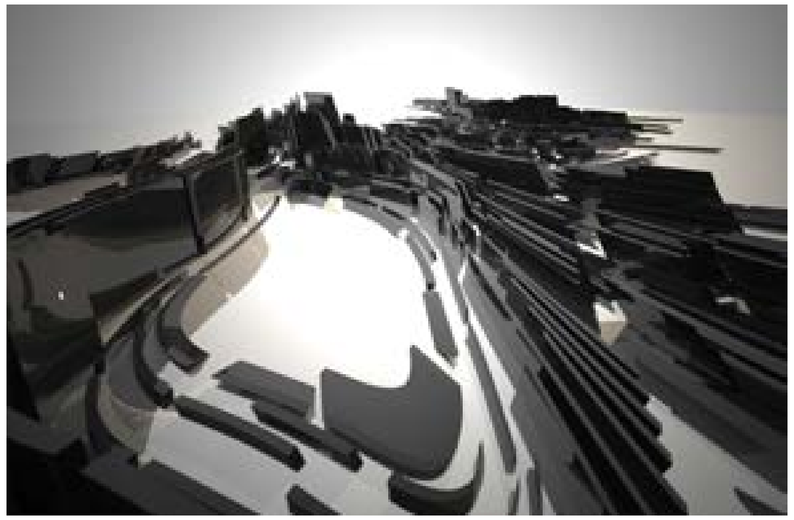
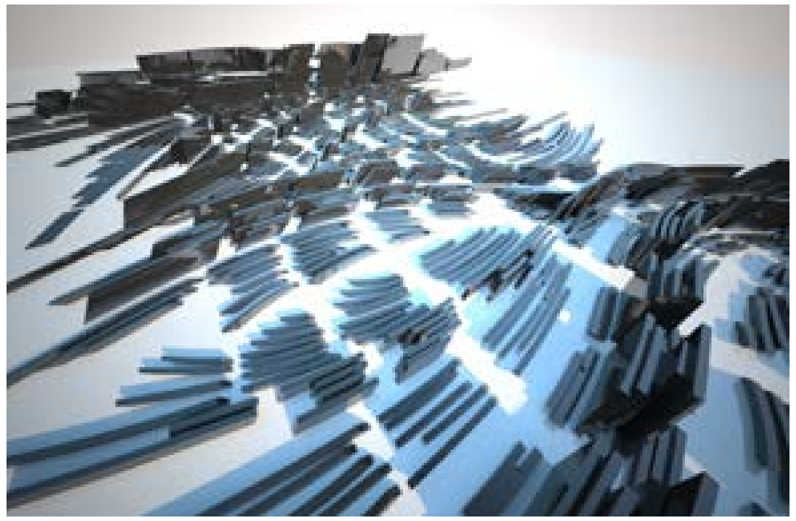
NEIGHBOURHOOD, SINGULARITY AND SPEED | *analysis of mass articulation*



NEIGHBOURHOOD, SINGULARITY AND SPEED | *dynamic urban landscape*





APPENDIX

dqdx_urban economic consultants
LAND USE ALLOCATION

A Rationale for Regeneration
Capacity Forecasting for the Istanbul Kartal Masterplan
Design Team Meeting 5 June 2007

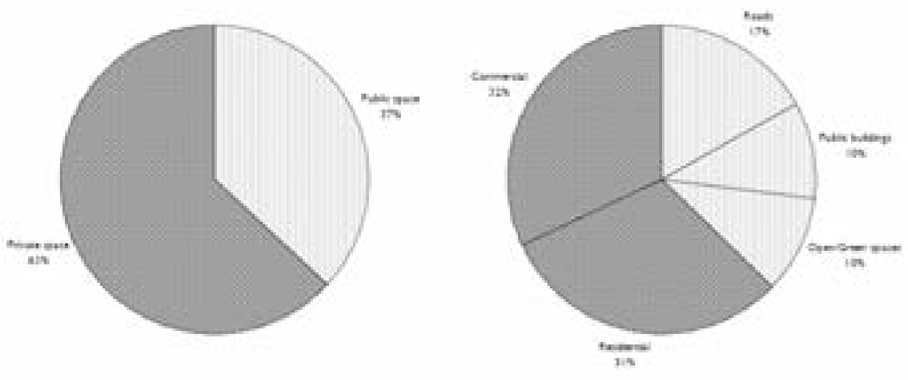
The Masterplan rests on a set of various forecasts which in turn are based on key assumptions about how the project area will develop. Key guidance is provided by the Client in the brief and this forms the basis for our reference points. However in matters where no specific criteria, we forecast using comparative benchmarks/best-practice in appropriate peer groups whilst making allowance for the specificities of an urban re-generation project in Istanbul.

Key assumptions (incl those from Design Brief)

- The project will be configured on a mono-centric urban spatial model – following on from DTM 1 we modify this slightly to demarcate the CBD into North and South zones
- The catchment area ("hinterland") for the development area has a population of 2m which the development area will serve
- For the purposes of this presentation, the project area is termed "New Kartal" (distinguishing it from the current urban concentration by the same name) and the catchment area is Greater Kartal.
- We assume a minimum of a 10 year time horizon for our capacity forecasts
- We assume 100,000 jobs will be created in New Kartal (as per brief)
- We assume micro-economic market mechanisms will operate and that in the long-run there will be no excess supply or demand as the market will clear at the equilibrium price
- We have assumed New Kartal will represent a world-class urban re-generation project, an iconic example of best practice, and have therefore selected our peer group for benchmarking accordingly

Preliminary land allocation assumptions

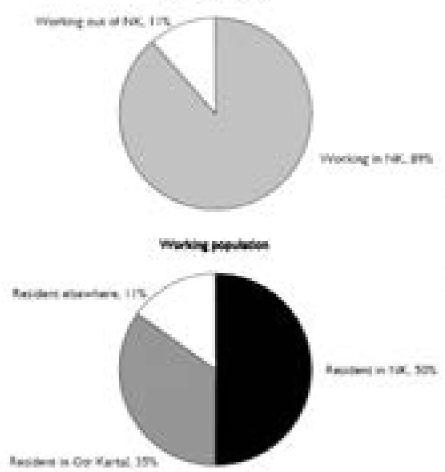
We present below the preliminary land use assumptions prepared by Zaha Hadid. These form the basis of our calculations for initial forecasts though come amendments are proposed for the next iteration.



Public/Private land use mix **Land use analysed in detail**

New Kartal: the demographic profile

Resident population



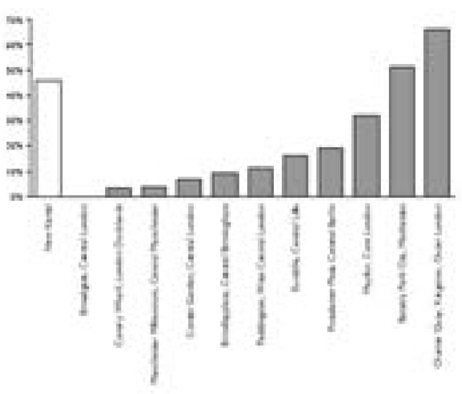
Source: dqdx Analysis

Model assumptions

- Key to developing an understanding of New Kartal's future urban complexion, are its demographics. These metrics are essentially assumption-driven and indiscriminate international benchmarking is inappropriate unless we wish to have regeneration clones.
- We base our estimates very approximately on the experience of London's Docklands regeneration though this is only a proxy calibration mechanism
- We forecast a very high New Kartal resident population which works in the area, in consonance with the Design Brief which indicates an "autonomous community"
- However given the current socio-economic profile of "Old" Kartal, this assumes a high number of residents coming to NK as "first-timers" to the area (we estimate c60%-70%) given the skill sets required to work in NK's professional/service-oriented CBD

Analysis of residential space

Residential land use in in comparison int'l re-generation projects



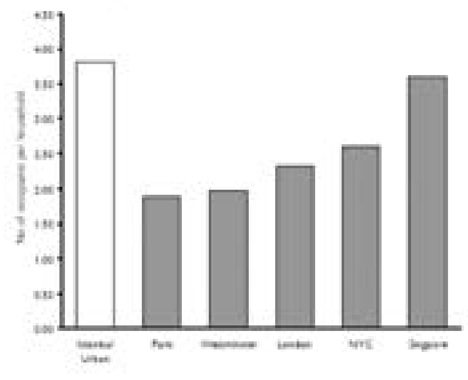
Source: Argent, KXC Regeneration

Key assumptions

- New Kartal is to be 24hr socially active and the brief therefore provides for residential new-build. This proportion is stated to be <40% in the brief though subsequently the Client has indicated the possibilities for flexibility.
- The proportion of residential build is a matter for public policy but will be a key factor in determining the social mix of the project, the complexion of the final re-generation exercise and will be crucial in determining the intangible "feel" of what New Kartal becomes. We list some examples of differing residential land use allocations here and the kind of regeneration that has ensued.
- Clearly there are also financial considerations which can favour private housing but with no indication yet of social housing from the client, we forecast little migration from "Old" Kartal to new (as in the Docklands experience).

Proposed mix of residential dwellings: impact of household size

Average household sizes – international comparisons



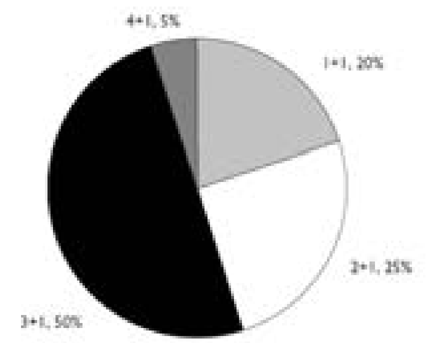
Source: National censuses

Key assumptions

- In order to forecast the proposed mix of private residential dwellings of different sizes, we look forward to average household size.
- The trend in urban Istanbul has been towards decreasing average household sizes, declining from 4.3 in 1980 to 3.9 in 2000, in line with general observed trends as economic prosperity increases.
- However, households are still substantially larger than European peers and match developed Asian countries such as Singapore, reflecting perhaps a closer cultural orientation.
- We do not feel the example of Western Europe is a strong predictor for this demographic and therefore we take a cautious view of decline in future household size when determining demand for residential property.

Proposed mix of residential dwellings: impact of household size

Breakdown of residential space by type of dwelling



Source: dqdx Analysis

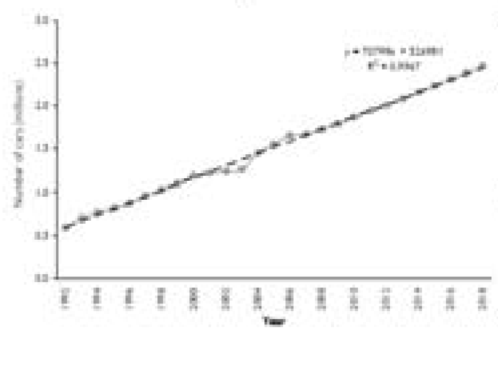
Analysis

- The mix of residential dwellings reflects the demand for private housing only.
- The following dwelling sizes are forecast, based on current purchaser preferences in Istanbul for new-builds but adjusted downwards to reflect future downward pressure on space as land values increase and housing inflation continues:

1+1:	50 sqm	6,718 dwellings
2+1:	75 sqm	5,598 dwellings
3+1:	100 sqm	8,397 dwellings
4+1:	125 sqm	672 dwellings
Total:		21,284 dwellings

Estimating residential parking: demand led estimates

Car ownership in Istanbul



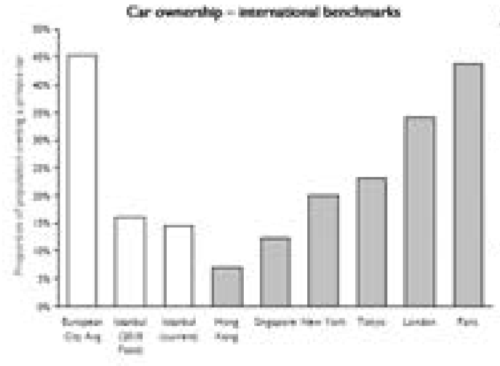
Source: Turkish Statistical Institute, dqdx Analysis

Analysis

- Estimates of residential parking can be derived from 2 perspectives, supply-side and demand-led
- Supply-side estimates are based on pre-determined planning standards set by regulating authorities which mandate parking metrics for any build type in the light of regional norms
- Demand-led estimates rely on forecasts of private car ownership in the relevant region and assume that developments will simply provide the parking for the cars residents will own
- Transport statistics are sparse in Turkey so we have developed our own forecast based on linear regression, time-series techniques, to estimate future private car ownership up to 2018

Estimating residential parking: supply-side forecasting

Car ownership – international benchmarks



Source: LRTP, dqdx Analysis

Analysis

- We have not been able to locate planning guidance for parking in Istanbul yet but are certain such guidance does exist.
- However, whether this guidance for today's economic and social environment will remain relevant for the future of New Kartal is debatable.
- We therefore use as a benchmark the parking standards for Central London (held to be now as an international model of traffic control) and adjust them for the different (lower) car ownership levels forecast for Istanbul to estimate supply-side parking forecasts.

Estimating residential parking: market clearing range

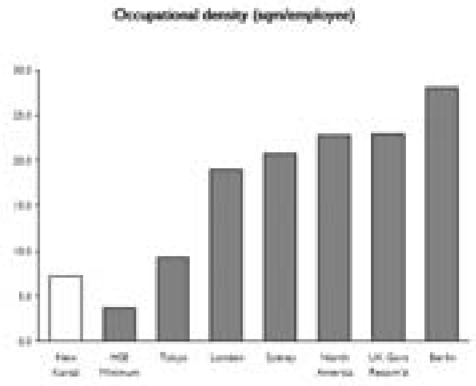
Dwelling size	Supply-side	Demand-led
1+1	1,590	9,094
2+1	2,651	
3+1	5,964	
4+1/duplex+	64	
On-street visitor	2,025	2,025
Total	12,295	11,119

Analysis

- Research has shown that demand for residential car parking is relatively inelastic. Households will still rely on cars for private travel, if not for commuting, not least for child care reasons.
- Therefore although there is an increasing global trend in major urban centres to discourage car ownership and usage (through eg taxation), drivers have proven remarkably resistant to regulatory pressures and still value the presence of residential parking and will actively seek it.
- In actual fact therefore, planning standards in the UK attempt to match the supply of residential parking spaces with the private car inventory in circulation (ie the market clears). Hence the narrow forecast range.
- Parking is assumed to be non-allocated (ie shared) and off-street. Visitor parking is on-street.

dq|dx

Analysis of commercial space

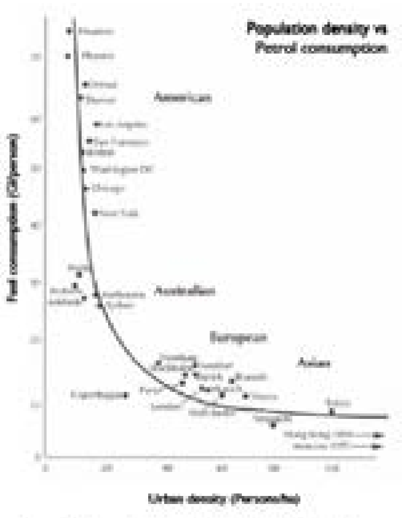


Commentary

- The current commercial (inc hotels) land allocation assumes a share of 22.7% of the project land area.
- However given the forecast employment figures of 100,000 within the CBD districts, this leads to a very low occupational density ratio.
- We therefore recommend a revision of the commercial space allocation or re-visiting the job creation projections to ensure land use is appropriately apportioned and macro-economic growth is realistically forecast.

Source: Jones Lang LaSalle, IFMA, City of Sydney, Mayor of London's Office, DETR, International Tenants' Assoc, dq|dx Analysis

Public transport: key to sustainable development

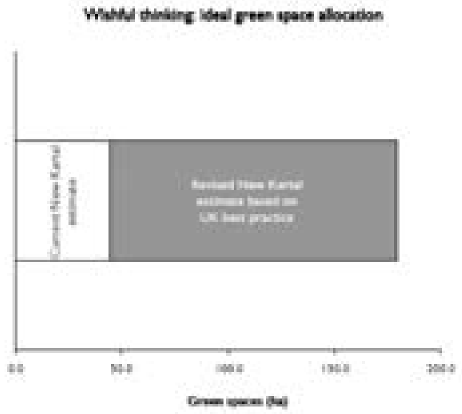


Source: Newman and Kenworthy in "Cities and Automobile Dependence: An International Sourcebook"

Analysis

- It is now axiomatic that all sustainable development in urban contexts is linked intimately to environmental performance. The "choked-up" city is the city not going anywhere fast.
- The graph we present here clearly shows far lower fuel consumption for higher density data points. What is less apparent but reliably inferred is that the lowest fuel consumptions is in cities which are renowned to be public transport efficient. The American data points clearly demonstrate an extreme position but are indicative of US policy towards public transport provision compared to Europe and Dynamic Asia.
- Therefore public policy in developing propitious environmental frameworks for sustainable development is closely linked to policy attitudes to public transport. We assume (with good reason) an enlightened attitude in Istanbul in this regard!

Green spaces: Applying best practice in New Kartal

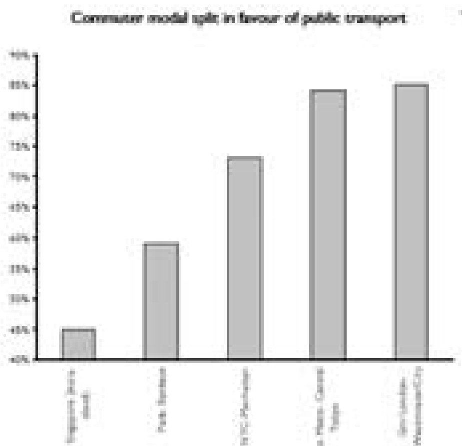


Source: UK Urban Task Force on Green Spaces, dq|dx Analysis

Commentary

- Green and natural spaces are essential to the quality of the urban living environment though the precise nature and scope of these spaces will be affected by natural as well as policy factors.
- It is probably therefore inadvisable to apply best practice standards from different countries to very different climates. However given it was England which introduced the concept of the public park in 1841, creating such a storm in Continental Europe, we are tempted to quote the current Green Spaces "ideal" of the UK Urban Task Force on Green Spaces.
- We should point out this is a "wish-list" rather than reality given that no local authority in England has yet to meet the recommended standard yet!

Commercial parking – key drivers



Analysis

- Research has shown that commercial parking requirements (ie commuter parking) correlate with jobs in the CBD area.
- However, unlike residential parking, this market can display significant elasticity and demand can be manipulated through supply and regulatory intervention.
- Commercial parking is therefore a function of public policy towards motor travel and public transport. Current trends in major urban centres are moving away from the "predict and provide" model (ie offer a space to anyone who wants to drive to work) to "parking restraint" (ie public policy will actively penalise you for driving to work).
- The transport modal splits for cities with controlled commercial parking are presented here.

Source: UITP, Singapore LTA, New York State Dept of Transportation, TfL, DVD - Mairie de Paris

Commercial parking – forecasting for New Kartal

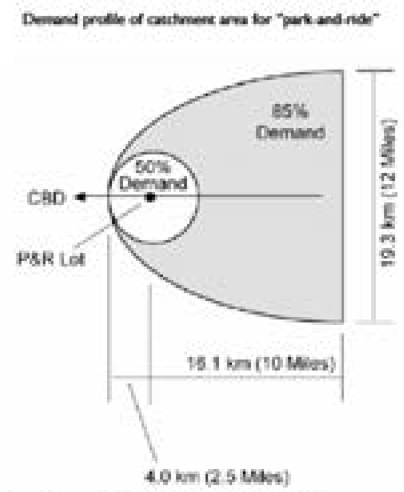
Supply-side parking estimate

New Kartal (public transport)	**80%**
New Kartal (private car)	**15%**
Employees in CBD	100,000
Proportion commuting by car	15,000
Forecast commercial parking	15,000

Analysis

- Using the example of Istanbul's aspirational peer group, we forecast restricted commercial parking supply in New Kartal and assume a high commuter modal split in favour of public transport (despite Singapore's apparent lower metric, this masks the high incidence of pedestrian traffic).
- This will imply however a strong public transport network in New Kartal, not just major nodes, but a dense intra-urban transport route map, correctly specified (unlike the initial under-capacity of the DLR!).
- At the minimum we would expect a high-capacity tram service within New Kartal with the possibility of spurs or feeder guided bus routes.

Forecasting "park-and-ride" facilities for New Kartal

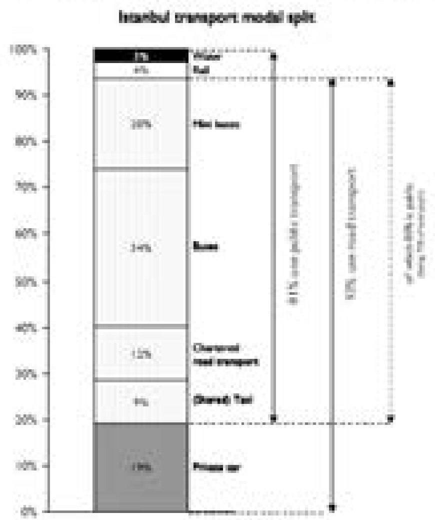


Source: Spiller, Park-and-Ride Planning and Design Guidelines

Commentary

- Park-and-ride (PNR) is a US concept designed to encourage commuters to use public transport even when major nodes are some distance from origin.
- For the purposes of estimating numbers in Kartal, its status as either a terminus on the Light Rail or simply an intermediate stop will affect parking forecasts since the proximity of competing transport nodes (ie stations further along the line) will undoubtedly impact demand at Kartal.
- Since "park-and-ride" however is principally used by commuters travelling out of the area, and given we forecast the majority of neo-Kartalians to work in the new CBD, we would estimate most users of PNR will come from the Greater Kartal region.

Minding the gap: public transport in Istanbul

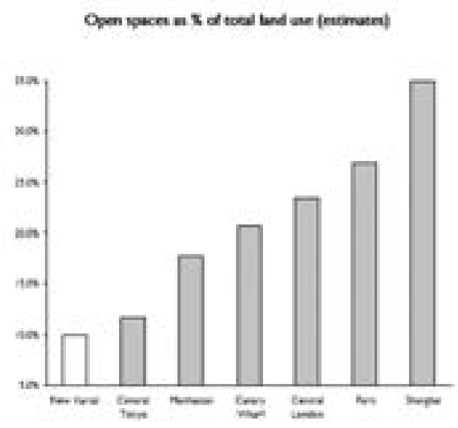


Analysis

- We assume an aggressive public transport modal share of 80% for our New Kartal modelling but curiously this is not wide off today's indicators.
- In fact, 81% of Stamboulites use public transport, as is to be expected given the comparatively low levels of private car ownership. However 9 out of 10 of these passengers will use some form of motorised public transport – clearly because there are almost no viable modal substitutes.
- We do not therefore think there are any cultural barriers to the use of public transport and that if rail-based alternatives were available, these would be popular and result in modal transfer.
- Research has shown than in terms of preference, passengers rate rail-based transport as their top choice for conveyance – consequently we believe if the capacity is available, ridership will follow.

Source: Evren and Calishan in "Fundamental Problems of Istanbul Transportation: Administration and its Ramifications", Istanbul Technical University

Analysis of green spaces



Commentary

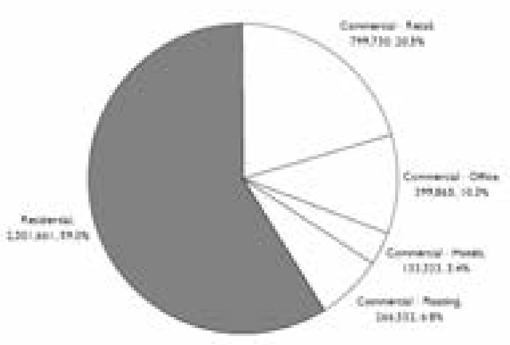
- The allocation of green and open spaces fall clearly within the domain of public policy since normal market or financial forces do not operate in this particular market segment.
- Comparative statistics can only be considered estimates as major cities (eg London) have not always kept detailed records of their green areas. We present the most accurate comparisons we were able to source as guide.
- In comparison, it appears New Kartal seems under-served in terms of green areas as well as falling below the threshold indicated in the Design Brief though this may have subsequently changed. We strongly advise revision of this assumption.

Source: Land Use of Tokyo, Tokyo Ward Area: Outline of Land Use, Survey for Fiscal, Community District Profile, NYC Department of City Planning, Generalised Land Use Database Statistics for England, Office of the Deputy Prime Minister (ODPM), Paris Carte de Commune Land Use, IAURIF, London School of Economics

Towards an optimal land use strategy
August 2007

Revised private space allocations in Kartal

We now work to revised assumptions for the private space and present these below. The public space is considered in the final slide.



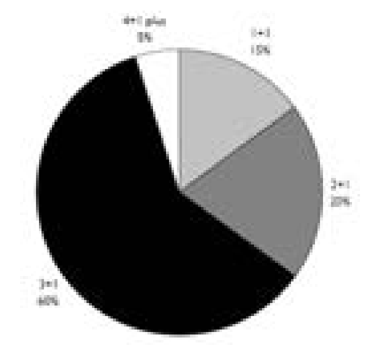
Private floor use analysed in detail in sqm

Total private Gross Floor Area = 3,901,121 sqm

Source: dqdx Analysis, Arup

Residential – re-working the numbers

Revised breakdown of residential space by sqm



Total residential floor space = 2,301,661 sqm

Source: IMP

Commentary

- We discussed in detail with the Client the profile and quantity of the residential accommodation required. The Client indicated New Kartal is to have a pronounced residential component.
- The Client desires very high specification residences, particularly for the waterfront area, and is highly confident there will be a strong demand for such accommodation.
- In terms of the dwelling mix, the Client has revised our initial assumptions to deliver the following numbers of residential units to be built:

1+1	5,312
2+1	5,115
3+1	11,248
4+1 plus	767
Total	22,342

Demographic profile

Revised working population

	Split	Numbers
Resident in New Kartal	29%	23,099
Resident in Old Kartal	43%	34,251
Resident elsewhere	28%	22,303
Total	100%	79,652

Revised resident population

	Split	Numbers
Working in New Kartal	29%	23,099
Working outwith New Kartal	11%	8,929
Not active	60%	48,042
Total	100%	80,070

Source: dqdx Analysis, Turkish SIS

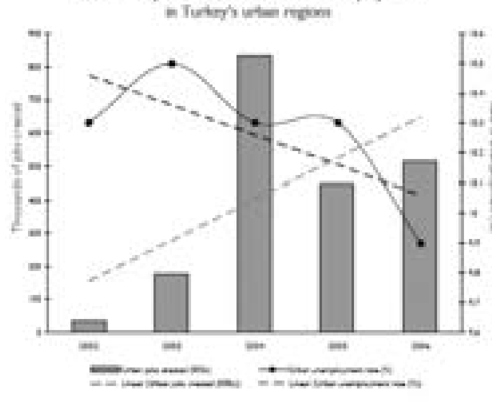
Commentary

- Feedback from the Client specifically indicated that New Kartal was to cater to the needs of families.
- We have therefore revised our assumptions to take account of this changed forecast demographic profile which will significantly impact the numbers of those resident in NK who are also working in NK.
- If a demographic profile is family oriented, the proportion of the resident population which is part of the labour force declines due to factors such as a greater preponderance of children, housewives and home-carers. Figures for labour force activity come from the Turkish State Institute of Statistics.
- In line with discussions with Arup, we slightly relax the assumptions of resident workers within New Kartal whilst assuming a Pareto tendency in accordance with the objectives in the Design Brief.

Commercial – employment prospects in Kartal

The external analysts' view

Looking good on the job front:
Increase in job creation vs decline in unemployment in Turkey's urban regions



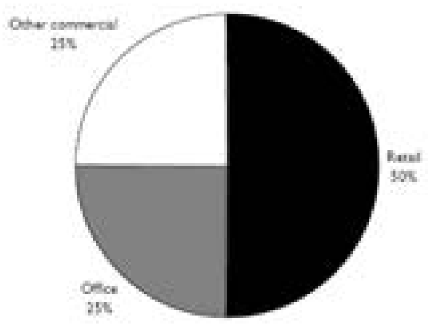
Source: Turkish SIS

Commentary

- A full employment projection model is beyond the scope of this project. However we sense-check client data on employment as the whole configuration of commercial space in NK depends on it. Clearly the graph presented here shows increasing job creation and decreasing unemployment since the last economic crisis.
- In our discussion paper, however, we outline that job creation prospects are intimately tied to economic futures. We have appraised forecasts from ING Economics, Merrill Lynch, Pricewaterhouse Coopers and Deutsche Bank, all of whom are optimistic about Turkey but veer towards a long-term average of 4% y-o-y. This would imply lower job creation than is currently envisaged in New Kartal and therefore we strongly advise regular re-forecasting to ensure development of commercial space is in line with macroeconomic performance, its key demand-side driver.

Commercial – initial space allocation: the Client view

Preliminary allocation of commercial GFA



Total commercial floor space = 1,599,460 sqm

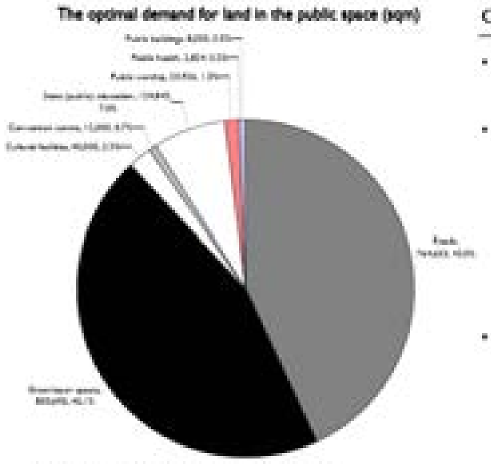
Source: IMP

Commentary

- We present the initial view of the Client of commercial space allocation following the workshops. Other commercial is intended to be a "free mix" but must contain hotels as per the Brief (for the purposes of this slide, "Hotels" are included in "Other" (cf breakdown in Slide 2)). Other installations are to be specified.
- The mix is currently heavily geared towards retail. In our discussion paper, we outline the key assumptions required to successfully support such an allocation.
- Since this is a long-range forecast, we strongly advise regular re-forecasting to ensure sector development is tailored towards demand and towards capacity drivers (see previous slide on job creation).

The public space – the demand for land area

The optimal demand for land in the public space (sqm)



Total demand for public land = 1,776,938 sqm

Source: dqdx Analysis

Commentary

- We have modelled the minimum land required in the public space to support its key components.
- For the built component, we have first modelled demand for GFA and converted this to imputed demand for land using the following plot ratios:

Cultural facilities	2.5
Convention centre	2.5
State (public) education	1.5
Public worship	1.5
Public health	2.5
Public buildings	2.5

- In order to meet this demand for land however, it is clear that the peripheral areas may need to be considered in the public space. We expand on this in the discussion paper.

Public land available	1,211,152
Quarry	413,121
Recreational	218,654
Total	1,842,927

Scenario Analyses on Plot ratios
June 2007

dq|dx

Scenario Summary – Plot ratios – New Kartal - the private space

Different PRs	Private 2.0 Public 1.5	Private 2.1 Public 1.5	Private 2.2 Public 1.5	Private 2.3 Public 1.5	Private 2.4 Public 1.5	Private 2.5 Public 1.5	Private 3.0 Public 1.5
Commercial PR	2.0	2.1	2.2	2.3	2.4	2.5	3.0
Residential PR	2.0	2.1	2.2	2.3	2.4	2.5	3.0
Schools PR	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Mosques PR	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Retail GFA	690,000	690,000	690,000	690,000	690,000	690,000	690,000
Total commercial GFA	1,968,122	2,066,528	2,164,934	2,263,340	2,361,746	2,460,153	2,952,183
Residential GFA	1,968,122	2,066,528	2,164,934	2,263,340	2,361,746	2,460,153	2,952,183
Total pvt built area GFA	3,936,244	4,133,056	4,329,868	4,526,681	4,723,493	4,920,305	5,904,366

Scenario Summary – Plot ratios – New Kartal - the demand for public space / the supply of public space

Different PRs	Private 2.0 Public 1.5	Private 2.1 Public 1.5	Private 2.2 Public 1.5	Private 2.3 Public 1.5	Private 2.4 Public 1.5	Private 2.5 Public 1.5	Private 3.0 Public 1.5
Roads (land)	764,650	764,650	764,650	764,650	764,650	764,650	764,650
Total public GFA	1,744,477	1,793,438	1,842,378	1,891,338	1,940,278	1,989,238	2,233,979
Total public land	1,646,090	1,690,134	1,734,179	1,778,223	1,822,268	1,866,312	2,086,535
Total supply of public land	1,691,533	1,691,533	1,691,533	1,691,533	1,691,533	1,691,533	1,691,533
Public land surplus/ (deficit)	45,443	1,399	(42,646)	(86,690)	(130,735)	(174,779)	(395,003)

Scenario Summary – Plot ratios – New Kartal - demographic KPIs

Different PRs	Private 2.0 Public 1.5	Private 2.1 Public 1.5	Private 2.2 Public 1.5	Private 2.3 Public 1.5	Private 2.4 Public 1.5	Private 2.5 Public 1.5	Private 3.0 Public 1.5
Resident in New Kartal	22,463	23,565	24,667	25,769	26,872	27,974	33,484
Total NK employees	80,225	84,161	88,097	92,034	95,970	99,906	119,587
Total resident pop'n	68,466	71,890	75,313	78,736	82,160	85,583	102,700

dqdx Consulting : Strictly Confidential

As economic consultants, dq|dx are appointed by Zaha Hadid Architects to determine the optimal land allocation strategy to meet the stakeholders objectives of the Istanbul Kartal Development Corporation.

We have worked closely with the design team at Zaha Hadid as well as Ove Arup Transport and Infrastructure to ensure assumptions are consistent.

2.0 The broad outline

The project land area extends to approximately 3 million sqm. Based on a plot ratio of 2.5, we envisage a built area of approximately 4.5 million sqm in the private space. The Client has instructed us to divide the project land area in the following proportions: 40% public space and 60% private space, the latter imply income-generating edifices.

Each space in turn will be segmented into sub-sectors, outlined below. We emphasise however that all figures quoted in this report relate to the entire project area taken as a whole and we do not present analysis for sub-regions at this stage.

3.0 The private space

The land area allocated to the private space totals 1,816,728 sqm, being 60% of the total project land area. We are advised by the Client that the sub-allocations should be as follows:

40% Private housing
30% Commercial – retail
15% Commercial – office
15% Commercial – other income generating

3.1 Residential

There is a chronic shortage of housing in Istanbul. The discussion for the causes are beyond the scope of this document but relate to high population growth and inward migration, unauthorised, unplanned and therefore inadequate residential provision historically and currently, entry barriers such as price which prevent wide spread access to the new projects which are being developed to address historic insufficiency.

For Kartal, we worked on the basis of two housing forecasts, the IMP/SIS's own projections and our own data which effectively sense-checked the latter. We did not have access to the SIS's methodology but our own methodology is based on standard Western European demographic forecasting techniques. The resultant data for both forecasts closely mirrored one another and revealed an ongoing housing shortage in Istanbul of around 100,000 units per year.

For the purposes of Kartal, we need to consider how the residential build will contribute to "clearing" the housing market. Certainly, although there is a demand for residences looking forward city-wide, location, price and space will be key criteria in the consumer purchase decision and this dynamic will affect the prospects for residential take-up in Kartal. For the initial purposes of the space allocations in the Masterplan, we have carried out a supply-side forecast based on the above space allocation which generates the following base housing configuration:

Table 1: Breakdown of housing units

No of residential units built	Total res units	Total number of residents	Total surface area of dwellings m^2
1+1	4,192	9,530	272,509
2+1	4,037	13,214	363,346
3+1	8,720	37,263	1,090,037
4+1 plus	606	3,193	90,836
Total	17,555	63,200	1,816,728

3.2 Commercial

The commercial space consists of retail, office, hotels/other commercial facilities (to be specified), allocated by the Client as 50%, 25% and 25% respectively of the GFA in this sector. The breakdown is presented below:

Table 2: Breakdown of the commercial space (GFA in sqm)

Retail	50.0%	1,362,546
Office	25.0%	681,273
Hotels	4.9%	133,333
Other	20.1%	547,940
Commercial total	100%	2,725,092

Our view is that the weighting given to retail is significant. Although our research shows there is considerable scope for retail expansion in Istanbul due to historic undersupply, the current and future pipeline is very active and therefore developers are moving fast to meet demand. We would therefore conclude that for such high levels of retail space to be tenable (ie acceptable levels of occupancy and rents), there would need to be sustained GDP growth above our base case scenario of 4.5%, increasing consumer expenditure in retail to support higher sales densities and competent asset management to ensure sustainable footfall in the project area. At the very least, we would envisage Kartal to be the shopping nucleus *par excellence* for the whole of Anatolian Istanbul (not just the hinterland as described in the Brief) for the retail space to clear. Both public policy and developer strategy are key in ensuring a successful outcome but we would strongly advise regular revision of assumptions and re-forecasting to ensure projections are consistent with the appropriate economic context prevailing.

In terms of office space, our long-range forecast for the whole of the city of Istanbul indicates an ongoing demand for high specification, Grade A office accommodation, in line with economic growth and forecast job creation. However, Kartal will be faced with competition from other CBDs in the city, particularly the established Levent-Etiler-Sisli-Taksim (LEST) axis but also up-and-coming areas such as Altinuzade. Again therefore public policy and developer strategy will crucially affect prospects for take-up and we would advise regular re-forecasting in accordance with changes in the economic environment.

The space requirement for hotels are derived from the requirements in the Brief and "Other Commercial" is a floating area which could be allocated to private educational facilities, private healthcare, private recreational facilities in accordance with market demand.

4.0 The public space

The land allocated to the public area is possibly fluid but maximally, can consist of (in sqm):

Public land available	1,211,152
Quarry	413,121
Recreational	218,654
Total	1,842,927

The configuration of the public space is vital to ensure a sustainable and dynamic re-generation enterprise. There are certain mandatory sector allocations within this space which are effectively inelastic since no urban environment is functional without them. These include roads, green spaces, key worker installations (schools, acute/emergent healthcare etc) and public administration and public worship. Once the space for these is satisfied, then other, discretionary allocations are considered.

The allocations for roads are fed in from Arup/ZHA and for green spaces, we observe the minimum IMP planning standard of 10 sqm/resident. All other allocations are derived from our own economic forecasting. The following breakdown is suggested:

Table 3: Breakdown of the demand for public space (Land/GFA as indicated, sqm)

Roads	764,650	Land
Green/open spaces	631,998	Land
Cultural facilities	100,000	GFA
Convention centre	30,000	GFA
Education	147,810	GFA
Public worship	53,777	GFA
Public health	5,572	GFA
Public buildings	20,000	GFA
Total	1,753,807	

4.1 Cultural facilities

This therefore leaves the cultural area. We have allocated a preliminary space of 100,000 sqm for cultural facilities, which we understand will include certain prestigious or iconic monuments such as an Opera House. Statistics on comparative demand for cultural facilities are not widely collected although Eurostat is embarking on a project to address this. As a rough estimate, the UNESCO World Cultural Report, indicates a requirement of 5-7 (European average) performing arts venues per million population, though no indication of size or artistic focus is provided. For Kartal (based on the forecast of 3.1 million hinterland), this approximates to around 15-21 venues. This does not include museums/art galleries.

However we caveat our recommendations with regard to cultural spaces with the proviso that "culture" is not a *prima facie* profit-maximising activity and as such, not readily amenable to economic analysis or forecasting. "Culture" whilst an integral element of urban landscapes and sustainability, enhances the populace's well-being, its utility. These variables are subjective, and not easily quantifiable in accordance with standard metrics.

It is true that space will of course be a function of footfall, ie the visitor demand for such attractions, but given these installations will fall within the public space, price will (should) not be a market-clearing instrument and conceivably, demand could be uncapped. Furthermore, an inappropriate cultural mix may be controversial, ultimately unpopular and therefore financially loss-making. An excess of "elitist" installations (eg classical performing arts venues) will not, by its very nature, attract mass interest therefore other facilities which would appeal to a wider population (public libraries, museums, media exchanges, concert arenas) may need to be considered.

4.2 Green and open spaces

Quite apart from the welfare-enhancing and social utility of green spaces, a preponderance of such areas has been shown to increase land value in the proximate built environment. A study by GLA Economics in London showed that for every 1% increase in green space, average house prices in the proximity can rise by 0.3-0.5%. In New York, the accountants Ernst and Young report that commercial real estate rents close to Bryant Park rose by up to 225% in a decade, following massive investment in the green spaces in the area, the increase far outstripping the growth in locations more distant to the regeneration. There are other several examples worldwide which demonstrate that investment in public open spaces is not just socially desirable but generates economic returns also.

5.0 Conclusion

The optimal space allocations in Kartal can only be considered estimates at this stage, given actual build and construction will be phased over a number of years. The Client has a very clear idea of the initial land use strategy and our advice is to continually assess this mix in accordance with the future economic environment to ensure a properly planned urban regeneration.

Ove Arup_Engineering consultants
Bogazici University, Bebek, Istanbul
SUSTAINABILITY

Introduction

On 2006 Zaha Hadid Architects (ZHL) has been appointed to design Kartal - Pendik Masterplan in Istanbul. The project comprises a mixed used development of approximately 4,5000,000m2 of development in a 340Ha site situated to the east of the city of Istanbul, along the coast of the Marmara sea (see Figure…).

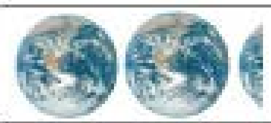
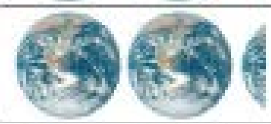
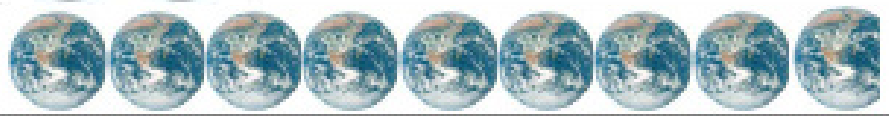
On March 2007 Arup were asked to provide engineering input for the Masterplan design to be submitted in 2007. This report brings together all the sustainability issues that arise amongst the different engineering disciplines. It also covers other issues which have not been considered in the other parts of the report, such as environmental design of buildings.

1.1 Sustainability

Sustainability has been most famously defined by Gro Harlem Bruntland as "development that meets the need of the present generation without comprising the ability of future generations to meet their needs". Sustainability is commonly used as an umbrella term for a whole breadth and depth of issues which can generally be related to under the headings of societal, economic, natural resources and environment. The focus in this sustainability strategy is on addressing natural resource use and environmental impacts through an ecofootprint 'one planet living' approach. The development should also aim to ensure that societal and economic factors are considered and where appropriate these have also been addressed in this report.

1.2 Global Ecofootprinting

One planet living requires the reduction of ecological demand below the Earth's available biocapacity. The concepts of ecological footprint and biocapacity can be measured in terms of land area in the units of global hectares (gha), which represent a hectare with world-average ability to produce resources and absorb wastes. Where reference is made to ecofootprinting, information is taken from the Living Planet Report 2006 (a) produced by the WWF. Where information relates to the United Arab Emirates in particular information is taken from the Project Edition 2006 National Accounts for the United Arab Emirates (b) produced by the Global Footprint Network. The Earth's biocapacity is 1.8gha/person. The current average global ecofootprint is 2.2gha/person which corresponds to humanity requiring around 1.22 planet Earths to be able to sustain itself at current levels. To reduce this to one planet requires an overall reduction in ecofootprint of around 1/5th. Individual nations vary above and below this average with large parts of the developing world below the 1.8gha/person limit and the majority of the developed world above the limit. Cuba is the only nation that was found to meet both requirements for development and ecofootprint.

	Ecofootprint gha/person	Equivalent number of Earths
Global Average	2.2	
Turkey	2.1	
USA	9.6	
Europe, Global	4.8	

Earth image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Centre

1.3 Resource Cycles

A city consumes products and produces waste which result in an ecological demand for the production of the resources and absorption of the wastes. The resource flows that are required for a city to operate can be reduced to the key flows shown below:

A traditional model such as that in the diagram above has a linear flow of resources in and waste out. In moving towards one planet living there is a need for an eco-systems type approach to resource flows where cyclical processes are created. A move towards cyclical processes can be achieved by adopting the hierarchy below.

In adopting the hierarchy and moving towards cyclical resource flows a much more integrated approach is required to the resource streams. Instead of being considered as separate elements the resource flows should be seen together as a whole integrated resource cycle where the waste from one stream can become a useable resource in another.

Sustainability indicator targets

The idea of sustainability is to achieve quality of life and equality, employment and prosperity, environmental protection and the cyclical use of natural resources, for both current and future generations. The challenge is to achieve a balance that fulfils all of these objectives within the context of the development site. As such sustainability cannot be considered in absolute terms; it needs to be integrated into the thinking and design of the project from its initial inception to its ultimate retirement. It should be a holistic process that leads to the best possible results. Broadly, sustainability can be considered to cover environmental, natural resource, economic and social issues. Within these sectors a list of indicators can be identified to highlight the sustainability issues and opportunities relating to a development. Such a list is given below. For the proposed Masterplan site in Turkey it is immediately apparent that some of these indicators present both the greatest challenges and the greatest opportunities for achieving sustainable development.

maximise return on investment
flexibility and adaptability of development
maximise asset value through design
diversification of economic activity
meeting performance needs first time
new benchmark for standards
building adaptability, flexibility for personalisation
future proofing
density of development
site context
diversity of development
brownfield site
flood plains
reclamation of land
efficient building envelopes
reduce carbon emissions
zero ozone depletion
increase renewable energy
building energy/heating/cooling systems
facilities for occupier monitoring of energy and water use
direct emissions to the air
indirect emissions to the air
dust and particulate matter
low water use, capture and recycling
drainage strategy; local storage or re-use
water discharges and sewage treatment
minimise use of raw materials through design
maximise use of sustainably sourced materials
minimise construction waste impacts
facilities for end-use waste recycling
improve site biodiversity
enhance green spaces in the city
enhance diff local habitats, protect sensitive ecology
design for utilisation of the public realm
private and public open space
crime reduction by design
access to goods and services, healthcare, schools, sport and leisure
local jobs
walking, cycling and public transport
choice and equality of transport modes
socially inclusive design
recognise community cultural needs/lifestyle
diversity of age, race and culture – individuality
health and welfare
sight, sound, smell, air quality and daylight
outdoor climate; wind, temp, shading, rain sheltering
business opportunities for new and existing local companies
planning for skill needs and training to create jobs for locals

Sustainability issues throughout the report

3.1 Transport

Few alternatives exist for the provision of transport energy other than gasoline and diesel. Both of these are carbon based fuels which have a significant impact on ecological resources and therefore the most effective way of reducing the impact of transport energy is by reducing the demand for private travel by road. Public transport is much more efficient in terms of energy per passenger mile and therefore encouraging use of public transport is an effective way of reducing transport energy demand. Walking requires no energy input other than a person's normal food intake and therefore encouraging walking within the city also reduces transport energy demands. As discussed in the Transportation strategy the development encourages the use of public transport by providing an accessible and fully integrated network. Private car use in the city is discouraged by restrictions on parking.

3.2 Water saving technologies

Several options to save water have been regarded in the report targeted to the reduction of irrigation water utilised on site. In the Utility Strategies Report, Section 8 discusses the reuse of grey water and storm water for irrigation. These strategies could potentially save up to an estimated 3,000m3/day of irrigation water.

3.3 Energy provision: Renewables

Renewable energy generation provides energy with no ecological demand as energy from the sun, wind, and wave and tidal forces is used which is inherently available from the environment and cannot be used up. Renewable energy produces no emissions and so by replacing energy generated from carbon based fuels the ecofootprint is reduced through the use of renewables.

In the Utility Strategies Report, Section 3 of on power strategy and Annex C1 discuss the different options on provision of renewable energies.

3.4 Energy provision: High efficiency thermal system

High efficiency thermal systems generally reduce power demands for heating / cooling the buildings by utilising available heat sinks to maintain the temperature within the comfort zone. There are different options available in order to provide a development such as centralised seawater cooling, centralised groundwater cooling or energy piles. These options are discussed in the Utility Strategies Report section 3 and Annex C2. Depending on the vincinity to the shore and availability of groundwater, different options might apply for individual blocks.

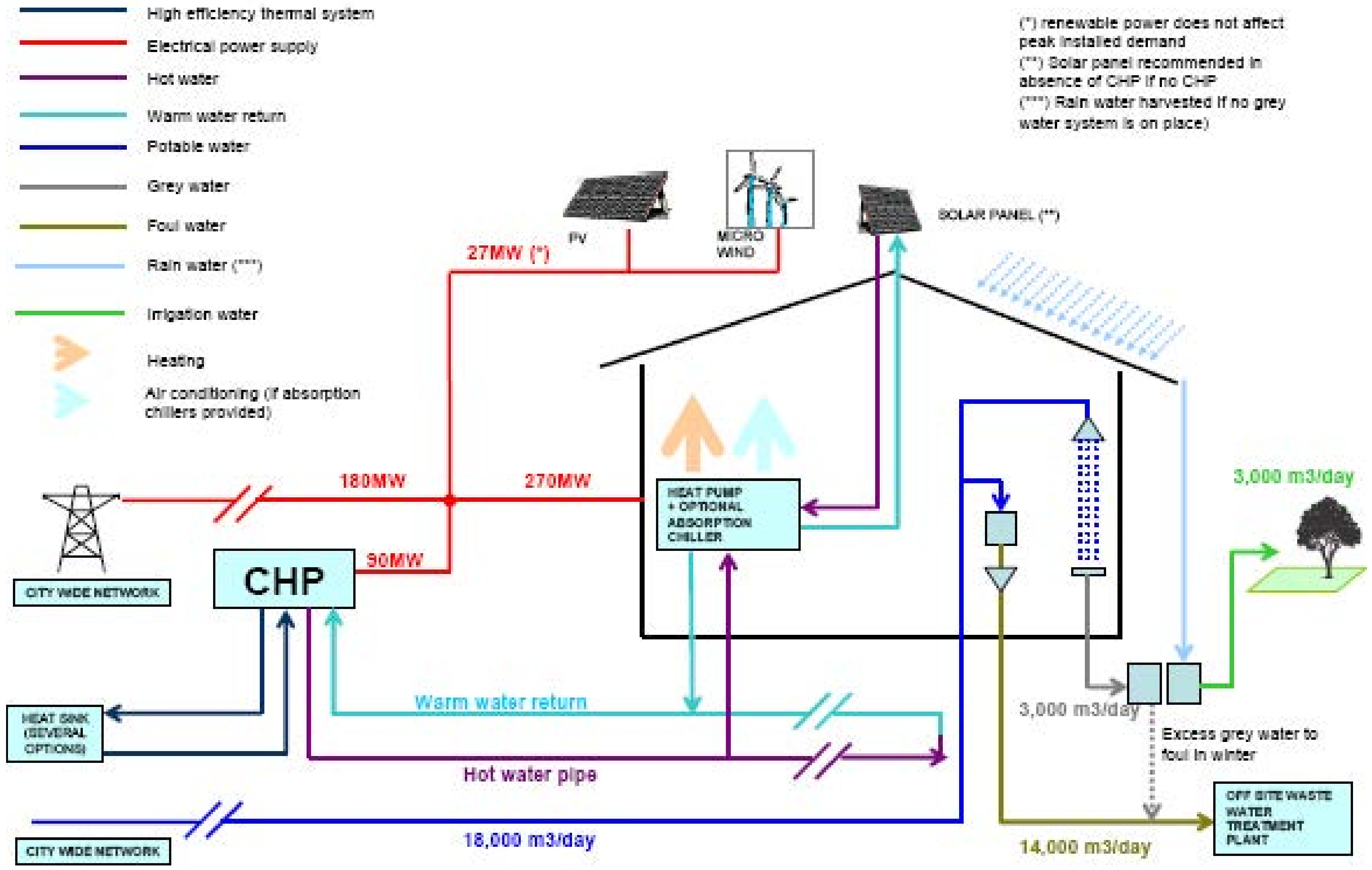
3.5 Combined Heating and Power generation (CHP)

Combined Heating and Power generation represents a way of making the most of the use of the heat generated to produce electricity in plats. The generation of power, generally coming from a gas plant, is linked to a district heating network which distributes hot water which can be used for heating during winter and cooling with the help of absorption chillers locally installed in each block.

In the Utility Strategies Report, Section 3 of on power strategy and Annex B discuss this option.

3.6 Sustainable Urban Design Systems

Stormwater can carry pollutants of different kinds which might need to be intercepted before they reach sensitive areas. In the Utility Strategies Report, Annex D discusses the different strategies suggested in this report.



Overall Strategy

Environmental building design

This section outlines some of the main issues regarding microclimate design in the layout of buildings in the street. These factors, altogether with other design details at a smaller scale, should influence on the overall performance of the buildings in terms of energy usage. Annex A includes a set of benchmarks which can be used in the future in order to assess the energy performance of the development.

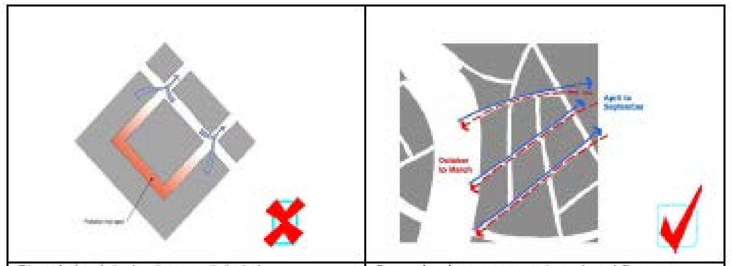
4.1 Street comfort

As part of any masterplanning process due consideration is given to the opportunities to reduce the energy used in achieving comfort conditions and also to how building geometry and orientation and inter-relationships can assist in reducing demands.

It is feasible to use the proximity of buildings and air movement to create the best possible external environment to encourage walking and external activity.

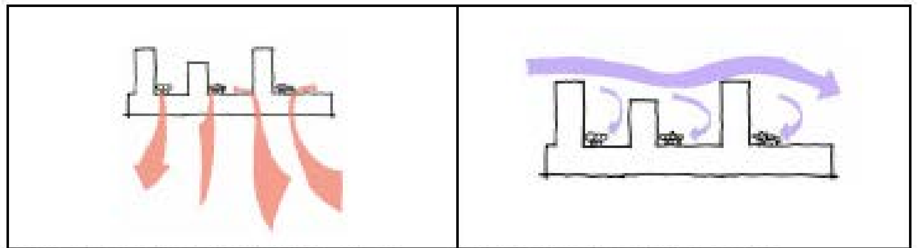
A deliberate policy is to have a hierarchy of circulation spaces from pedestrian only through limited vehicle use to heavy vehicle use.

Pedestrian only circulation between buildings can be relatively narrow and should not suffer from the pollution that motor vehicles create. Limited air exchange coupled with high mass surfaces and cool radiation and air leakage from surrounding buildings will assist in reducing the energy needed to control the environment in these areas. The narrow "streets" are designed to prevent direct solar radiation reaching the lower levels where people circulate.



Closed street design traps polluted air | Open streets encourage cleansing airflow

1 – Schematic of good practice for microclimate and avoiding hot spot pollution


Summer – dense planting providing local protection | Winter – trees providing solar access

Schematic of good practise for micro-climate

In short the aspiration should be to create a micro-climate at low level that improves comfort and reduces energy consumption. In these zones airflow is discouraged particularly if it involves drawing air from adjacent un-shaded and hot spaces.

On the larger streets planting of trees that provide a shading canopy can significantly reduce solar radiation striking people and vehicles directly, it also lowers the air temperature since heat is neither being re-radiated from hot street surfaces nor causing convection adding to the temperature.

The cooling effect of adjacent buildings becomes less significant and is small compared to the heat generated by passing and parked vehicles. Although heat gains from occupants and vehicles cannot be avoided, discharge of warm or hot air at street levels from buildings should be strictly controlled. In the streets where traffic fumes will be generated some air movement is beneficial.

Shading of pedestrians and parked vehicles is the primary aim to improve comfort, reduce damage to vehicles and their contents and reduce vehicle air conditioning energy.

4.2 Solar Ventilation

The powerful solar gain can be used to drive ventilation in areas where external air is desirable. Such an example might be residential accommodation where only parts of the apartment may have air conditioning.

By using the sun to heat up air within a space at high level and then allowing this to escape at high level creates a chimney or vent effect. Cool air can be encouraged to flow through the apartments on its way to making up the volume of air escaping through the roof.

The size of openings is designed such that apartments near the top have large opening onto the communal space and the apartments at lower level have smaller openings. This has the effect of balancing the airflow to ensure that it flows equally through the apartments.

Examples of this technique have been designed by Arup and have been tested when built. They have been proven to work even in an UK climate although strong winds tend to become a significant factor in driving the ventilation when they occur.

4.3 Advantages of High Density

In addition to the issues of cool microclimate created by buildings being close together, proximity also has the benefit of reduced exposure to solar gain. Initial calculations have indicated that apart from the comfort gains for people moving between buildings there is also a real energy saving of the order of 1.0 to 1.5% of air conditioning load. This isn't huge but it is a saving to the project and brings many benefits. The shading of one building to another will help to reduce heat gain but has other advantages in that a high density makes centralised servicing more economic. Not only is the infrastructure cost reduced but also the transmission costs and losses.

As discussed in Section 9 it is proposed that serious consideration be given to Central Cooling Plant (CCP). This is where power generation is linked to district cooling by either driving vapour compression chillers via steam turbine on the back of power generation or by using waste heat to power absorption chillers. (Figure 14.2)

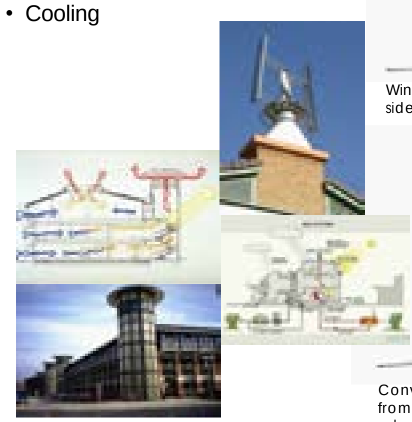

An example of cowls at Bedzed, UK (also green roofs)

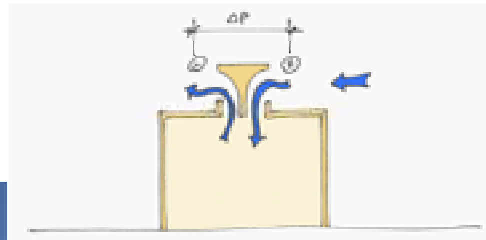
Natural ventilation to provide:

- Fresh air requirements

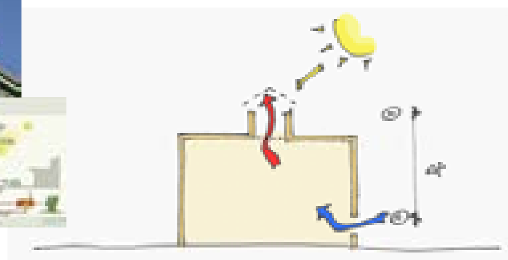
&

- Cooling





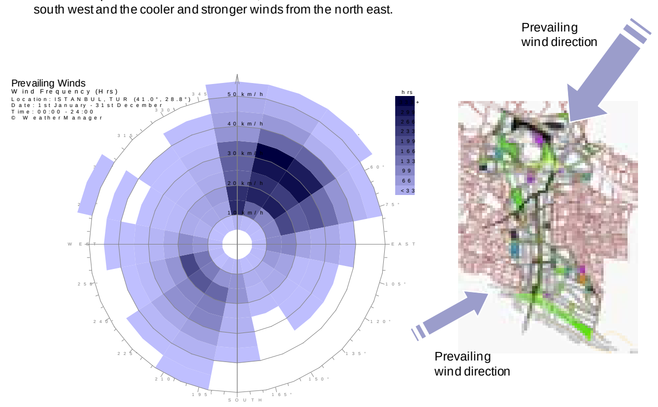
Wind driven – pressure differences on windward and leeward side of tower used to create airflow.

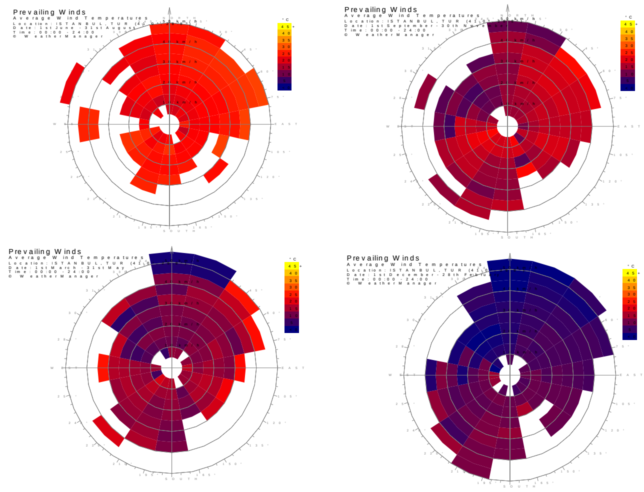


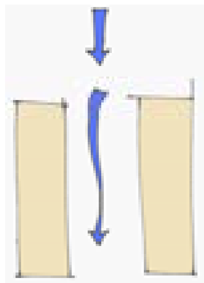
Convection driven – buoyancy effect of hot air used to pull air from low level to high level. Extra heat in the chimney such as solar or heat rejection increases flow.

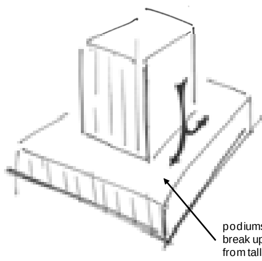
Annual wind variation

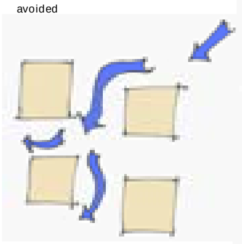
There are 2 predominant wind directions; the warmer Mediterranean winds from the south west and the cooler and stronger winds from the north east.

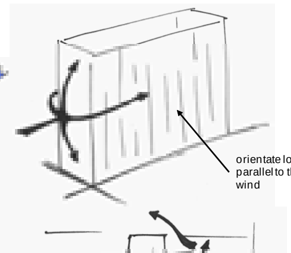





Long streets aligned with wind channel the flow and should be avoided

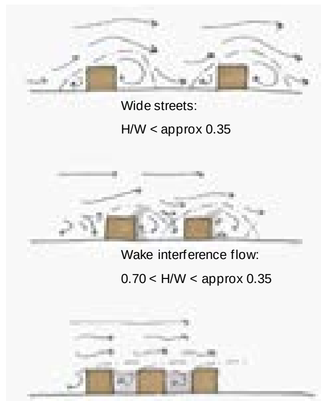

podiums or projections can break up downdraughts from tall buildings


Broken up streets allow wind to permeate without accelerating


orientate long buildings parallel to the prevailing wind


stepped building forms rather than large cubes help break up wind flows

Some wind flow in streets is required to remove pollutants, skimming flow should be avoided and where there is significant traffic streets should be wide.



Ove Arup_Engineering consultants
TRANSPORT

Istanbul

2.1 The Centres

Currently Istanbul is largely mono-centred, though dynamic. The CBD has spread northwards from Taksim, stimulated by the apparent gains in accessibility provided by the construction of major arterials and the two Bosphorus Crossings. The apparent gains in accessibility are rapidly being eroded by increases in traffic coming to the Centre and its car parks. Not only is the Centre coming under pressure but population to the west, and especially to the east, have poor access to the CBD with its employment, social and cultural attractions.

In response, the Municipality is promoting two Centres, the eastern one being Kartal-Pendik. (Figure 1)

2.2 Transport Infrastructure

European-type cities mostly have a grid or hierarchal system of streets and often a mixture of the two. The grid offers a generally even distribution of traffic. A hierarchy assigns traffic volumes to streets, according to their role in the hierarchy, which may consist of five levels; motorways, arterials, secondary, distributors and access streets. Istanbul is largely characterised by motorways, some arterials but then often little between these and access streets (Figure 2). The result is a great concentration of traffic on the major highways.

The rail systems (heavy, metro, LRT and tram) are currently in an embryo state but there are projects, both under construction and planned (Figure 3). When complete the European site will have a comprehensive and interconnected rail network able to play a very important role in the transport system. The Asian side is more limited, as discussed later.

2.3 Use of Transport

The number of trips undertaken by each inhabitant of Istanbul was 1.54 in 1997, of which one-third were longer distance pedestrian trips. The equivalent statistic would be by 2.5 to 3.0 trips per person in European cities. Some of the difference may be explained by varying demographics but mostly it is due to the transport weaknesses discussed above. The statistics point to a large latent demand for travel.

Excluding movement by foot, 67% of trips are by public transport and 33% by private car (Figure 4). Of the public transport trips, 75% are by bus/mini-bus, 12.5% by taxi/shared taxi, 8.5% by rail and 3% by water.

Apart from the Gebze local express running to the east, the rail systems are running well below capacity. A possible explanation for this is the fact that the system is not extensive as yet and thus only attractive, compared to other modes of transport, for a limited number of journeys.

2.4 Car Ownership and Parking

Some 2.5 million vehicles are registered in Istanbul, of which 70% are cars and 20% trucks (Figure 5). Car ownership is probably in the region of 115 to 125 per 1,000 inhabitants. This is a low figure by reference to European cities; Paris 450 and London 350. However, if compared to some European-type cities elsewhere in the world, the range runs from 125 in Singapore to 230 in Tokyo. These cities have population densities nearer to Istanbul and hence are a more reasonable reference. The low Singapore figure is due to a combination of excellent public transport and punitive taxes on private vehicles. Car ownership in Istanbul has grown rapidly in recent years, fuelled by a buoyant economy. The ownership rate has been forecast to reach 160 per 1,000 by 2018. This increase will put pressure on scarce road space and health unless car usage is controlled. A further issue is that as car ownership levels rise, car occupancy rates fall, especially for journeys to and from work.

The car parking standards for non-residential uses indicate a requirement which encourages the use of private cars.

For offices, 1 space per 30m² equates to 70 to 80% driving to work, while no distinction is apparent in location or function. A local shop is treated the same as a department store. In most cities there are inner, inner suburban and suburban standards, those in the inner city being very prescriptive. In Central London, for instance, it is only possible to provide disabled and essential operational parking.

The journey to and from work is the major contribution to peak hour congestion and the standards encourage driving but, for entertainment/cultural off-peak activities,, car use is, if anything, constrained.

The residential standards vary according to the size of housing units from 1 space per 3 units to 2 for 1 unit for units over 150m² in size. Generally, residential spaces were not in Northern Europe subject to much limitation as car use, not ownership, was the prime occupation of the transport authorities. However, greater ownership leads both to more mobility per person and a higher proportion by car. New restrictions in inner areas are being imposed, varying between 1 per 2 housing units to 2 per 3 units. The Istanbul standard seems very reasonable.

2.5 Some Conclusions

The access qualities of the site, the transport infrastructure of Istanbul and study of the experience of other European cities allows some conclusions to be drawn concerning the transport strategy for the development.

Public transport must play the predominant role in delivering people to and from the site.

Public transport and walking must play the predominant role in movement within the site.

Parking control and management is needed to ensure use of public transport, protect the environment, including air quality, and help to provide an ambience where people want to be.

The quantum and mix of land uses needs careful consideration to achieve a balance between attraction to the area and the ability of the transport systems to deliver visitors. In addition, a balance needs to be achieved between residents, workers and visitors which will provide a vibrant community at all times.

Location and Access

3.1 Asian Side Context

The project area stretches from the E5 to the coast at a point some 20kms from the Bosphorus.

The structure of the major highways in the Asian side is two arteries running south-east, parallel to the coast, with a series of cross links (Figure 6). These are the E5 which runs between 2 and 4kms of the coast and the E80 motorway to Izmit and Ankara which lies some 11kms from the coast at Kartal. The strong cross links occur near the Bosphorus, being rings from the two bridges intersecting the south-east radials. There is then a gap of almost 20kms before the next strong connection after which there are two connections in the next 15kms, the last being at Gebze. Kartal lies in the middle of the 20km gap.

These major highways have support from some secondary arterials but these are of variable width and capacity. A Coastal Highway runs through the site as a 2 x 3 lane route. East of the site it soon converges with the E5 while, to the west, it becomes urbanised. There are further cross-connections made by these secondary highways, one forming an intersection of the northern end of the site with the E5. Although there are three interchanges on the E5 with these cross routes, they converge to provide just one with the motorway.

Rail transport is currently restricted to the suburban heavy rail service between Hydarpasa and Gebze. This has many stops on its 35km route, including ones at both Kartal and Pendik but not one on the site. The line has only two tracks and provides for suburban, express and freight services. Thus its suburban service capacity is limited by the other two services. Its daily capacity has been estimated to be 164,000, of which 75% is taken up. It can be assumed that, at peak periods, it has little or no spare capacity.

The Marmary Project, including the Bosphorus Railway tunnel, runs along the European Coast (19kms) and the Asian Coast (43kms) (Figure 7). A third track is to be provided and station rebuilt with 225m long central platforms. The project promoters state that the average speed will be 45kms including stops, so journey times, especially for the European side, will be substantially reduced. The promoters claim that the maximum capacity in each direction will increase from 10,000 to 65,000 passengers in 2015 and 75,000 in 2025. The capacity stated is nominal and would only be approached with crush-loaded trains at close intervals. However, the capacity will be very substantial, opening possibly by 2010 or 2012.

The LRT previously planned to run along the E5 corridor was upgraded in 2004 to be an underground metro. In the first phase this will run from Kadikoy to Kartal, interchanging with the suburban rail at Ibrahimagu Station. The distance from Kadikoy is 22kms. The opening date is not known but 2012 has been suggested. In the longer term this line is to extend east, parallel to the coast with a branch to the new airport. Station plans shown an 8-car metro implying a nominal capacity of 50,000 in each direction.

Buses currently dominate the public transport. They will continue to be important after the rail system has come on line but their role will change. They will carry less long-distance trips along the coast but will continue to cater for trips in other directions, local trips and feeders to the railway stations as well as serving areas outside the railway catchment.

3.2 Local Context

The site is defined by the sea in the south, the E5 in the north and to the east and west the edges of Pendik and Kartal respectively (Figure 9).

Kartal and Pendik both have an ill-defined road network with few corridors of any width which are continuous. Apparently clear corridors regularly terminate or become local streets. Links to the Coastal Highway are relatively few and, even then, narrow due to the railway.

Access from the E5 to both Kartal and Pendik is moderate. Defined grade-separated junctions lie 3.0 kms to the west of the site interchange and 3.6 kms to the east. There are some limited turn access points between the major interchanges (Figure 10).

The poor connections between both Kartal and Pendik and the E5 and the Coastal Highway indicate that there will be a strong demand for traffic to pass through the site to meet the major roads.

3.3 Road Access

Road access opportunities are restricted to the E5 interchange in the north and the Coastal Highway in the south. To the east and west numerous but mainly low capacity streets offer access.

The E5 has reduced to 2 lanes by the time it reaches the site from Istanbul and capacity is further threatened by some not too well defined partial junctions. The interchange on the E5 has circular ramps of a capacity in the order of 1,500 vehicles per hour (vph) (Figure 11). The capacity of the system is further compromised by the junction design on the E5 where entering and exiting traffic conflicts.

The Coastal Highway offers more opportunities for access. However, its role is more local than the E5.

3.4 Public Transport Access

The upgraded suburban rail and proposed metro will offer very substantial capacity for site access. Attention needs to be given to station location for both systems. The metro station is inconveniently located and there is no suburban rail station (Figure 13).

The lines are 2.5km apart so there need to be good internal transportation between the stations and the site.

Buses will serve the site in the roles described previously. It should be noted that while the rail systems offer excellent capacity, their coverage is limited and buses need to respond to this.

The existing ferry services running to the site are limited by the lack of current demand for public access by sea at the site. With the proposed masterplan brings an increase in requirements to provide public transport facilities, and sea transport is an ideal method at the proposed site. With the upgrading of the suburban rail in particular the role of ferries will change more to leisure and across the Sea of Marmara.

3.5 Some Conclusions

Public rail transport will be very important to provide the degree of accessibility necessary for the development to flourish.

Public road transport must not be overlooked as it provides coverage and flexibility which rail systems, by their nature, cannot.

The major road system has limited capacity and only the E5 offers reasonable journey times for medium to longer distance trips.

The site and its junctions with the Coastal Highway and E5 will be used extensively by through traffic.

The development must rely extensively on public transport, especially for journeys to and from work.

To achieve accessibility, the capacity of the railway lines will need to be matched by bus systems serving the site and surrounding areas, together with strong internal transit to and from the railway stations.

Strict parking regulations in terms of supply, use and management are essential.

Analysis

4.1 Transport Model

A transport model was established with the main objectives of predicting public transport and vehicular demand both to and from the site and within it. In addition, parking demand was assessed for weekdays and weekends.

The model was used to test combinations of land use mix and modal splits.

The application of employment and residential densities allowed an estimate to be made of total employment and residents and then the number of economically active residents. The economically active ones were assigned to appropriate jobs on site and the remainder assigned to jobs off-site.

Factors were then applied to the jobs in the various land uses to establish the number present on the design weekdays.

Trip making daily rates and the percentages in a.m. and p.m. peaks were applied to determine, by direction, the peak hour person movements. These were analysed by mode for internal-external and internal only movements separately by applying different modal splits.

This enable the number of people, by mode, and vehicles moving to and from the site in peak periods and by combining them on site demand. 'Present' factors were applied to establish demand for parking daytime and evening by weekday and weekend by land use.

Site access capacity by public transport was assessed and the results compared to these. Land use mix and/or modal split was adjusted to reach a balance between transport capacity and land use.

The results are expressed under 5 categories of land use:-

- Residential;
- Commercial
- Offices;
- Other Private;
- Public.

The transport model sub-divided the non-residential uses into 14 sub-uses.

4.2 Major Assumptions

4.2.1 Residential

Apartments would be mainly for mid to high income professional and management people. Age would be relatively young:

Average household size	3.6
Average density	30m²/resident
Average apartment size	110m²
Economically active	40%
% Work/Live on site	65-75% depending on ratio of economically active residents and 'appropriate' professional/ managerial jobs on site.

4.2.2 Commercial

It was assumed that all operations would be successful, irrespective of size. So that a larger retail floorspace would be filled by a larger catchment so footfall/m² remains constant.

4.2.3 Public Floorspace

Public floorspace for items such as schools, health and local government were in a fixed ratio to the number of residents.

4.2.4 Modal Split and Vehicle Occupancy

It was clear that car use would need to be restrained or built area reduced. Hence the initial tests were carried out using the lower spectrum of car use which might prove acceptable to residents, employers and visitors.

The critical assumptions for external trips and internal trips are presented below in tabular form.

Table 1 – Car Use and Occupancy Assumptions

Land-use	Motive	Origin	% by Car	Occupancy	% Driver
Office	Work	External	33	1.2	27.5
		Internal	155	1.2	12.5
Retail/Hotel Leisure, etc.		External	17	1.2	14.0
		Internal	12.5	1.2	10.5
Retail (Weekday)	Visit	External	40	1.7	23.5
		Internal	25	1.7	14.5
Leisure		External	35	2.25	15.5
		Internal	25	2.25	11.0

4.3 Options Tested

The options tested had a Private gross floor area (GFA) of 3,900,000m² only mix, public social buildings and modal split were varied.

Option A represents the IMP mix of 40% residential, 30% commercial and 15% of both offices and other private uses (Figure 13). The modal split assumptions were as discussed above.

Option B increased residential to 59% of the private sector and apportioned the remaining with a greater emphasis on offices than in Option A.

Option C uses Option A land uses but reduced car use to give similar vehicle flows to Option B in peak periods.

4.4 Outputs

4.4.1 Residents and Employment

The basic statistics for residents and employees are given in the table below and the relationship of home and workplace is shown in Figure 14.

Table 2 – Residents and Employees

	Residents				Employees		
	Total	Active	Live/Work	Work Out	Total	Live/Work	Live Out
Option A	54,000	20,000	15,000	5,000	92,000	15,000	77,000
Option B	80,000	29,000	19,000	10,000	74,000	19,000	55,000

Option B decreases the importation of employees into the site by 30%, it doubles the export but this is a very much smaller number. These changes are due to the reduction of employment economically active residents from over 6:1 in Option A to less than 4:1 in Option B.

4.4.2 Person Trips

The total person trips at peak hours are shown in Figure 15. In the A.M. peak hour the movements in Option A are slightly greater than B, however the external proportion is 38% in A but 50% in B. This is largely due to the greater number of work and school trips by the higher residential population.

In the evening the internal proportions for the options are within 5% but the overall trips in A are noticeably higher. This is due to the larger workforce and more attractive retail generating more external trips.

4.4.3 Modal Split

Options A and B have similar overall modal splits, as would be expected, as the same values were used (Figure 16). Due to different land use mixes, Option A is slightly more biased towards car use and taxis and slightly less to public transport and walking. The public transport share is 50% in the morning, declining to 45% in the evening. The percentage walking drops by 10% from 27 to 17%, mostly due to lack of educational activity in the evening. The car share is 20% for Option A in the morning, rising to 30% in the evening. Option B being slightly less. The rise is explained by the advent of shopping trips in the evening.

Option C exhibits significantly lower car use, 10% in the morning and 15% in the evening; public transport share is almost constant at 55% while walking declines by 10% from morning to evening.

Concerning only external trips for Options A and B the walking mode accounts for about 7%, taxis 8% and cars 23.5% and public transport 60 to 65% in the morning (Figure 17), evening sees a rise to 33% car and public transport, less than 50%. For Option C cars accounts for less than 15% in both morning and evening and public transport some 67% of movements.

4.4.4 External Vehicle Flows

The vehicle flows entering and leaving the site are shown in Figure 18. Option A produces 9,000 vehicles incoming in the morning and over 9,500 in each direction in the evening.

Options B and C have a morning inflow and evening outflow of some 7,000 vehicles while the evening inflow is 6,350.

The flows have been distributed onto the roads accessing the project in Figure 19. The E5 is estimated to carry 55% of the traffic and the Coastal Highway 25% while the various smaller roads from east and west account for 20%.

The critical point is the E5 interchange which takes 55% of the traffic. The total generated movements passing through it and heaviest flows on the slip roads to and from the west are given in the table below:

Table 3 – Peak Traffic Flows at E5 Interchange

Option	Total at Node		On-slip West		Off-slip West	
	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
A	6,251	12,075	502	2,049	1,913	2,056
B	5,235	7,367	513	1,500	1,510	1,346
C	4,760	7,434	357	1,521	1,482	1,351

Flows for B and C are similar as the modal split for Option C was input to reach similar flows to B. Option A flows are 65% higher through the node in the p.m. peak and, apart from the low a.m. on slip, flows are 28 to 52% higher on the slip road.

4.4.5 External Public Transport Flows

The public transport trips, excluding taxis entering and leaving the project, have been assessed (Figure 20). For all the options the greatest one-way flows occur in the morning when between 21,350 (Option B) to 26,350 (Option C) arrive in the peak hour. The evening two-way flows for Options A and C are the largest at 30,000 and 39,500 respectively but are quite evenly balanced by direction.

The critical line capacity issue is the morning arrivals. A range of use and passenger flows is given in the table below.

Table 4 – A.M. Peak Public Transport Flows

Transport Mode	Range %	Passengers Pedestrian Mode		
		Option A	Option B	Option C
Metro	30-40	7,175 – 9,550	6,400 – 8,550	7,900 – 10,550
Suburban Rail	20-30	4,775 – 7,175	4,275 – 6,400	5,275 – 7,900
Bus	30-45	7,175 – 10,750	6,400 – 9,600	7,900 – 11,850
Ferry	0-10	0 – 2,400	0 – 2,150	0 – 2,350

The importance of buses is often under-stated, they will need to serve significant areas to the north where there is no mass transit, together with more local trips where change to rail is less convenient.

4.4.6 Parking Demand

Parking demand has been calculated for the 14 non-residential uses and is presented in simplified form in Figure 21. This presents an assessment of demand for weekdays and weekend for daytime and evening.

The first four columns show the total demand for each period. The fifth shows the parking provision needed if each of the 14 uses were considered separately. The largest of the first four columns show the maximum requirement if all non-residential spaces were shared.

Table 5 – Car Parking Demand

Option	Separate			Shared		
	A	B	C	A	B	C
Non-residential	41,000	27,750	35,225	28,000	18,750	24,175
Residential	15,075	22,250	15,075	15,075	22,250	15,075
Total	56,075	50,000	50,300	43,075	41,000	39,250

The difference between separate and shared varies from 9,000 in Option B, 11,000 in Option C to 13,000 in Option A.

Disregarding the relatively small proportion of parking that can be accommodated on-street, the parking ratios for selected land uses are compared with Municipality Standards in the table below.

Table 6 – Calculated and Municipal Parking Standards

	m² GFA per space			
	Municipality	A and B	C[2]	Comments
Offices	30	100	150	
Retail Local	30	115	135	
Retail Centre	30	35	40	Overall retail is
Entertainment	20	30	35	40 for A/B,
Health	75	100	200	45 for C
Hotel [1]	240	300	750	
Education	300	150	325	

[1] Municipality is 1 per 4 rooms

[2] The traffic model gave as much road space as possible to commercial land uses which developers view as needing car access

The comparison shows that the use of cars for journey to work is very constrained, even in Options A and B; the impact on retail visitors is less, especially if a differentiation can be made between local and centre shops.

4.5 Discussion

4.5.1 Highway Access

In addition to traffic generated by the project there will be other traffic from Kartal and Pendik using the site. The critical issue is likely to be the E5 and its interchange. The following peak hour flows have been assumed for through traffic using the E5 interchange.

Table 7 – Through Traffic on E5 Interchange

	a.m. peak hour				p.m. peak hour			
From/To	K + P	E5 (E)	E5 (W)	North	K + P	E5(E)	E5 (W)	North
Kartal/Pendik	//////	300	800	350	//////	200	350	225
E5 East	150	//////	//////	//////	300	//////	//////	//////
E5 West	350	//////	//////	//////	750	//////	//////	//////

The combination of through and generated traffic is shown diagrammatically in Figure 22 for Options A and B. Option C, being close to B in peak one-way flows, has been omitted.

The circular slip roads have a capacity of less than 1,500 vph and will be severely overloaded by factor of at least 67% in Option A and 30% in Option B. The other slip roads may have a capacity of 1,750 vph but are overloaded by about 60% in Option A by 20%.

The capacity of the E5 itself will be in the order of 4,000 vph in each direction. Option A will require some 53% of this capacity in the morning and 70% in the evening while, for Option B the figures are 47% and 53% respectively.

The flows entering and leaving the site in the p.m. peak are 6,740vph and 6,170vph for Option A and 4,840vph and 4,760vph for Option B.

Option A would require a new major road to be built east-west between the E5 and the Coastal Highway.

Option B would require extensive works on the E5, including making it three lanes through the site and further east; remodelling of the site interchange and improvement of the limited movement junctions to offer an alternative to passing through the site.

This would reduce the proportion of the E5 capacity used by the project and traffic from Kartal and Pendik to 30 to 35% and enable the slip roads to operate reasonably well at peak periods.

4.5.2 Internal Public Transport

A tramway is postulated to run from the Metro Station to the Suburban Rail/Bus Station and terminate at the ferry. There is a possibility of a branch to Kartal.

The table below shows estimated demand in the higher direction of flow in peak periods. The Kartal branch peak is in the opposite direction to the peak on the common track between the tram junction and the station.

Table 8 – Estimated Tram Demand

Section	Frequency per hour	Passenger Demand		Capacity	
		Option B	Option C	3-car	4-car
Common	24	6,350	7,550	7,200	9,600
Kartal	8	3,000	3,000	2,400	3,200
Boulevard	12	5,075	6,200	4,800	6,400
A 4-car system is appropriate					

4.5.3 Public Transport Access

Both the Metro and Suburban Rail are stated, in the long term, to have a capacity of 75,000 passengers per hour in each direction. This is a theoretical capacity and the real might be 50,000 to 60,000. The ferry could offer up to 1,200 nominal, say 1,000 realistic, in each direction. In addition, one could postulate a bus every 2 minutes each way on five main directions of approach, giving a further capacity of 7,500 per hour in each direction.

There are other users of the transport systems who are not related to the project. The table below gives assumptions regarding available capacity.

Table 9 – Public Transport Demand and Capacity

Mode	Capacity per hour	Available Capacity		Comment
		%	No.	
Metro	110,000	15	16,500	
Suburban Rail	110,000	15	16,500	Significant
Bus	15,000	50*	9,000	% express buses*
Ferry	1,000	30	300	
Total			42,300	

These are quite conservative assumptions and a one-way capacity of 50,000 passengers per hour in the peak periods could be achieved. The demand varies from 20,500 (Option B) to 26,500 (Option C). Comparison with the assessment in Table 4 shows significant capacity for each mode except buses.

4.5.4 Parking

The parking strategy and its management is a key issue in controlling traffic, together with good public transport.

The foregoing analysis has shown that the IMP's desired land use cannot be achieved unless very severe constraint is applied to car use. For instance, only 20% of office workers from outside drive and 15% of retail visitors from outside come by car. The rate of car use is less for people living on site so the overall office driving is approximately 15%.

For Option B the overall office driving percentage is over 20% and retail visitors for outside 40%.

The issue of sharing is important. It is considered that residential parking should not be shared. Regarding office use it is recommended that sharing be encouraged to lower the overall ratio of parking to total GFA. This can only be done on an area-by-area basis and should be carried out as the plans for each area become defined.

The management of the parking needs to be addressed by the public and private sector working together. Issues to resolve are pricing to regulate short, medium and long-stay users in the right proportions by weekday and weekend and even differentiate between day and evening on weekdays. In addition, consideration should be given to leasing spaces for companies' workers up to the allowed level and for what periods these spaces are reserved.

4.5.5 Options

Option A is not a realistic solution as the highway network cannot cope.

The issue is whether Option C can be tenable in view of a number of factors. First is a question of the viability of such a large element of commercial land use. Secondly, as the car use for work journeys is depressed to 15% drive for offices and a few other uses but to 10% for most, whether this is culturally and commercially viable. On the retail side, shoppers from outside the project are restricted to 15% by car. The latter is nearer a figure found in large city centres, not large city secondary centres.

4.6 Recommendations

Unless that finds otherwise, it is recommended that the land use mix of Option B is adopted together with its assumptions on use of transport.

The project must be heavily reliant on public transport and this must be recognised in the Masterplan.

An integrated transport strategy for the site must be instituted, including a parking policy designed to restrain car use to the levels appropriate to Option B.

The IMP initiates a study for upgrading on the E5 and, in particular, the project access interchange to meet the criteria and issues established in this analysis.

Need for Change

5.1 Social Attitudes

The analysis has shown clearly that the accessibility of the new Asian Centre of Istanbul needs to rely on a low proportion of people being able to drive to and from work. This applies both to people living outside the project and working within it and also to residents, either working outside or inside the project boundaries. Parking will be severely limited for commuters and somewhat restrained for shoppers and residents, while the restraint is slight for activities such as entertainment and culture.

The only alternative may appear to reduce drastically the programme for the project. This is not really a tenable argument as it prevents the project fulfilling its role and parts would be built elsewhere generating traffic. The issue is universal for Istanbul and needs to be confronted.

Developments in Istanbul, especially those aimed at the more affluent members of the middle classes, have catered for their demand for parking at home or at work. Indeed, with the problems of public transport possibly, there was not considered a viable alternative.

As the economy has progressed well in recent years, more people have moved into car ownership and use and yet more aspire to.

As recognised some years ago by the Authorities, mass transit must be built to allow mobility without social, economic and environmental consequences of mass motoring.

It is now necessary to wean citizens away from current car use and aspirations to buy and use a car for some journeys. Likewise, developers no doubt feel that if they do not provide car parking at very generous levels, people will not buy the homes they have built and companies rent their offices.

These are very difficult issues to face. For some, the dream of owning a car is about to be fulfilled only for the Authorities to endeavour stopping them from using it by regulation and price. For others, used to driving, the thought of using public transport would, in some countries, imply a loss of status and social stigma. However, attitudes can and do change quite rapidly. For instance, a pedestrian in France ten years ago was almost regarded as a target by drivers. One sees now, in the large French cities, a very different situation of care and courtesy. Some twenty years ago Margaret Thatcher, a small town woman by upbringing, remarked that anyone who travelled by bus must be a failure. Absurd remark then but an attitude shared by a substantial minority of middle-class Londoners. Now in London, among those same middle classes, there are some who are giving up car ownership and many who regard people driving unnecessary in London as both selfish and uncivilised.

Offered an efficient alternative to car driving, one must have faith in human nature in the longer run and plan for a sustainable future rather than be fixed in the present.

5.2 Legal

The implementation of some strategies, in particular car parking provision and control, may be outside the current legal framework of Istanbul and Turkey. This is a subject obviously outside the Design Team's remit and expertise. Nevertheless, if this is the case then it needs to be addressed by the Municipality and, possibly, the State. Without an appropriate legal framework, complex major development projects cannot be expected to fulfil their ambitions.

Masterplan design Engineering Input (extracts)
October 2008

Site Wide Level Strategy

Site levels range from +120m AOD close to the M5 motorway in the north, down level +0m AOD at sea level in the south. Average slope for the site is 3%-4%, with localised areas of up to 10%. (See Figure 9)

Gradients along the streets should be below 5%, taking into consideration disabled access requirements. Absolute maximum of 7% slope can be reached occasionally.

Figure 9 indicates site levels, as well as slopes on proposed street network which are greater than 6%. In these cases, special measures such as the levelling of plots to achieve 6% average or reprofiling of sidewalks in order to introduce resting areas are recommended. Local regulations will be required for further detail on these issues.

4.1 Level Strategy for the Main Boulevard

This section outlines the strategies followed in order to define the vertical alignment of the main spine leading from the cloverleaf junction in the north. Figure 10 shows the plan and Figure 11 the proposed longitudinal section of the road. The vertical alignment is based on the following criteria:

- The average slope of the site is 3.6%, with areas close to 6%.
- Maximum desirable gradient 5,% with localised slopes of 6% and absolute maximum of 7%
- Sliproads from highway into junction at slopes of 9%

4.2 Level Strategy close to Marina

This section outlines a level strategy which links the following elements (shown in section location in Figure 12):

- Main Boulevard
- Railway line Railway station
- Coastal Road 1 and 2
- Bus station

Figure 12 and Figure 13 show a series of sections outlining the proposed level layout for the Main Boulevard. In short, this can be described as follows:

- The proposed strategy for the railway layout is leaving railway at grade (see section 6). This implies that road levels need to be modified in order to allow connections north-south in the locations proposed.
- Site levels need to be raised to the north of the proposed railway line, in order to be able to coordinate with the main boulevard and marina.
- Coastal road 1 and 2 in a lesser extent need to be raised.
- Areas between new railway and coastal Road 1 may need to be raised in order to fit with surrounding levels. Sections 2 and 3 in Figure 13 show these areas remaining at grade linked to boulevard though ramps.
- It is understood that there are proposals to locate a bus station close to the railway station. The area east of boulevard can be used to locate this facility, as shown in sections 1 and 3.

Principles of Tram Layout

A tram system is proposed to connect the ferry terminal (south part of side) and Kartal Marina (outside the dite to the west) to the proposed metro station in the north (see Figure 14). This section outlines the principles adopted for the layout of the tram across the site.

5.1 Section Layout

The two way tram is proposed to be located on both sides of the Main Boulevard along 3.65m wide corridors. Northwards from the boulevard, the tram should run within a single corridor, partially existing the road and crossing the CBD public square before finally crossing the motorway underneath, reaching the metro station connection and adjacent depot.

5.2 Plan Layout

The horizontal alignment of the tram has been designed with a minimum turning radius of 40m.

The tram stops have been located at 300m average intervals. In case there is conflict with a traffic junction, the tram should be located immediately after the junction in the directio0n of the traffic.

Tram stops will consist of 50m long platforms which will take the place of parking spaces adjacent to the sidewalk.

- A tram depot is planned for the north of the site. Initial estimates of the tram fleet suggest that 14 three car trams would be needed to serve both lines as shown in Figure 14. From comparisons with other tram facilities (The Therapia Lane facility west of Croydon, London UK, 2.5Ha 16 two car vehicles), it is estimated that an approximate area of 2Ha - 2.5Ha would be required for the depot. This depot is planned to be located in the space between the quarry and the M5 motorway.

5.3 Interface With Metro

- Connection to metro station is proposed via a subway below the M5 which has separate access both sides of tram platform.
- The south exit of the subway connects to bus stop which can be used by buses along north side of quarry.
- The tram line continues to the depot further north

Railway Alignment

A series of tracks cross the site west-east parallel to the coast. Long distance trains connecting to Ankara, as well as freight trains use these on a regular basis. It is understood that an upgrade project would allow these to be suitable for use by high speed trains is proposed (no details available). It is also understood that a new train station is planned to be built on the site.

The railway poses important opportunities and constraints for the development. On the one hand, the station will provide connectivity to the site, on the other the tracks will also cause segregation problems. In either case these problems need to be solved and it should be recognised that significant costs may be incurred. This section analyses the options available to deal with this potential segregation.

6.1 Geometrical Parameters for Railway Design

- Maximum curvature for high speed trains is constrained to minimum radius of 1,000m.
- Assuming that freight trains are likely to be passing through the site, a maximum slope of 1/80 (1.25%) is recommended. This value could be more relaxed (up to 3%) for high speed trains. A compromise value of 1.5% is assumed for the development.
- Vertical alignment transitions can be assumed to be 2,000m radius
- The railway station should be located on a level area of the vertical alignment (see note in Figure 18), which coincides with east of Main Boulevard (see Figure 12).
- Headroom for railway and structure is assumed to be 7.5m

6.2 Horizontal Alignment

Figure 18 indicates the proposed horizontal alignment. The horizontal alignment is based on:

- The design has been carried out in such a way that the impact of the realignment is minimal and falls almost entirely within the site boundary.
- The proposed alignment relocates the tracks south of their current alignment. As a result of the terrain sloping the vertical alignment will have to be lowered in order to remain at grade.

6.3 Options to Avoid Segregation

In order to avoid segregation of the fabric, two options have been considered. The difference between them lies in the vertical alignment strategy. The horizontal alignment is common to both. The following options have been considered.

- **Option 1**: Lower the tracks to allow a cut-and-cover tunnel across the entire width of the site. This allows the topography of the site to be unaffected in the areas adjacent to the tracks. Figure 16 shows the extent of the aligment that would be required (500m to 650m depending on the depth of the tunnel).
- **Option 2**: Remain at grade: In this option, the tracks remain at grade with the terrain. Roads and landscape must be raised around the railway to provide access over the tracks. Alternative sub-options may consist of raising the terrain only in certain areas and/or leaving parts of the site or plots segregated when landowners consider it uneconomic to build over

Assessment Criteria

The following assessment criteria have been used to compare the two options:

- Minimise capital cost
- Flexibility of construction phasing
- Allow flexibility for different land owners to take a different approach to mitigating impact (e.g. build over/do not build over)
- Minimise impact on adjacent sites
- Minimise influence on alignment of roads (boulevard and others)

6.4 Option Assessment

In order to evaluate the relative merits of the 2 options discussed, a qualitative assessment of each has been undertaken against specific criteria and scored from 1 to 5 where '1' is very poor '3' is average and '5' excellent. The criteria and assessment are summarised in the table below:

	Option 1: Tunnel	Option 2: At grade
Minimise Capital cost	2	5
Allow flexibility in construction phasing [1]	2	4
Allow flexibility for different owners	2	3 [2]
Minimise impact on other developments	2	4
Minimise influence on alignment of roads	5	2
TOTAL SCORE	13	18

[1] Works outside the site would need to be completed in Option 1. This may impact on phasing

[2] Option 2 allows for sub options, where not all the site is raised if land owners do not find it appropriate to invest in the cost of the works.

6.5 Proposed Alignment Strategy

Option 2 (at grade) is proposed as the preferred alignment strategy as it provides a higher degree of flexibility and minimal impact outside the development.

Figure 17 shows the modified plan alignment of the railway while Figure 18 shows a long section. The indicative vertical alignmentfollowing should be noted:

- In order to remain at grade, the alignment of the junction with the boulevard needs to drop 3.0m (see sections in Figures 17 and 18,) which need to be gained from a point close to the boundary site.
- The proposed track meets the existing tracks at grade and joins the existing alignment within the site.

It should be noted that, due to the lack of accurate data at this stage, the assumptions made for this study are indicative only of the potential implications of these alignments across the masterplan.

6.6 Railway Station

The station configuration is based in the following assumptions:

- A third track is to be added into the alignment across the site
- Railway station on site should have a central platform configuration (consistent with our understanding of other stations, excluding structure for walls.

Overall section in station will be as follows (Figure 17):

- 4m wide corridor for one way track
- 9.5m wide island platform
- 8.5m wide corridor for other two tracks

The overall station requirements add up to 22m corridor. For the purposes of the masterplan, an overall 25m wide corridor has been allowed across the entire site.

It is understood that the length of the platforms should be no less than 225m.

Marina and Ferry Terminal

Environmental Conditions

2.1 Prevailing Wind Directions and Wave Heights

Prevailing winds are from the north-north-east, see Figure 3. Less frequent winds are from a south-west direction.

The worst case scenario for largest waves at the intended marina site will be the from south-west type wind directions. This direction has an average wind speed of 11 knots, and it has been provisionally estimated that a 1 in 50 year significant wave height will be approximately 2.8m. The wave climate needs further study to establish the frequency and persistence of adverse sea states. There will be some dissipation in wave energy due to the Princes Islands located offshore, but these have been ignored at this pre-feasibility stage.

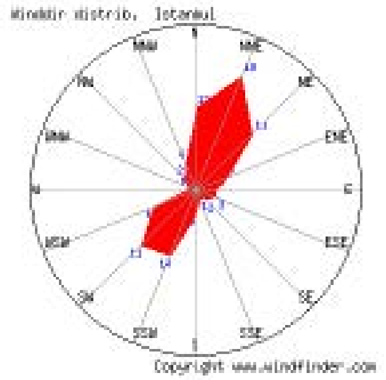
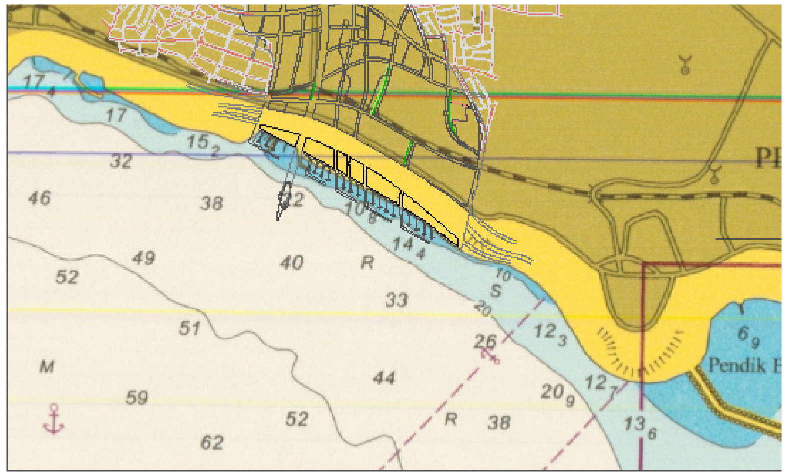


Figure 3 - Wind Rose for Istanbul

2.2 Bathymetry

The bathymetry of the site is particularly steep, and hence deep water is reached relatively closely to the shoreline. Most of the existing marina facilities are small and tucked into near shore locations where they are constructed in less than 10 to 15m of water (refer to Section 3).

See Figure 4 below for an excerpt of the Admiralty Chart. The yellow colour indicates dry land, the dark blue shows water depths to 10m, the light blue to 20m and beyond that specific water depths are given as spot heights.



2.3 Other Environmental Conditions

These have not been researched or assessed given the limitations of the brief and time constraints. These include: seismic activity and effect on wave heights, currents, surge, swell, joint probability of wave and water level events, climate change and so on.

Existing Facilities

Istanbul Sea Buses Company (IDO) operates Kartal and Pendik Wharfs which runs the following services from those locations:

- Pendik to Yavlova (fast ferry service which takes cars) – this journey takes 45 minutes and departs every hour and a quarter from each location;
- Kartal to Yavlova (sea bus services which is passenger only) – this journey leaves every few hours with up to seven services per day from each location;
- Pendik to Kartal (sea bus service which take passengers only) – this journey takes 15 minutes but is only provided on working days for one journey one way at rush hour.

Sea buses are fast catamaran type boats. Fast ferries are slower but larger than sea buses. See Appendix A and B for details of complete routes that that are covered by IDO's services.

3.1 Kartal Marina and Ferry Terminal

This marina has approximately 100 berths of varying sizes including a mix of large vessels and small sailing yachts. It is sheltered from south-westerly storms by a rock breakwater in shallow water depths i.e. less than 10m.

To the west of Kartal Marina there is a conventional passenger ferry terminal which is unsheltered. This is used for sea buses (catamarans) which at present can carry up to 450 passengers and measure 42.9m x 12.4m x 3.8m i.e. length, breadth and draught. It is assumed that this berth is unsheltered for one of two possible scenarios: it could be either that the service runs in summer only, or that large berth movements of the sea bus are allowed because only passengers use the service and/or that the service is cancelled or diverted in bad weather.

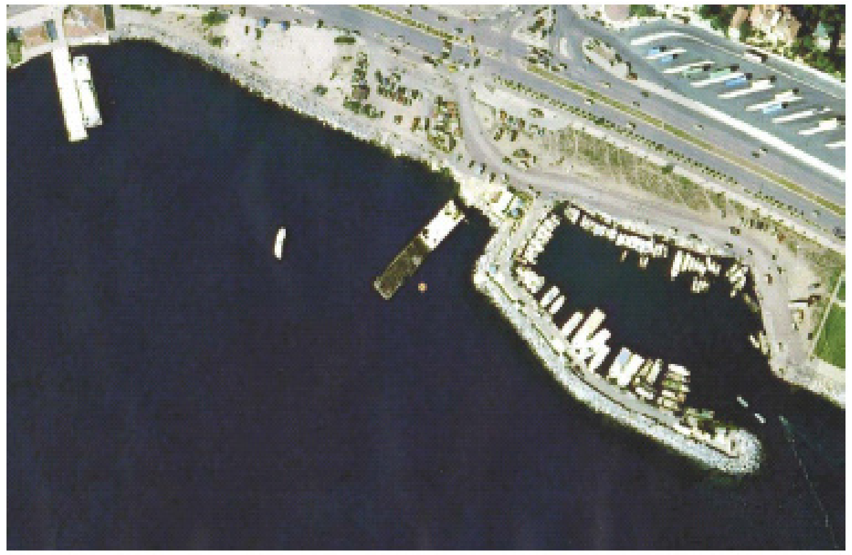


Figure 5 - Existing Kartal Marina and (Unsheltered) Passenger Ferry Terminal

3.2 Kartal Industrial Berths

This contains 6 'finger' quays providing 12 berths for large vessels used for industrial activities at present. Large vessels only use these unsheltered berths, because large vessels remain unaffected by shorter period waves, but are severally affected by long period swell-like waves which are rare at this site.

Conversely shorter period waves will affect smaller recreational vessels but not longer period swell waves, and hence breakwaters are used to provide sheltered conditions for marinas around this stretch of the coastline.

3.3 Pendik Marina and Ferry Terminal

Pendik Marina has a large rock breakwater in shallow water providing a haven for approximately 150 small sailing yachts. The outer breakwater and landside extremity is used for berthing larger vessels. See Figure 7 and 8.

A car and passenger ferry terminal is situated within the breakwater as sheltered movement is required for transition of cars from land to ships. It is likely this service is used all year round, until conditions exceed those which the ferries are designed to operationally withstand either inside or outside the breakwater.

Existing vessels (car and passenger ferries) carry approx 600 people and 112 cars, and measure approx 80.8m x 20.8m x 3.6m i.e. length, breadth and depth.

It is likely the existing ferry turning space and navigational channel marks the boundary (plus an allowance) to the yacht moorings. <u>The upgrade of Pendik Marina has been excluded from Arup's brief and it is assumed that others have taken forward the concept studies for this facility.</u>

Figure 6 - Kartal Industrial Berths (Unsheltered)

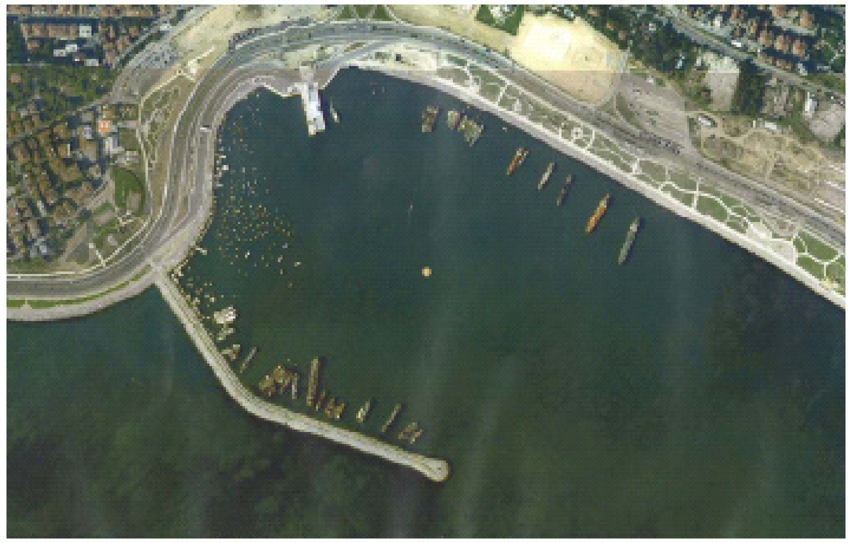
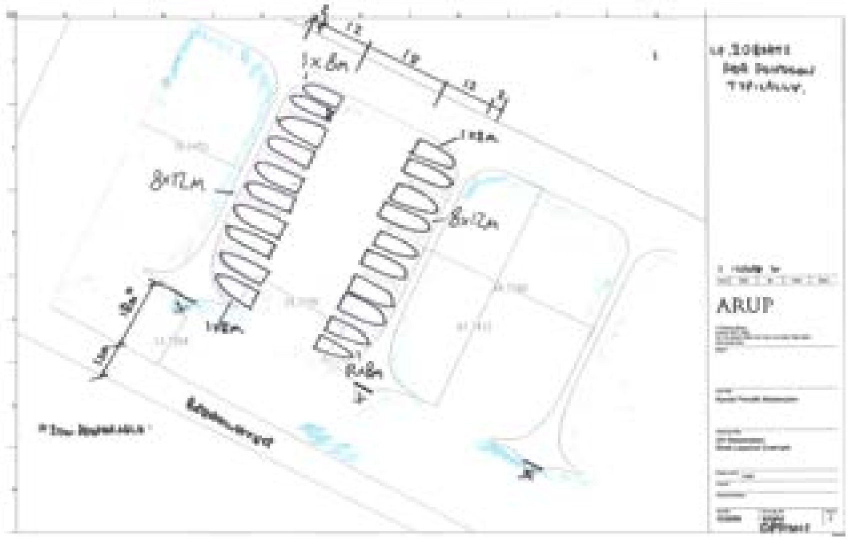


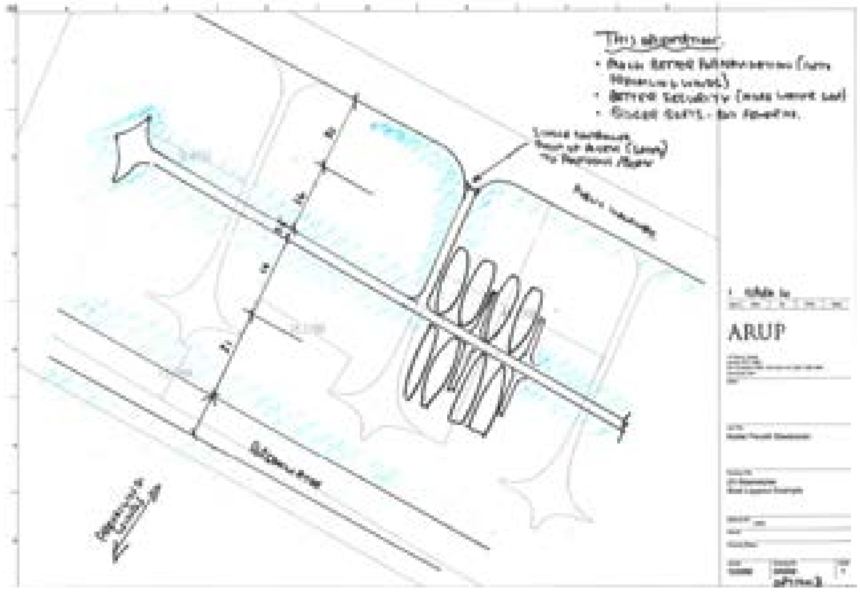
Figure 7 - Pendik Marina North (Sheltered Passenger and Car Ferry Terminal)

Figure 8 - Pendik Marina South

Marina Layout Guidelines

4.1 Berths





It is anticipated that wet berths will be kept to shallow water locations to keep costs down. The dry stacked area assumes a stacking ratio of 3 vessels high. It should be noted that as long as the dry stacking space is within a short drive from the marina launch facilities, it can be situated away from the waterfront and need not take up valuable waterfront space.

4.2 Vessel Size

The marina requires an optimised berth size mix to reduce the overall dimensions of the marina. This will be a graded mix dependant on the local leisure market conditions in Turkey. We have assumed a typical graded mix which varies from 8m to 25m length, which can be seen in Appendix C.

Additionally, the berth layout requires optimisation for berthing during prevailing wind conditions and for maximising the number of berths available. Prevailing conditions are predominantly north-north-easterly's or, to a lesser extent, south-westerly's and hence berths will be best aligned perpendicular to the shoreline. However at this preliminary stage we have assumed berth layouts parallel to the shoreline so as to maximise the number of

4.3 Breakwater

The marina will require a solid breakwater to protect and shelter moored vessels. For this location it is likely that a floating pontoon breakwater will not be suitable as wave conditions will frequently be too rough. The alternative floating solution – an anchored superstructure such as that used at Port Hercule in Monaco – would be prohibitively expensive.

Ideally the breakwater structure should be constructed in limited water depth i.e. shallow water. A structure height beyond 20 metres will be unrealistic financially, although not technically unfeasible from an engineering point of view. It is recommended that the breakwater structure be situated in a preferred 10m water depth up to 15m water depth at the most. It should be noted that as an indicative estimate the cost of a breakwater structure will be proportional to square of the water depth in which it is constructed.

Given the conclusions reached above, the existing linear shape of the coast and the number of required wet berths, it is therefore necessary for the plan outline of the marina to become a long thin 'strip' running alongside the coastline.

The alignment of the breakwater will need to be perpendicular to prevailing wave direction and preferably in uniform depth for simplicity of construction i.e. from west-north-west to east-south-east.

4.4 Phasing and Layout

Due to the long narrow shape of the marina, and the fact that the ferry terminal is to be placed in the middle of the marina area (refer to Section 5.2), it is therefore sensible to divide the marina into Phase 1 and 2. This is appropriate for two reasons:

Phase 1 will be situated on top of the existing quay facilities at Kartal industrial berths, which are currently unsheltered, and will cater for 162 berths or 1.9ha of water space. This assumes four pontoons with between 33 and 49 berths per pontoon. Phase 2 is much larger at 538 berths or approx 6.7ha water space or say, sixteen pontoons at between 12 to 40 berths per pontoon. Refer to Appendix C for the pontoon berth capacity and vessel size mix.

Both Phase 1 and Phase 2 marinas will have a 'shallow water' breakwater in no more than 15m of water for Phase 1 and an average 10m of water for Phase 2, which will be economical for construction cost purposes. The breakwater will be constructed by a levelled rock bund and concrete caisson placed on top. Dredging will be required to level the sea bed within both marinas to a minimum depth of -6m.

4.5 Dredging/ Excavation

There is an option to either fill out in front of the exiting coastline with reclamation or dredge out behind the coastline to create additional land space or water space where required. The more the marina layout depends on this type of activity however, the more expensive the operation will become. So the ideal situation is to create a balance of cut and fill requirements for the shape for the coastline.

4.6 Land Side Facilities

The masterplan will need to allow for associated land space required, which has been estimated at 0.5ha. This space will be required for the harbour master and port administration office, customs building, washing (showers, toilets etc), workshops, chandlery, fuel, launching quay and so on.

Given the narrow shape of the marina, facilities should be evenly spaced along side the water edge so that it is not inconvenient for marina users to access facilities required.

4.7 Public Space

The majority of land adjoining the water frontage have been earmarked as 'green' areas for public realm space. This must be retained to maximise public amenity and waterfront development space. Visually the link between the waterfront space and the marina should be retained to allow for the 'sense of place' that a high quality marina development and associated waterside facilities (bars, cafes and so on) will provide.

A key part of the Masterplan will be to reduce the emphasis on the existing coastal road (a two by three lane highway) which at present works to cut off the water from the land space.

4.8 Car Parking

Car parking will need to be located in walking distance of the marina, but as in the case of the dry stacking, shouldn't take up valuable waterfront land.

Ferry Terminal Layout Guidelines

5.1 Clients Brief

It is not explicit that a new ferry terminal is required under the client brief; however it has been added to the masterplan to increase accessibility of the site from the sea both for the retail centre intended and the commuter transport opportunities to the Bosphorus and Istanbul city centre.

5.2 Location

It is a key requirement in terms of transport planning to locate the ferry at the south coastal end of the proposed arterial route. Ferries entering and leaving their berths can play a key part in helping to provide the bustle and activity which can make this waterfront development very attractive.

5.3 Ferry Type

It is anticipated that a passenger ferry facility is preferred to a combined ferry and car facility, which means that no offshore breakwater is needed to shelter the berths. If a combined ferry and passenger service is needed, a sheltered berth is required (which is not practical at this site). It can be seen from the unsheltered ferry terminal at Kartal that this arrangement is feasible. The assumptions made in Section 3.1 will need to be tested for the proposed facility and verified for appropriateness to the masterplan in further stages on study.

5.4 Navigational Interaction

It is recommended that the marina traffic (which will mainly be smaller pleasure craft) and the larger ferries are kept separate to limit the potential for delays and/ or collision avoidance. The marina traffic should only cross the ferry channel within a well defined zone well offshore of the ferry manoeuvring area. Navigation channels for ferry routes and marina entrance exit routes should be kept well apart.

5.5 Design Vessels

The largest current IDO sea bus carries up to 450 passengers and its length is approximately 43m. It is likely that future expansion of fleet will bring larger ferry vessels, so some allowance for vessel increase will need to be made on the berths.

5.6 Turning Circle

Using the existing ferry terminal length, the maximum turning circle could be anything from 1.6 to 2.0 multiplied by the length, that is to say, 70 to 85m diameter. This can be reduced depending on whether the ferries are fitted with bow thrusters which will allow them to turn in smaller areas.

Given the existing sizes of ferry vessels, turning circles are likely to be less than 85m diameter, and hence it will be possible to locate a small craft crossing channel offshore of the turning area. Proper care should also be taken when detailing the location of navigational and entrance channels to separate different types of traffic. If ferry sizes vary dramatically to those used at present the channel positions would need to be re-reviewed.

5.7 Berths

It has been assumed that the ferry terminal will provide two berths. The preferred layout is berths perpendicular to the coastline on either side of a 'finger pier', as this will enable optimum berthing conditions given prevailing wind conditions.

The estimated wave height at the site is 3m, however it should be understood that if wave heights exceed 0.7m the passenger berth may not be suitable for use to load and embark passengers and hence there will be a certain amount of downtime associated with the site specific environmental conditions which are not known at this stage.

5.8 Ferry Terminal Building

A ferry terminal building will be required. Assuming the present sea bus capacity of 450 passengers, the terminal building will need to cater for 900 passengers at any one time. The majority of these passengers will be commuters without luggage, and hence the scope for the terminal building will include provision of shops, waiting areas and seats, toilets, telephones, ticket purchase, enquiries, therefore say a footprint of some 4000m² footprint for the ground floor. The first floors will have other uses: harbour master office for the marina and ferry terminal, admin offices and customs.

This building could be utilised for restaurants and bars to share the prominent location are the views that it will afford over the water.

5.9 Public Transport Ferry Route

It is assumed that the ferry terminal will provide a service between the masterplan site and the southern end of the Bosphorus for example Kadikoy or Uskudar.

Assuming 450 passengers per ferry utilising two berths with three ferries per hour per berth, the terminal will be able to accommodate some 2,700 passengers per hour. This represents some 10% of the total public transport capacity of the site which assumes to bring in 26,000 passengers per hour. It should be noted that for future needs the frequency of ferry services could be increased if needs be to perhaps a 10 minutes turnaround per ferry, which would increase the capacity to 5,400 passengers per hour. Refer to the Transport Report for full details.

Summary

6.1 Summary

The masterplan has maximised its potential by incorporating a ferry terminal for public transport and leisure/tourism needs, a marina for private users, terminal buildings which can double as key restaurant settings and several kilometres of waterfront space which can be enjoyed by all.

The proposed marina will provide a 'sense of place' which people will enjoy, both for the private users and their amenity benefits, but also for the space provided where public space meets the waterfront.

The ferry terminal will provide some 10% of public transport access to and from the site, which will play a key part in helping to provide the bustle and activity which can make this waterfront development very attractive.

Ove Arup_Engineering consultants
GEOTECHNICS AND REMEDIATION

Istanbul and Turkey have a history of seismic activity which provides the development with significant potential risks. The North Anatolian Fault strikes through the Marmara Sea to the south of the Kartal Pendik coastline, and is responsible for three deep marine depressions.

The geotechnical and seismic aspects of the project require consideration in order to identify and mitigate the ground-related hazards and risks. Based on the limited available information this document provides a preliminary assessment of the likely geological conditions, as well as the risks associated with the design and construction of the proposed works. The detail contained within this preliminary report should only be considered to be appropriate to the masterplanning stage of the proposal.

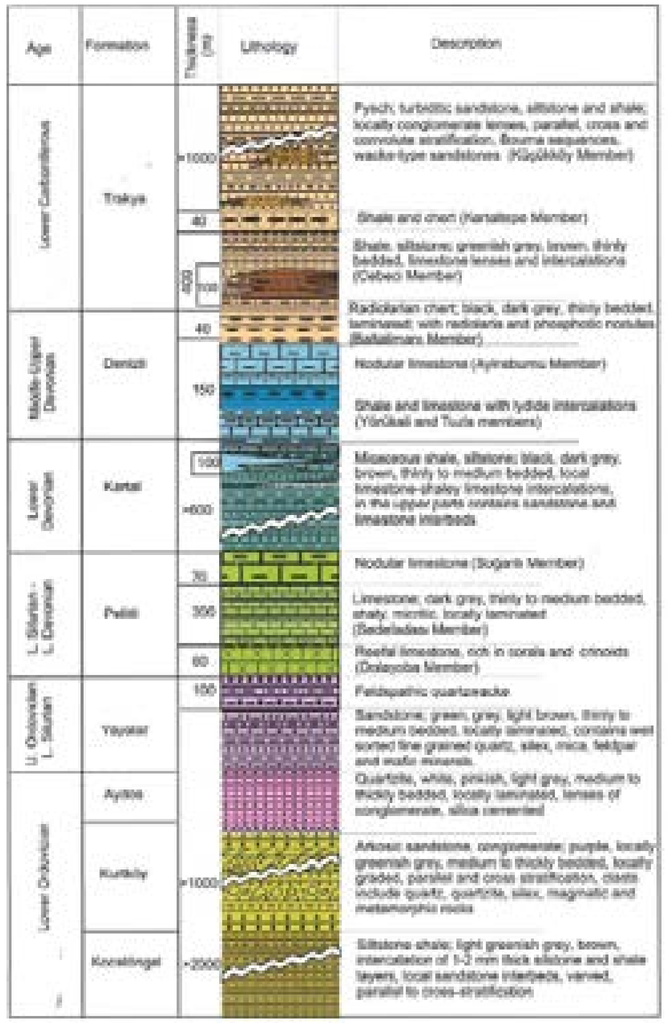
Geotechnical analysis and design should be developed in detail following a detailed desk study, ground investigation and interpretative report to fully appraise the geotechnical risks inherent in the development proposals.

This report has been produced for the use of the Client, Zaha Hadid Architects, in connection with the proposed development of the site. It is not intended for and should not be used by any third party.

Geology and Ground Conditions

4.1 Geological setting

The geology sequence for the Istanbul region is provided in Figure 4. Palaeozoic sedimentary rocks underlie a major part of the Istanbul metropolitan area. A report undertaken by GeoMar Ltd on behalf of Arup for a project in Istanbul [2] indicates the palaeozoic sequence is estimated to be over 5km in thickness. The geology of the area results in a significant variability of outcropping sedimentary rocks. The proposed development will require a detailed site specific ground investigation to be completed to provide a more detailed assessment of the geotechnical issues associated with the site.



KARTAL PENDIK MASTERPLAN
GEOTECHNICAL STRATIGRAPHY

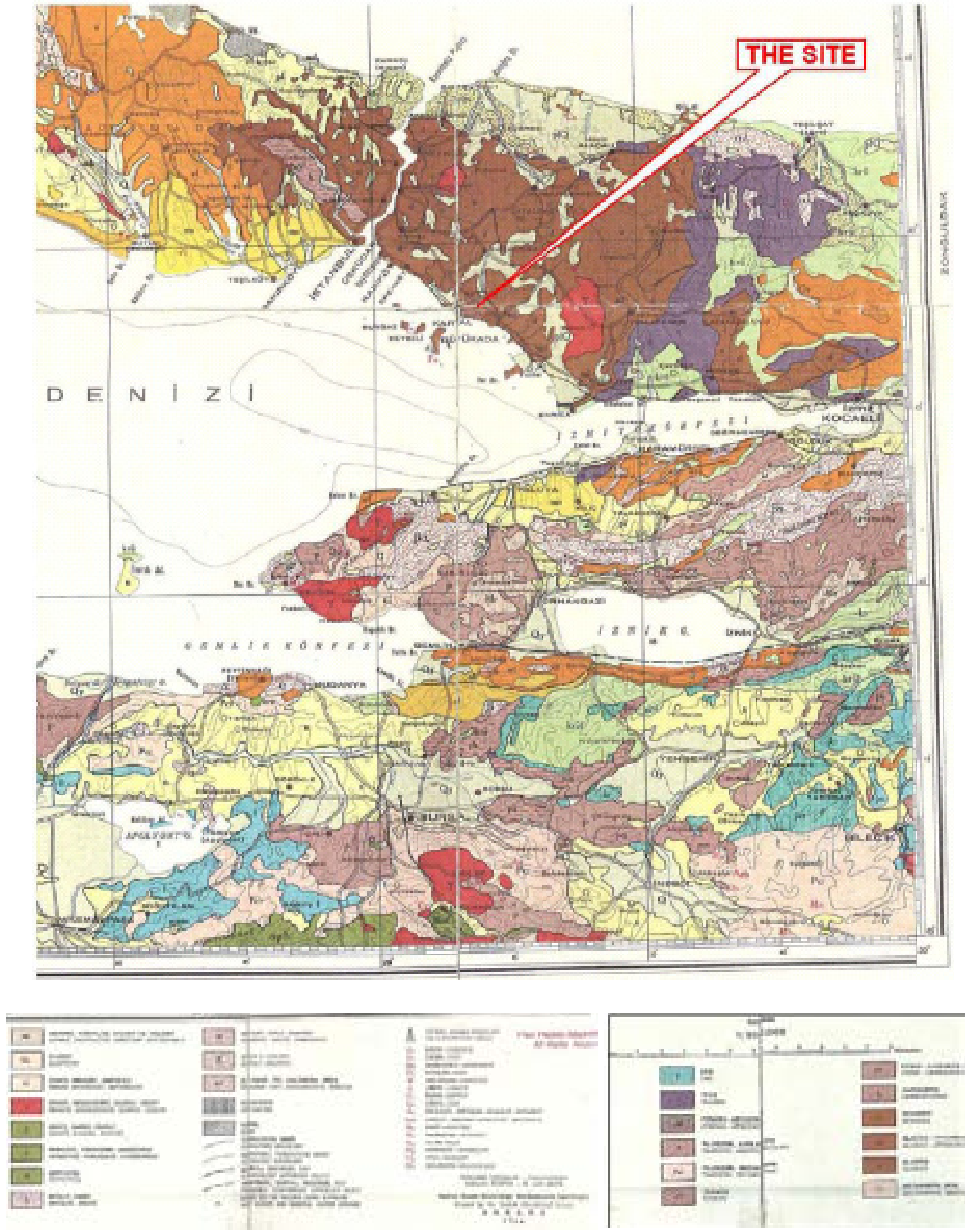
The 1964 Geological Map shown in Figure 5 for Turkey indicates the geological strata present in the Kartal Pendik area. Given the published date of the map, the land reclamation undertaken in the 1990s along the Marmara coast is not shown. The inferred geology from the map is as follows:

- Kartal formation from the Devonian period
- Dolayoba formation from the Silurian period

Recent man made fill is believed to dominate along the southern coast of the Asian side of Istanbul. The artificial fill is described by the Boğaziçi University report (2002) [3] as dense, coarse to fine gravel mixed salt, clay and cobbles.

Alluvium is anticipated to be encountered in creek valleys and plains where present. The identification of historical creeks and rivers should be assessed as part of a detailed desk study which is required as part of the process of gathering information for the proposed development area.

The Greater Istanbul Municipality Design Brief [1] suggests that alluvium has formed in the stream beds of rivers which previously flowed to the Bosphorus and Marmara Sea. Alluvium placed in the mid section of these rivers is considered by the Design Brief [1] to have "very weak characteristics".



4.1.1 Kartal Formation

According to the Boğaziçi University (2002), the Kartal formation is part of the Middle Devonian deposits and is composed of a brown and grey brown thinly to medium bedded very fossiliferous shale/mudstone, moderately weak to moderately strong; alternating with fine to coarse grained medium bedded sandy limestone, moderately strong to strong.

Kaya and Birenheide (1986) [4], suggests that the Middle Devonian sequence shows strong lateral changes in lithology. This indicates that the material may be highly variable across the site.

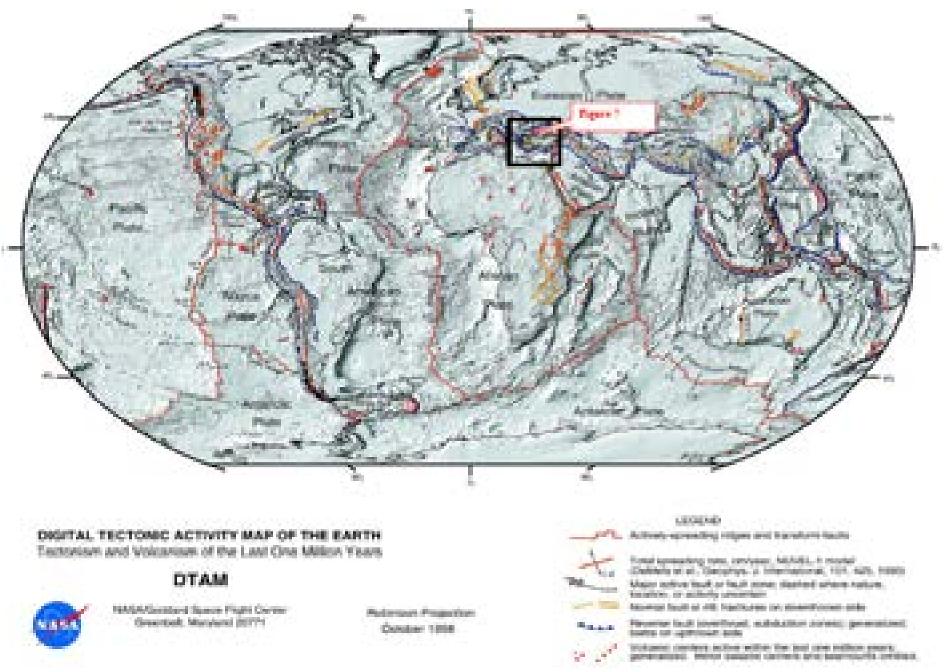
4.1.2 Dolayoba Formation

The older of the two deposits, the Dolayoba formation (Silurian deposit) would typically underlie the Kartal formation (Devonian deposit).

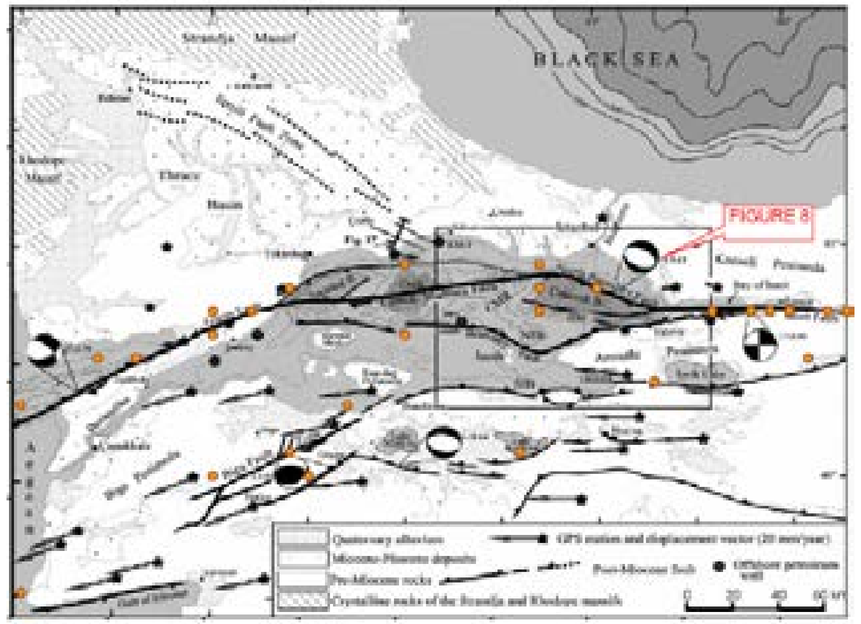
The Boğaziçi University publication (2002) [3] describes the Dolayoba formation as a light grey and blue grey coralline/fossiliferous limestone, strong; and blue dark grey, fine to medium grained bedded calcereous shale, moderately weak to moderately strong.

4.2 Tectonic Setting

The earth's crust is divided into six main continental-sized plates (African, American, Antarctica, Australia-India, Eurasia, and Pacific) and about 14 sub-continental plates and further micro-plates (see Figure 6). Turkey, which lies on the Anatolian microplate, is situated between the convergent boundary of the Eurasian, African and Arabian plates. This convergent boundary is part of the wider Alpine-Himalayan collision zone occurring between the Eurasian continent to the north, and the African, Arabian, and Indian Plates to the south. The active deformation within and around Turkey reflects the complex interaction between the Eurasian, African, Arabian, and Anatolian plates (Figure 7). The Anatolian plate is bounded to the north by the right-lateral North Anatolian Fault Zone (NAFZ), which separates it from Eurasia, and to the south and west by the active plate margin formed by the Hellenic and Cyprus trenches, along which the northward moving African Plate is being subducted. Slip rate estimates along the NAFZ fall in the range of 17 mm/year to 24 mm/year (Westaway 2003 [5]).



KARTAL PENDIK MASTERPLAN
TECTONIC ACTIVITY MAP OF THE WORLD
NASA (1998)



Historical Earthquakes > M 7.0

KARTAL PENDIK MASTERPLAN
TECTONIC MAP OF THE MARMARA REGION
(AFTER OKAY ET AL 2000) WITH HISTORIC
MAJOR EARTHQUAKES M > 7 (AFTER AMBRASEYS 2002)

4.3 North Anatolian Fault Zone

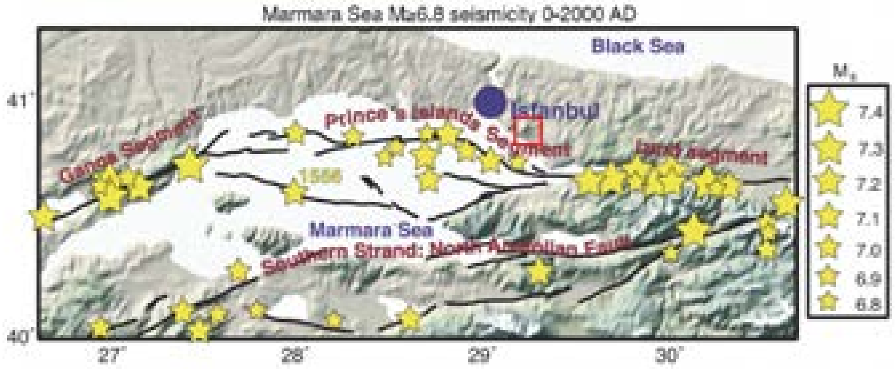
Transecting northern Turkey for approximately 1500 km, the North Anatolian Fault is a predominantly transform fault accommodating approximately 24 mm/yr of right-lateral motion and forms the boundary between the Eurasian and Anatolian plates. Its geometry is complicated as the plate boundary changes from mostly right-lateral transform in the east into transtensional system that has opened deep (pull-apart) basins beneath the Sea of Marmara, comprising both normal and strike-slip faulting.

The fault system is known to be the source of many large magnitude earthquakes in historical times (13 $M \geq 6.7$ earthquakes in the 20th century), with the Marmara region as a whole having experienced approximately 55 $M \geq 6.7$ earthquakes since 1 A.D., many causing extreme damage (Ambraseys, 2002 [6]). Many of these ancient events are likely to have been along this fault system (Figure 8), between A.D. 1500 and 2000 some nine $M \geq 7$ earthquakes occurred beneath or partially beneath the Sea of Marmara, a mean rate of one every 60 years. Table 1 presents the major historic earthquakes between A.D. 1 and 2000 occurring in the Sea of Marmara region.

Table 1: Table of Major Historic Earthquakes (1-1999 A.D.) After Ambraseys (2002)

Date	Coordinates		Magnitude		Region
DD/MM/YYYY	N	E	Ms	Mo	
--/--/0032	40.5	30.5	7	4.37	Nicaea
--/--/0068	40.7	30	7.2	8.71	Nicaea
--/--/0121	40.5	30.1	7.4	17.38	Nicomedia
10/11/0123	40.3	27.7	7	4.37	Cyzicus
--/--/0160	40	27.5	7.1	6.17	Hellespont
03/05/0180	40.8	30.6	7.3	12.3	Nicomedia
--/--/0268	40.7	29.9	7.3	12.3	Nicomedia
24/03/0358	40.7	30.2	7.4	17.38	Izmit
08/11/0447	40.7	30.3	7.2	8.71	Nicomedia
25/09/0478	40.7	29.8	7.3	12.3	Helenopolis
--/--/0484	40.5	26.6	7.2	8.71	Callipolis
26/10/0740	40.7	28.7	7.1	6.17	Marmara
09/01/0869	40.8	29	7	4.37	CP
02/09/0967	40.7	31.5	7.2	8.71	Balu
25/10/0989	40.8	28.7	7.2	8.71	Marmara
23/09/1063	40.8	27.4	7.4	17.38	Panio
01/06/1296	40.5	30.5	7	4.37	Bithynia
18/10/1343	40.9	28	7	4.37	Heraclea

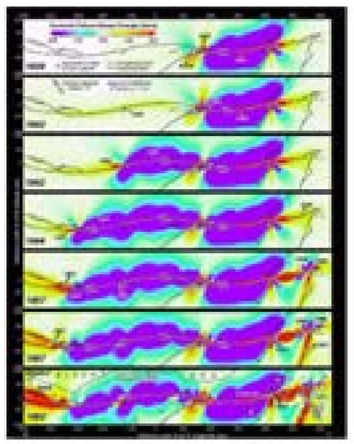
Marmara Sea M≥6.8 seismicity 0-2000 AD

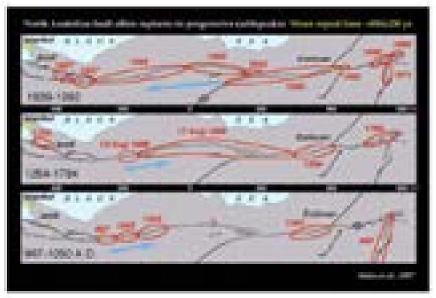


KARTAL PENDIK MASTERPLAN
SEGMENTS OF THE NORTH ANATOLIAN FAULT BENEATH THE SEA OF MARMARA AND LOCATIONS OF Ms ≥ 6.8 EARTHQUAKES (A.D. 1 – 1999) AS LOCATED BY AMBRASEYS (2002)
(AFTER PARSONS 2004)

Date	Coordinates		Magnitude		Region
DD/MM/YYYY	N	E	Ms	Mo	
01/03/1354	40.7	27	7.4	17.38	Hersamli
15/03/1419	40.4	29.3	7.2	8.71	Bursa
10/09/1509	40.9	28.7	7.2	12.3	CP
10/05/1556	40.6	28	7.1	6.17	Gonen
18/05/1625	40.3	26	7.1	6.17	Saros
17/02/1659	40.5	26.4	7.2	8.71	Saros
14/02/1672	39.5	26	7	4.37	Biga
25/05/1719	40.7	29.8	7.4	17.38	Ivmit
08/03/1737	40	27	7	4.37	Biga
22/05/1766	40.8	29	7.1	6.17	Marmara
05/08/1766	40.6	27	7.4	17.38	Gonas
28/02/1855	40.1	28.6	7.1	6.17	Bursa
10/07/1894	40.7	29.6	7.3	12.3	Izmit
09/08/1912	40.7	27.2	7.3	12.3	Ganos
18/03/1953	40.1	27.4	7.1	6.17	Gonen
26/05/1957	40.7	31	7.1	6.17	Abant
22/07/1967	40.7	30.7	7.2	8.71	Mudurnu
17/08/1999	40.7	30	7.4	17.38	Izmit
12/11/1999	40.8	31.2	7.1	6.17	Duzce

The 17th August 1999 M = 7.4 Izmit earthquake killed some 18,000 people, destroyed 15,400 buildings (EERI [7] estimate 60,000 to 115,000 buildings), and caused between US$10 billion and US$25 billion in damage (Parsons 2004 [8]). This was the most recent event of a largely westward progression of seven M ≥ 6.7 earthquakes along the North Anatoliean Fault since 1939. Stress triggering has been used to explain the 60 year sequence of earthquakes rupturing towards Istanbul (Ketin, 1969 [9]; Barka, 1996 [10]; Toksoz et al. 1979 [11]), in which all but one event prompted the next (Stein et al., 1997 [12]). Figure 9 presents the progression of ruptures along this fault in recent historic times.



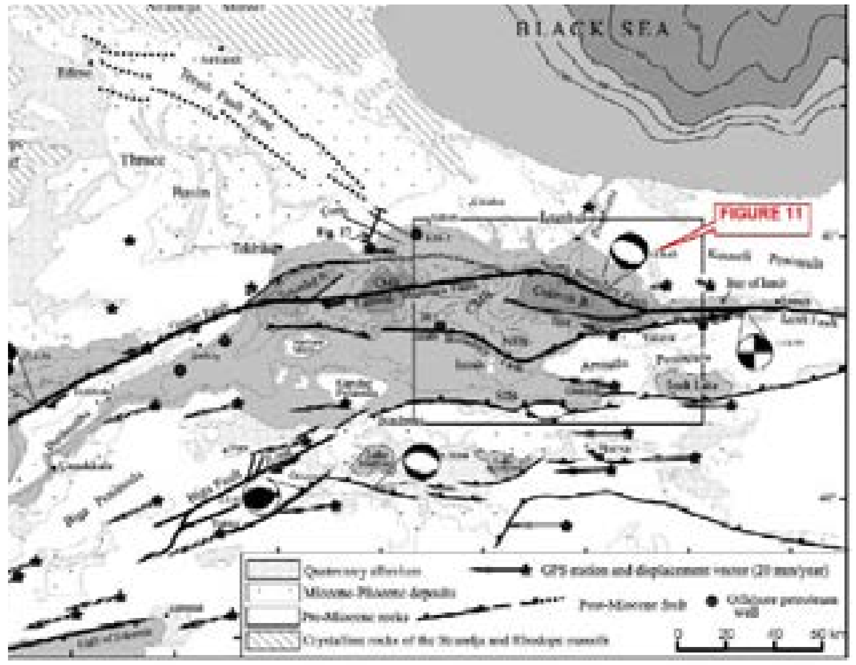


KARTAL PENDIK MASTERPLAN
HISTORICAL FAULT RUPTURES ALONG THE NORTH ANATOLIAN FAULT SYSTEM (PRIOR TO 1999 DUZCE & IZMIT EARTHQUAKES)
AFTER STEIN ET AL. (1997)

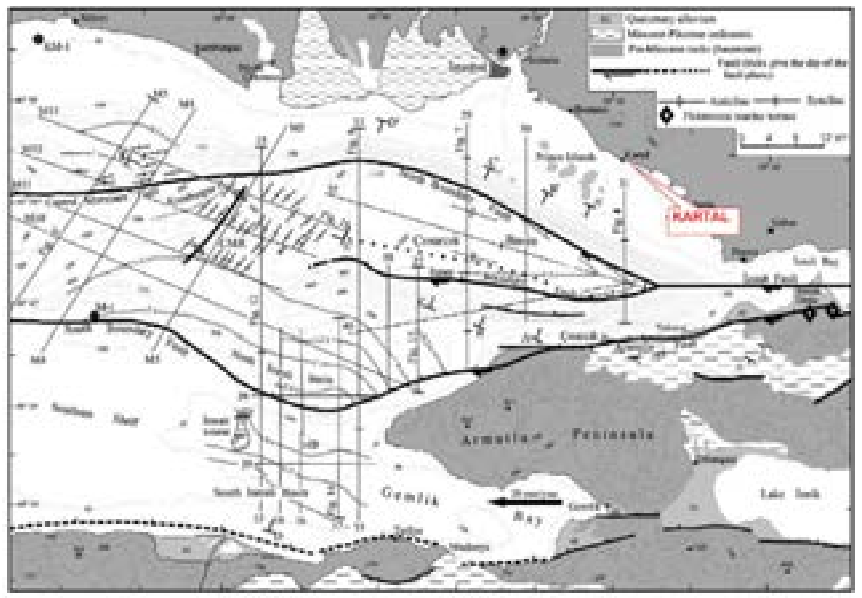
4.4 Faulting within proximity to proposed site

4.4.1 North Anatolian Fault Zone

Near its western end the fault strikes through the Marmara Sea to the south of Kartal and Pendik creating three deep marine depressions. Okay (et al) (2000) [13] provide a series of figures highlighting the proximity of these faults relative to Instabul and the surrounding area. Figure 7 shows the approximate boundaries between the continental plates, and the geological setting of the Marmara Sea. Figure 11 shows the active tectonic map of the Marmara region, with Figure 13 indicating the tectonic map of the eastern Marmara Sea and their location relative to Kartal.



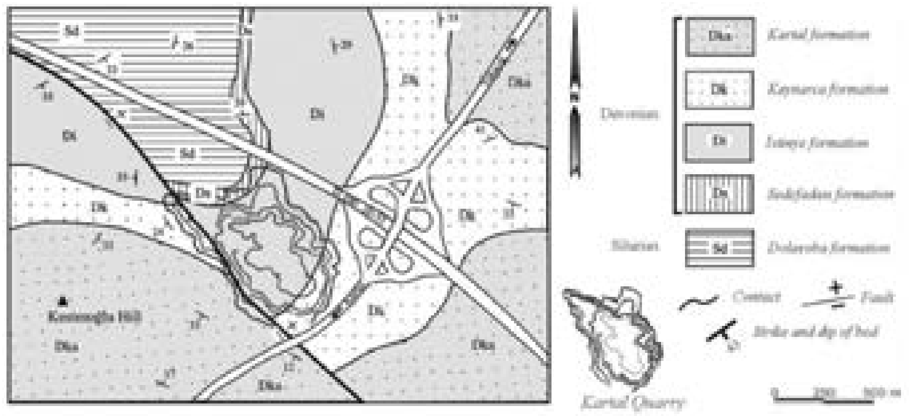
KARTAL PENDIK MASTERPLAN
TECHTONIC MAP OF THE MARMARA REGION



KARTAL PENDIK MASTERPLAN
TECTONIC MAP OF THE EASTERN MARMARA SEA

4.4.2 Quarry

Zarif and Turğal (2003) [14] assessed the properties of the limestone aggregate obtained from the now disused quarry in the northern section of the proposed development area. The paper suggests NW-SE trending faults are considered as "major structural features in the area". A fault line can be seen on the 1964 Geological Map (see Figure 5) passing though the site, and is shown in closer detail on the geological map provided by Zarif and Turğal (2003) (see Figure 12). Due to the trend of this fault it is unlikely to be active, but it could show some movement in response to a major event on the NAF. It would therefore be prudent to site structures away from this geological feature.



4.4.3 Tuzla Tunnel

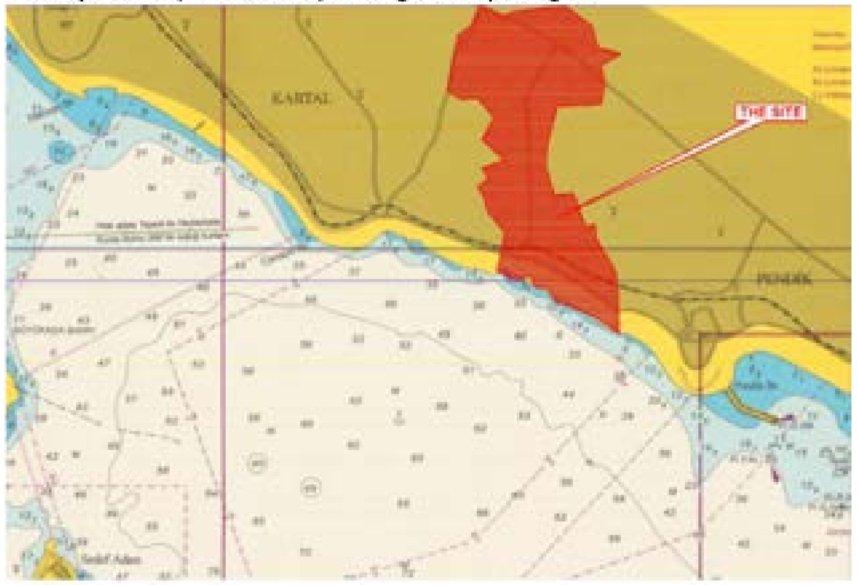
Further evidence of the fault zones were recorded during the construction of a 6500m sewerage tunnel completed approximately 5 km to the east of the proposed development. A paper by Dalgiç (2003) [15] indicates that the Tuzla Tunnel has an external diameter of 5m and was constructed at depths of approximately 15m to 20m. Figure 13 shows the approximate location of the tunnel relative to the site.

The Tuzla Tunnel was excavated in fault zones within the Kartal formation, with lithology varying along the tunnel route. Limestone and shales consistent with the Kartal formation alternated with each other, with "clayey" material recorded in the fault zones. Dalgiç (2003), indicates that two different fault directions were determined, the first group in the NW-SE direction with the second group in the E-W direction. The paper suggests that the northern blocks of the faults were raised whilst the southern blocks are fallen.

KARTAL PENDIK MASTERPLAN
TUZLA TUNNEL

4.5 Coastal environment - bathymetry

The bathymetry of the site is particularly steep with deep water reached relatively closely to the shoreline. Figure 14 contains an excerpt of the Admiralty Chart. The yellow colour indicates dry land, whilst the dark blue shows water depths to 10m, the light blue to 20m and beyond that specific water depths are given as spot heights.



KARTAL PENDIK MASTERPLAN
BATHYMETRY – ADMIRALTY CHART

4.6 Reviewed data

Figure 15 shows a collage compiled from a series of drawings provided as part of the package of information received from the Client. The figure shows the anticipated surface geology across the site, and broadly categorises the geology as follows:

- Kf-YU (Kartal Formation): Shale - siltstone - sandstone - limestone
- Df-YU (Dolayoba Formation): Block limestone
- Yd-AJ (Artificial Fill): Combination of loose construction debris, gravel, sand, clay
- Qal-AJ (Alluvium): Loose gravel sand and fill

This is broadly consistent with the geology of the area indicated in Section 4.1. Figure 15 also provides additional information relating to the location of the NW-SE fault line crossing the proposed site to the south of the quarry.

The Greater Istanbul Municipality Design Brief [1] categorises the geological areas indicated in Figure 15 as follows:

- KF-YU and Df-YU: "suitable for all kinds of construction, the foundations of the buildings should go at least one basement deep into the soil in order to be able to resist horizontal movements originated by earthquakes."
- Yd-AJ and Qal-AJ: "suitable for low-rise buildings and low density" structures. "Special importance should be given to the drainage of the surface and underground waters".

Six boreholes have been completed as part of a ground investigation completed for the Kartal Pendik project as part of the Environmental Impact Evaluation for the Kartal Marina [16]. The document was written in Turkish and has not been translated to English. The six boreholes were located off shore and were bored to a depth of 5m to 9m below the sea bed over plan area of approximately 100m by 550m.

A geotechnical report [17] written in Turkish and was received by the project team on the 27th July 2007. The report does not include any of the referenced appendices which detail the borehole logs and information relating to laboratory testing. Arup has undertaken a limited translation for sections of the document, although a full translation including the missing appendices is required to validate the soil depths, lithology, parameters and ground water levels suggested within the document.

From the limited translation of the geotechnical report [17], 35 boreholes of depths up to 20m were completed across the investigation area. The boreholes logs were not included within the appendices of the forwarded document and efforts to obtain this information have proven unsuccessful to date (August 2007).

The limited translation indicates that sections of the site are covered by Neogene and "Yamaç" rubble sediments. It is suggested that the Neogene sediments described as clay sand units and "Yamaç" rubble sediments are likely to be consistent with the Qal-AJ (Alluvium) categorisation, although this can only be confirmed following a full translation of the geotechnical report and associated appendices [17].

KARTAL PENDIK MASTERPLAN
GEOLOGICAL SECTIONS - COLLAGE

The translated section of the geotechnical report [17] indicates that the Devonian and Silurian deposits are underlain by Lower Ordovician deposits specifically Gözdağ and Aydos formations. Although Gözdağ formation is not indicated as a part of the Lower Ordovician deposits in Figure 4, the Gözdağ formation is however categorised by Ustaömer and Kipman (1998) [18] as Lower Ordovician.

- Gözdağ formation is described from the translation as consisting of brown, grey green unit consisting of shales and grovacs with stratum of varying depths.
- Aydos formation is described in Figure 4 as a quartzite, white pinkish, light grey, medium to thickly bedded, locally laminated, lenses of conglomerate, silica cemented.

The Arkoses formation is referred to in the geotechnical report and is understood to be part of the Ordovician deposits.

Due to the lack of available translated borehole logs, the depth and thicknesses of the geological stratum have not been detailed within this preliminary report.

As previously stated it is important that a full translation of the geotechnical report [17] is completed, including all of the missing appendices to validate the soil depths, lithology, parameters and ground water levels indicated within this document.

4.6.1 Groundwater

Based on the field testing reported by Dalgiç (2003) [15] during the construction of the Tulza Tunnel, ground water was not detected in the borehole within the shales and limestone of the Kartal formation. However during the tunnel excavation groundwater was detected as flowing or dripping in the fault zones.

The geotechnical report [17] indicated that groundwater levels were encountered during the installation of the boreholes from 1.0m to 13.5m; it is unknown whether these are datum levels or depths below the existing ground level. It is also noted that the groundwater levels appear to be higher to the south of the proposed development area and lower to the north of the site.

Across the site the groundwater levels are considered to be artificially lowered, caused by the localised pumping and use of groundwater. The geotechnical report [17] indicates that mechanical boreholes of 120m to 200m depth are located in the development area. Groundwater appears to be extracted from limestone, sandstone and quartzite. The shale and Arkoses is considered to provide a lower discharge rate than the limestone, sandstone and quartzite.

The geotechnical report [17] highlights a series of distinct dynamic water tables, Arkoses at 120m, shales at 90m, limestone at 70m with the sandstone at 60m. Static water levels were measured from water wells at 35m in Arkoses and 15m to 30m in sandstone and limestone.

A full translation including all of the missing appendices [17], when these are obtained, is required to validate the ground water levels summarised above.

4.6.2 Surface and water

The geotechnical report [17] indicates a series of brooks existing in the investigation area. It is believed that the Değirmendere, Savaklar, Cevizli and Balıklı brooks have been modified to discharge to the Marmara Sea. Modification works for Soğanlık Ağıl brook are believed to be currently ongoing.

A location plan for the five brooks was not contained within the sections of the geotechnical report [17] issued to the project team.

Engineering Properties

5.1 Geotechnical properties of principal stratum

Based on the available information [17], research papers and soil descriptions the following material properties are suggested:

Table 2: Anticipated engineering properties of principal strata*

Material		Unit Weight (kN/m^3)	SPT 'Na'	Strength Parameters: Total Stress c_u (kPa)	Strength Parameters: Effective Stress ϕ' (°)	Unconfined Compressive Strength Rock (MPa)	Rock Quality Designation (RQD) (%)
Fill		-	-	-	-	-	-
Alluvium (Neogene, Yamaç)		20	9 - 41	36 - 100	3 -17	-	-
Kartal	Limestone	26	-	-	-	100 - 55 (75)	50 - 70
	Shale	23	-	-	-	52 - 12 (28)	0 - 40
Dolayoba	Limestone	-	-	-	-	38 - 100	12 - 55
	Shale	-	-	-	-	5 - 50	
Gözdağ	Shale	-	-	-	-	15 - 47	0 - 33
Aydos	Quarzite	-	-	-	-	86 - 90	7 - 55

Note * subject to confirmation from full translation of geotechnical report [17] and further detailed site specific ground investigation

Dalgıç (2003) [15] indicates that the Kartal formation is medium to thick bedded (0.15m to 3.0m) and were on average medium bedded (0.3m). Shales vary from thinly to thickly bedded (0.01m to 0.4m), but are generally thinly bedded (0.03m to 0.05m).

A full translation of the geotechnical report [17] including all of the missing appendices when received is required to validate the soil parameters detailed within this section.

Key Geotechnical Hazards

6.1 Seismic

Earthquake hazard presents perhaps the most significant risk to the development due to the sites close proximity to the active North Anatolian Fault system. It therefore needs to be considered throughout the process - from the planning stages of the development and associated infrastructure, through to the detailed design and construction phases. This section of the report presents some of the key seismic risks that should be considered in relation to the proposed development at Kartal Pendik. It does not present a detailed site specific seismic hazard assessment but highlights the key seismic hazards that require consideration. A further detailed assessment is recommended for subsequent stages in the planning and in particular the detailed design of the project. Reference is made to previous seismic hazard studies carried out for the region to provide indicative level of the hazard at the sites of interest.

6.1.1 Risk, hazard and vulnerability

Seismic risk may be defined as the expected amount of damage due to a specific earthquake, which may occur at any given period of time.

Risk is a combination of *Hazard* and the *Vulnerability* of a particular structure to that hazard.

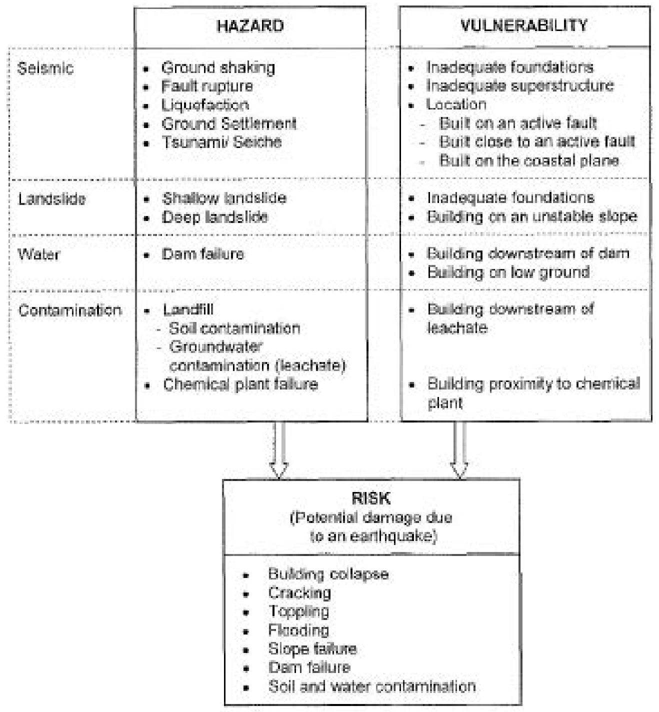
$$RISK = HAZARD \times VULNERABILITY$$

Hence a structure could have a low risk of damage, even though it is located in a region with a high level of hazard, provided its vulnerability is low. When an earthquake occurs, the risk of damage is high unless the vulnerability is reduced or the hazard is avoided.

A flow chart of example seismic hazard and vulnerabilities and how they conspire to determine the overall seismic risk is provided in Figure 16 (after BECT, 2000 [19]).

The following is a list of the main earthquake hazards:

- Earthquake ground shaking (Section 6.1.2)
- Liquefaction or loss of strength in saturated granular soil due to build up of pore water pressure under cyclic loading (Section 6.1.4)
- Earthquake induced settlement
- Fault movements, which normally cause severe damage to structures over the fault



(After: British Engineering Consortium for Turkey, 2000)

KARTAL PENDIK MASTERPLAN
HAZARD, VULNERABILITY AND RISK FLOW CHART FOR A SEISMIC EVENT

- Tsunamis or sea waves, which are caused by the sudden change in seabed level that may occur in an offshore earthquake, or caused by submarine landslide triggered by ground shaking. Wave heights tend to increase as they enter shallow water
- Landslides and mudflows, sometimes triggered by horizontal forces arising from ground acceleration reducing the factor of safety

Man-made objects often compound these primary natural hazards as follows:

- Collapse and/or structural damage of buildings and other structures
- Fall of objects from the outside of buildings, such as cladding
- Fall and displacement of objects inside buildings, such as furniture
- Floods due to dam failures
- Fires caused, for instance by electrical faults, overturned fires, fractured gas pipelines, after an earthquake
- Explosions of gas and oil tanks and release of dangerous chemicals

This report will focus on highlighting the potential hazards to the proposed development, and some mitigation strategies. It should be appreciated that with the current level of engineering knowledge, structures can be designed and constructed to survive an earthquake intact and hence significantly reduce the loss of life (as occurred in recent events in Izmit and Düzce in 1999). However, to do this there must be an appreciation of how the hazards listed above can affect the given structure.

6.1.2 Seismic Ground Motion Hazard

The most widespread hazard posed by a fault rupture on the nearby North Anatolian Fault or other nearby source is that of the ground motion itself, as this affects all proposed structures within the development. Most structural failures that occur during earthquakes are as a result of ground shaking, with most serious injuries and deaths caused by the collapse and damage of buildings. The level of ground shaking is affected by many factors, including but not limited to the proximity to the active fault, soil conditions, and the topography of the site.

When a fault ruptures, seismic waves radiate away from the source and travel through the earth. When the waves reach the ground surface they may produce shaking that may last from several seconds to a few minutes. The nature of shaking – its amplitude and duration at a location depends on the size, location and characteristics of the ground rupture. The shaking is also dependant on the characteristics of the travel path for the seismic waves and particularly on the characteristics of the site where the shaking is felt.

Assessment of the Ground Motion Hazard

The ground motion hazard is commonly assessed via two methods;

1. A probabilistic seismic hazard assessment (PSHA) following the method of Cornell (1968) [20] which incorporates all the historical recorded and reported seismicity typically within 500 km of the site, with the adoption of a magnitude-recurrence relationship after Gutenberg and Richter (1965) [21] followed by a probabilistic analysis that incorporates the inherent uncertainty with assessing the seismic hazard and the ground motion at the site of interest.
2. A deterministic seismic hazard assessment (DSHA) based on data on known significant faults within the region, where length of rupture and slip rates are adopted based on field studies on the faults carried out by geologists. Relations such as those presented by Wells & Coppersmith (1994) [22] are used to estimate earthquake magnitude from such data.

For both types of study (PSHA and DSHA), empirical attenuation relations are used to estimate the ground motion at the site for varying frequency. The resulting output of either form of study is a uniform hazard response spectra (UHRS), typically for the median ground motion predicted by the attenuation functions adopted (NB: This is a slight simplification). This would include the common design parameter used in geotechnical design; that of peak ground acceleration (PGA).

A response spectrum is a plot of the response of a series of oscillators of varying natural frequency to an applied dynamic load. In the case of earthquake loading, the response spectrum provides designers with an estimate of the peak ground motion likely to occur to the structure at its natural frequency. Response spectra are typically plotted assuming 5% of critical damping in the structure being considered. Methods of estimating the response spectra without performing a site specific hazard assessment are typically found in design codes requiring knowledge of the type and purpose of the building being designed, and the site ground conditions. For complex structures, modal analysis may be required to identify the modes of oscillation, and the critical damping in the structure being considered. Such analyses are beyond the scope of this report, and are typically performed during detailed design.

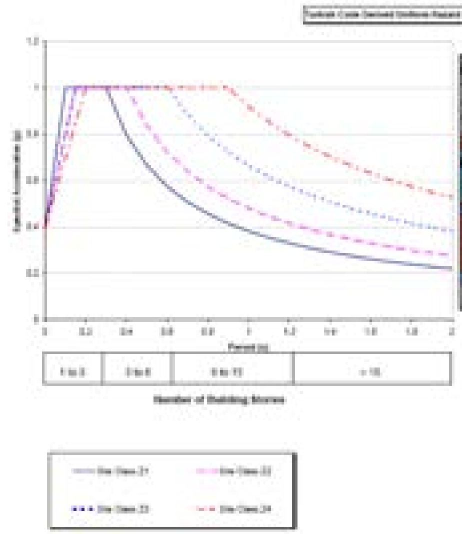
The following sub-sections provide information on available studies from the wider vicinity of the site that provide an initial indicative ground motion hazard for the site. For some references this is merely in the form of peak ground acceleration, and not the response spectra, in other cases merely in terms of the risk of a specific earthquake event occurring.

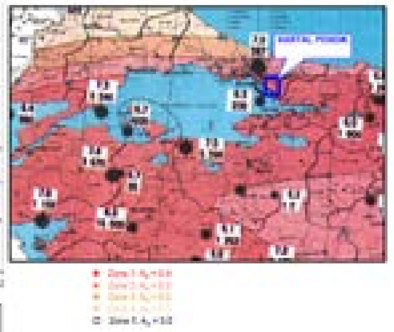
Turkish design code (1998)

The methodology for the determination of the design seismic loads for structures in Turkey is described in the Specification for Structures to be built in Disaster Areas, Part III – Earthquake Disaster Prevention (1998) [23]. According to this code Kartal Pendik falls into Seismic Zone 1, corresponding to a peak ground acceleration of 0.4 g (see Figure 17). The Peak Ground Acceleration does not account for the natural frequency of the structure being designed, and buildings of several storeys may experience considerably larger loads, and hence significantly more damage, if not designed accordingly. It is therefore important to specify the entire design hazard spectra.

The Design Hazard Spectra derived from this code is presented in Figure 17, assuming an Importance Factor of 1. Buildings within other categories will require appropriate scaling according to the code. For tall, multi-storey buildings, the spectral acceleration may be relatively low compared to shorter structures, but the corresponding spectral displacement is large – recognising that the buildings with long natural periods will tend to undergo larger displacements during an earthquake. These factors need to be taken into account for design.

The code states that there is a 10% probability that this effective ground motion will be exceeded in 50 years. Note that this corresponds to a design return period of 475 years.





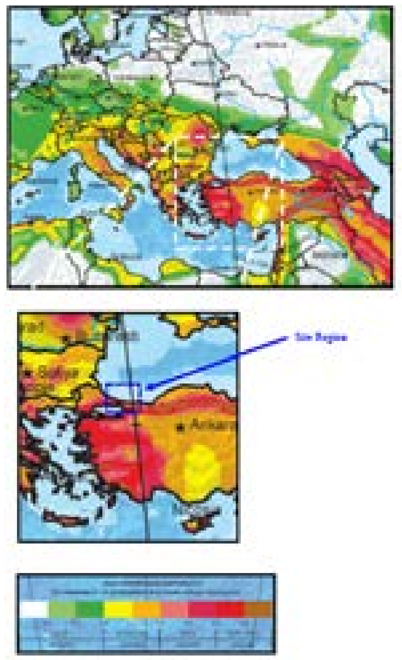
KARTAL-PENDIK MASTERPLANNING STUDY
TURKISH DESIGN CODE DERIVED
UNIFORM HAZARD RESPONSE SPECTRA (LEFT)
CODE ZONATION MAP (RIGHT)

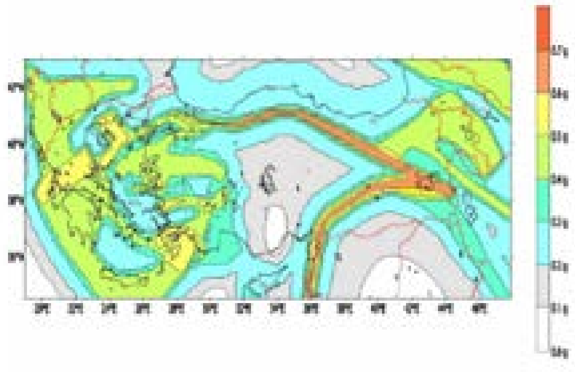
FIGURE 17

Global seismic hazard assessment program (GSHAP, 1999)

The culmination of the Global Seismic Hazard Assessment Program [24][25] was the production of a global seismic hazard map which provides in colour code an estimate of the peak ground acceleration (PGA) anywhere in the world (for onshore sites), for a 10% probability of exceedance in 50 year hazard level (corresponding to 475 year return period). The GSHAP map of PGA provides a useful first assessment of the expected bedrock ground motion for a region of interest. It is derived using probabilistic seismic hazard method.

Figure 18 is an excerpt from this hazard map covering Istanbul and the surrounding region, showing the context in relation to Europe. The map indicates that the hazard level at the site of interest in the "very high" range, with an estimated level of PGA for the site itself is in the range of 4.0 to 4.8 m/s² (approximately 0.4g to 0.48g). A more detailed seismic hazard map of Turkey, after Erdik et al. 1999 [26], from which the GSHAP map was produced is presented in Figure 18. This concurs with the Turkish Seismic Design Code value for PGA of 0.4g.



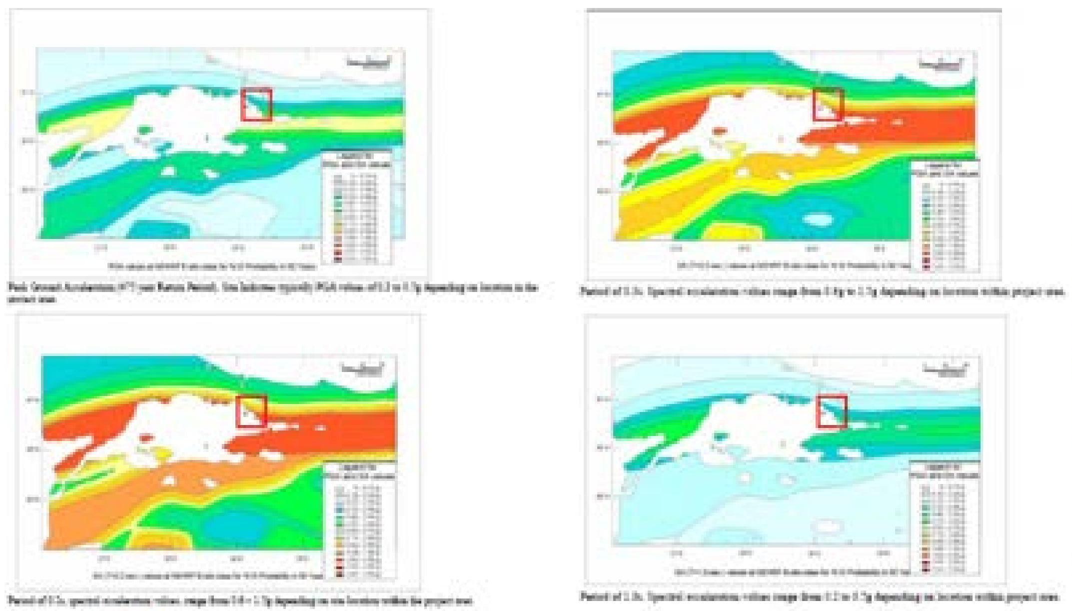


KARTAL PENDIK MASTERPLAN
GSHAP MAP FOR WESTERN TURKEY REGION (LEFT)
GSHAP MAP OF TURKEY AFTER ERDIK *ET AL.* 1999 (RIGHT)

Earthquake risk assessment for Istanbul Metropolitan Area. Erdik et al. (2002)

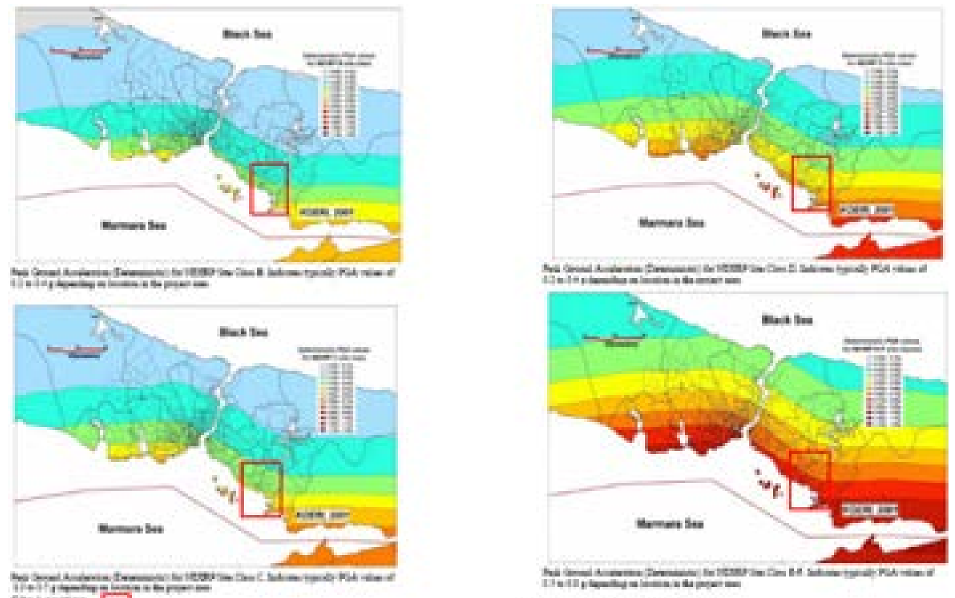
A further seismic hazard study was carried out for the Istanbul Metropolitan Area by Erdik et al. (2002) [27]. This study considered by probabilistic seismic hazard (PSHA), and deterministic seismic hazard (PSHA). Results of the PSHA study for Site Class (B) sites is presented in Figure 19 in terms of maps of the regional ground motion at varying frequencies.

The deterministic seismic hazard study considered a maximum credible earthquake scenario of a rupture along the segment of the fault beneath the Sea of Marmara, adjacent to Istanbul, resulting in a Magnitude 7.5 event. Figure 20 presents the DSHA results for PGA at different National Earthquake Hazards Reduction Programme (NEHRP) site classes, showing the significant effect of the local soil type on the expected ground motions. Figure 21 and Figure 22 present site dependent expected ground motions from such an event at different PGA (Period T=0.2s, T=1.0s) and peak ground velocity (PGV).



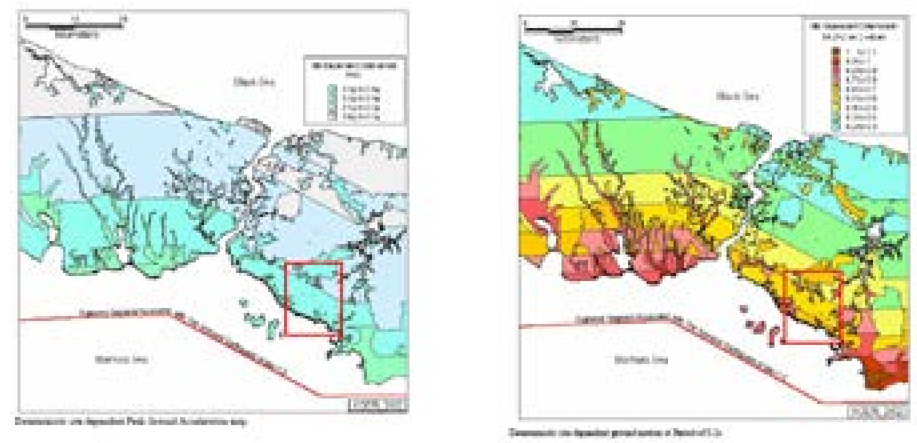
Site location

KARTAL PENDIK MASTERPLAN
SEISMIC HAZARD MAPS FOR ISTANBUL REGION, EASTERN TURKEY
AFTER ERDIK ET AL (2002)



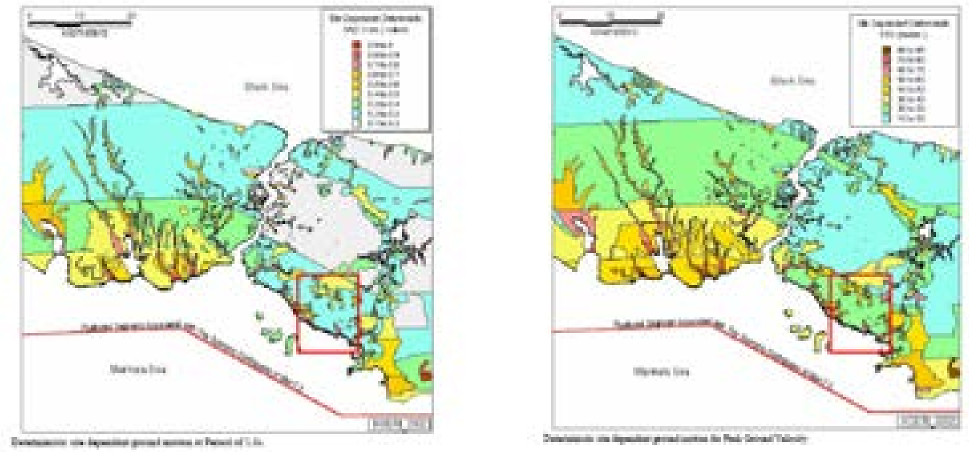
Site Location

KARTAL PENDIK MASTERPLAN
DETERMINISTIC SEISMIC HAZARD ASSESSMENT RESULTS
(AFTER ERDIK ET AL. 2002)



Site Location

KARTAL PENDIK MASTERPLAN
SITE DEPENDANT DETERMINISTIC SEISMIC HAZARD ASSESSMENT RESULTS
(AFTER ERDIK ET AL. 2002)



Site Location

KARTAL PENDIK MASTERPLAN
SITE DEPENDANT DETERMINISTIC SEISMIC HAZARD ASSESSMENT RESI
(AFTER ERDIK ET AL. 2002)

Parsons (2004)

Parsons of the USGS provided a revised seismic hazard assessment for the Sea of Marmara, incorporating time-dependent interaction techniques. The calculations are significant in that, although adopting a probabilistic methodology, Parsons breaks from the traditional PSHA calculation model which adopts a Poissonian process that assumes all earthquake events are independent. This assumption is conventionally made despite the fact that it has been recognised for more than 100 years that a temporary seismic rate increase that decays with time (Omori, 1894 [29]) results from stress changes (Dutton 1904 [30]) i.e. earthquakes are not physically independent of one another. This is assumptionis made in order to simplify the hazard assessment, where it would be often too complicated and require more data than available to do otherwise. Also, when specific faults are modelled in such a study, under the Dieterich (1994) [31] model, a fault or multiple faults are treated as potential sources of an infinite number of potential earthquake nucleation sites that are near to failure, with the conditions of rupture being Poissonian and independent of the rupture history of the fault, i.e. despite the stress drop caused by an earthquake, there remains an infinite number of potential rupture sites capable of producing the same magnitude earthquake (Parsons 2004 [8]).

However, for the Marmara region this assumption would be potentially misleading as it has been observed from the historical earthquakes that have occurred along the North Anatolian Fault system, that they are not statistically independent of one another (See Section 4.3). Parsons notes:

> *Globally, seismicity rates are observed to rise in regions of calculated stress increase and fall where the off-fault stress decreases (e.g. Kagan and Jackson, 1991 [32]; Kagan, 1994 [33]; Parsons, 2002 [34]). The M 7.4 Izmit earthquake, as well as most background seismicity (Ito et al., 1999 [35]), occurred where the failure stress is calculated to have increased 0.1-0.2 MPa by $M \geq 6.7$ earthquakes since 1939 (Stein et al. 1997 [12]; Nalbant et al., 1998 [36]; Parsons et al. 2000 [36]). The Izmit event, in turn, increased the stress beyond the east end of the rupture by 0.1-0.2 MPa, where the $M = 7.2$ Düzce earthquake struck, and by 0.05-0.5 MPa beyond the west end of the 17 August rupture, where a cluster of aftershocks occurred (Parsons et al. 2000 [36]). The correspondence seen between calculated stress changes and the occurrence of large and small earthquakes, also reported by Hubert-Ferrari et al. (2000) [38], strengthens the rationale for incorporating stress transfer into a seismic hazard assessment.*

Parsons' analysis considered the effect of the transfer of stresses that occurred during the Izmit and Düzce earthquakes considering a number of possible slip models derived from various data sources (teleseismic, strong ground motion, geodetic) as well as post-seismic deformation that occurred following these events. The uncertainty in the models was also incorporated into the hazard assessment. The stress changes were calculated adopting an elastic-perfectly plastic Mohr-Coulomb failure model using the finite element method to model the fault rupture mechanism and calculate loading rates along the various segments of the North Anatolian Fault.

Parsons compares the time-dependent 30-year interaction probability values for the Sea of Marmara region and finds they are not too dissimilar from a simple Poissonian model (53% +/- 18% compared with 38%), however values for the Eastern Marmara are very different (41% +/- 14% compared with. 21%). This is due to the effect of the recent 1999 events. Further, when the Prince's Islands fault segment is considered, with both time-dependence and stress interactions taken into consideration, the probabilities vary significantly (31% to 54% compared with 11%). Parsons concludes that the probability of a $M \geq 7$ earthquake rupturing beneath the Sea of Marmara is approximately 35% to 70% in the next 30 years if a time-dependent model is used that includes coseismic and post-seismic effects of the 1999 Izmit earthquake.

The implications of the Parsons study is that the risk of large magnitude earthquakes affecting the Istanbul region is larger than would be estimated using a traditional Poissonian PSHA such as is carried out under the GSHAP program, and the Turkish Design Code on which it was based. Parsons estimates the return period of a $M \geq 7$ earthquake causing MMI ≥ VIII shaking in Istanbul as being between 38 and 95 years (compared with 127 years for the Poissonian model). Thus for the 475 year design return period criteria adopted by the Turkish code, we would expect larger ground motions than previously estimated by GSHAP or specified under the code. Under this design situation where a given fault has such a large probability of rupture, the use of deterministic seismic hazard method may also be appropriate for calculating the ground motions for design at the site, or adoption of a suitable accounting for the deficiency in the traditional PSHA should be made for a site specific seismic hazard analysis. These considerations should be made as part of the detailed design of the project.

6.1.3 Site specific ground information

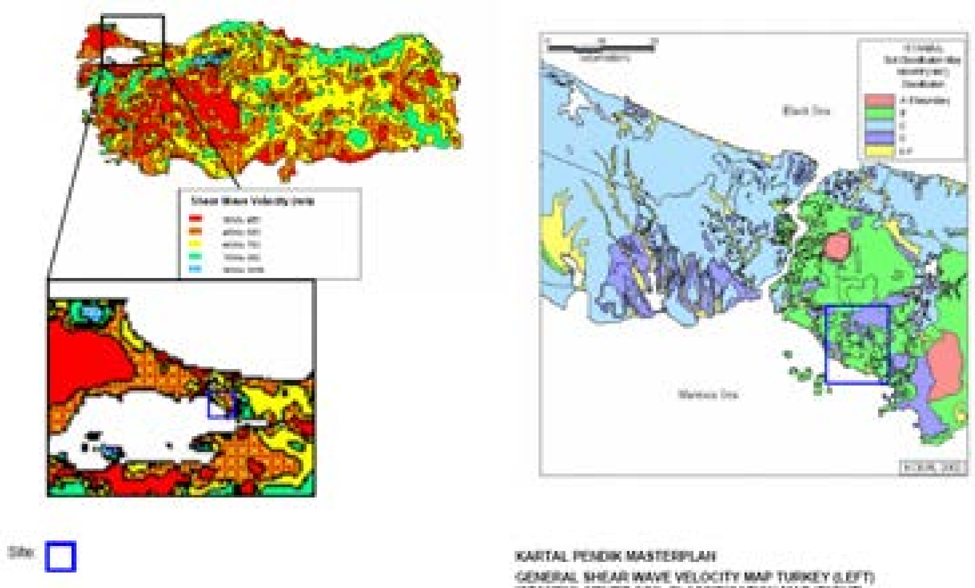
The site specific ground information at this stage is provided by geological maps, as no borehole information was made available. A detailed ground investigation will be required for all major developments at a later stage, with consideration made to the hazards presented in this report that will need to be addressed at that time.

Site classification

Site classification

The soils on the site will require classification into the respective site classes in order to assess the local site response on the spectral acceleration. This classification is required as part of the Turkish design code. Table 3 presents the Turkish code classification system for soils and rocks, and is reproduced from the Specification for Structures to be Built in Disaster Areas, Part III – Earthquake Disaster Prevention (1998) [23]. It provides guidance on the classification of soils into four soil groups, A (hard rock) to D (soft clay). The code then categorises these soil groups into site classes (Z1 to Z4 respectively) based on soil group classification and soil layer thickness (Table 4).

These site classes are similar to those provided in the NEHRP guidelines (BSSC 2003 [28]), but with some differences. Figure 23 presents general map of the Istanbul region with the site classes classified according to NEHRP. It also provides a shear wave velocity map for Turkey, albeit with very low resolution for the Istanbul region. Inferred shear wave velocities (Vs) are of the order of between 450 m/s and 750 m/s. Some interpretation is required for categorising to the Turkish code based on the NEHRP map. The map indicates that the soils typically fall in the range of Type B (rock: Vs > 760 m/s) and Type D (stiff soil sites: Vs 180 – 360 m/s), with some localised areas of Type E-F soils (soft/ loose material: Vs < 180 m/s) under the NEHRP classification. These correspond to Groups (B), (C), and (D) respectively under the Turkish code.



KARTAL PENDIK MASTERPLAN

GENERAL SHEAR WAVE VELOCITY MAP TURKEY (LEFT)
ISTANBUL NEHRP SOIL CLASSIFICATION MAP (RIGHT)
AFTER ERDIK *ET AL.* (2002).

Table 3: Turkish Site Classification (after 'Specification for Structures to be Built in Disaster Areas, part III –Earthquake Disaster Prevention, 1998')

Soil Group	Description of Soil group	Standard Penetration [N blows/ 300 mm]	Relative Density [%]	Unconfined Compressive Strength [kPa]	Shear Wave Velocity [m/s]
(A)	1. Massive volcanic rocks, unweathered sound metamorphic rocks, stiff cemented sedimentary rocks.	-	-	>1000	>1000
	2. Very dense sand, gravel.	>50	85-100	-	>700
	3. Hard clay, silty clay.	>32	-	>400	>700
(B)	1. Soft and volcanic rocks such as tuff and agglomerate, weathered cemented sedimentary rocks with planes of discontinuity	-	-	500-1000	700-1000
	2. Dense sand, gravel	30-50	65-85	-	400-700
	3. Very stiff clay, silty clay	16-32	-	200-400	300-700
(C)	1. Highly weathered soft metamorphic rocks and cemented sedimentary rocks with planes of discontinuity.	-	-	< 500	400 -700
	2. Medium dense sand and gravel.	10-30	35-65	-	200-400
	3. Stiff clay, silty clay	8-16	-	100-200	200-300
(D)	1. Soft, deep alluvial layers with high water table.	-	-	-	<200
	2. Loose sand.	<10	<35	-	<200
	3. Soft clay, silty clay.	<8	-	<100	<200

Table 4: Local Site Classes (after 'Specification for Structures to be Built in Disaster Areas, Part III -Earthquake Disaster Prevention (1998)')

Local Site Class	Soil Group according to Table 3 and Topmost layer thickness (h_1)
Z1	Group (A) soils Group (B) soils with $h_1 \leq 15$ m
Z2	Group (B) soils with $h_1 > 15$ m Group (C) soils with $h_1 \leq 15$ m
Z3	Group (C) soils with 15 m < $h1 \leq 50$ m Group (D) soils with $h_1 \leq 10$ m
Z4	Group (C) soils with $h_1 > 50$ m Group (D) soils with $h_1 > 10$ m

6.1.4 Other seismic hazards

The other potential seismic hazards that are of significance to the proposed development will be discussed briefly.

Tsunami – seiche hazard

Tsunami are caused by the displacement of a large volume of water within an open water body such as an ocean or sea. Similar phenomenon within an enclosed water body such as a lake are referred to as a *seiche*. Tsunami can be generated by fault rupture of the sea floor that causes the sea floor to displace upward, resulting in the displacement of the water above. The waves generated can travel large distances across the open water at high speed before reaching an exposed coastline. The phenomena may also occur when a large volume of landslide debris enters a lake or enclosed coastal inlet, or displaces the sea floor.

Alpar et al. (2003) [39] considered the Tsunami risk to Istanbul. They note that during the last 1600 years, at least 21 historic tsunami are known to have been observed in Istanbul (in the present era in years: 368, 407, 447, 477, 478, 480, 557, 740, 989, 1231, 1265, 1332, 1343, 1344, 1419, 1509, 1571, 1646, 1766, 1878, and 1894). Nearly half of these events impacted its coasts. In 407, ships were damaged in Istanbul, and in 557, 1231, 1343 and 1344 the sea inundated 2 km to 3 km inland. In 1509 the tsunami wave height is estimated at over 6 m above sea level. In 1894 the sea receded up to 50 m and then returned inundating bridges on the Golden Horn estuary. Other abnormal behaviour sometimes causing damage has also been observed more recently, including in 1999.

Using numerical modelling procedures, and a digital terrain map (DTM) of the Istanbul region, Alpar et al. estimated run-up heights for coastal areas in front of four sites in Istanbul, but did not include the proposed site at Kartal Pendik. Further studies (e.g. by Herbert et al (2004) [40]) were not reviewed for this masterplan study, and a full desk-study of the potential impact of tsunami on the foreshore area of the proposed development including the effect on proposed marinas should be carried out. This will enable appropriate mitigation strategies to be adopted to minimise losses during an expected tsunami.

The clearest mitigation strategy is to develop above approximately the 5 m contour, and as the project area is largely rising from the sea this will not be too difficult to achieve. However there is considerable infrastructure proposed along the foreshore area including highway and rail tunnels and marinas. Any such developments occurring between sea level and the 5 m contour will need to consider the effects of tsunami in their design, and providing barriers and appropriate strategies to deflect incoming waves and prevent inundation of critical infrastructure.

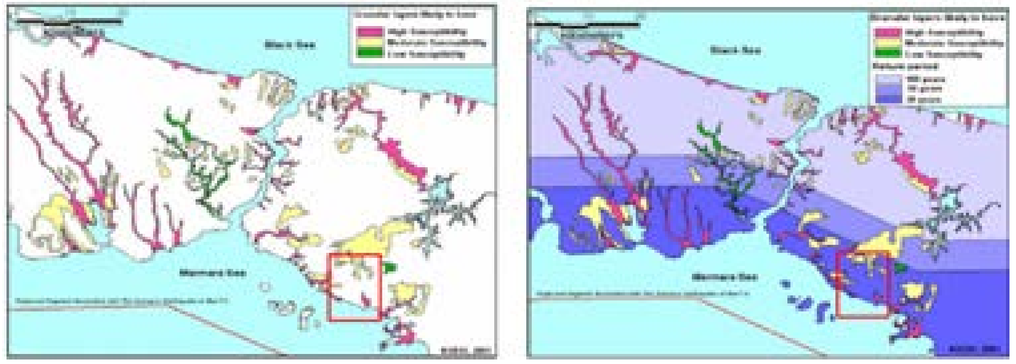
Liquefaction hazard

The phenomena of liquefaction occurs when saturated granular soil deposits are shaken, such as during an earthquake, and the tendency for the deposit to densify on shaking causes additional stress on the pore water between the soil grains. The rise in pore water pressure that results cannot rapidly dissipate during the shaking, and consequently the soil loses strength and ultimately may "liquefy". This may result in large deformations occurring to the soil, or in some cases flow failures, referred to as lateral spreading. The latter is particularly significant at unsupported margins such as occur at ports, marinas and along streams and river banks affecting bridges and other nearby infrastructure.

The assessment of liquefaction risk requires information on the soil profile across the site, the ground water table, and strength testing of the soils insitu, such as boreholes with Standard Penetration Testing (SPT) or Cone Penetrometer Testing (CPT). Information on soil gradation is also required.

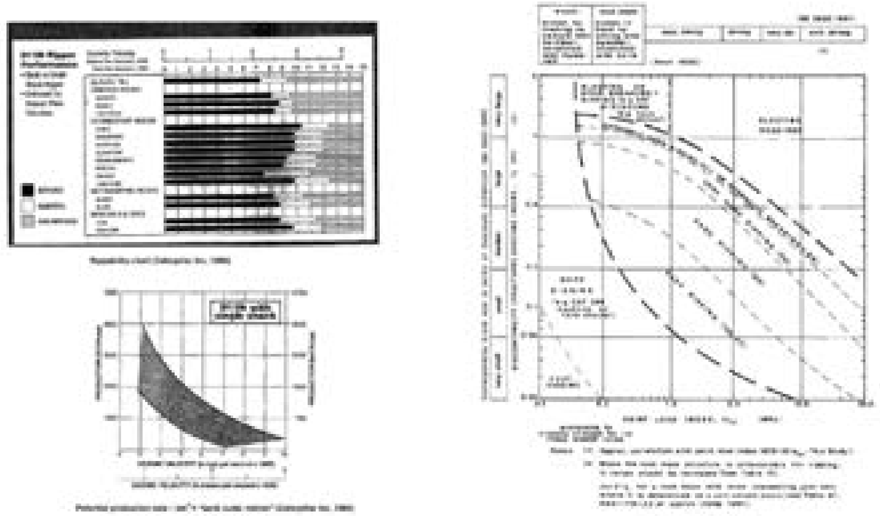
The effects of liquefaction may include large scale ground deformations, sand boils, densification and settlements, flow failures and the initiation of slope failures. Piled structures designed with the aid of lateral support along the pile shaft may undergo severe deformation, and structures on shallow foundations may experience bearing failure and excessive settlements. Buried services such as tanks, manholes, and pipelines may also experience floatation due to buoyancy within a liquefied soil.

A large scale liquefaction potential map based on soil type, and associated liquefaction risk map (incorporating the seismic hazard) is presented in Figure 24 after Erdik et al. (2002)



Site Location

KARTAL PENDIK MASTERPLAN
LIQUEFACTION SUSCEPTIBILITY AND LIQUEFACTION POTENTIAL MAPS
(AFTER ERDIK ET AL. 2002)



Caterpillar Handbook

Pettifer and Fookes

KARTAL PENDIK MASTERPLAN
EXCAVATION OF ROCK MASS

[27]. Particularly susceptible soils include man-made hydraulic fills, loose to medium dense alluvial and marine silts, sands and gravels.

It is recommended that a site specific hazard liquefaction assessment be carried out as par of design, in those sites noted as being of risk, particularly the waterfront areas, in areas of existing man-made and alluvial soils. Any areas elsewhere where susceptible soils are found to occur during the site investigation phases will require a liquefaction assessment.

Landslide hazard

The effects of ground shaking may also cause slopes that are otherwise stable under static conditions to fail and exhibit movement – in some cases with tragic consequences. The movements may also be aided by elevated pore pressures generated under cyclic loading. On initiation of liquefaction the soil completely loses shear strength, and slides may initiate on very low slope angles.

Such seismically initiated landslides may occur in soil or rock materials – the latter typically along unfavourable discontinuities within the rock mass, allowing toppling, wedge or sliding failures to occur. Excavations in rock, including tunnels need to consider the effects of seismic loading on the soil and rock cut faces.

Fault movement hazard

Structures located on top of a fault that ruptures typically suffer significant damage from the dislocation that results across the fault plane. It is unknown at the time of writing (August 2007) whether the faults that intersect the site (refer Section 4.4) are active. Any fault that is deemed active on the site will require assessment of the potential slip on the fault during an event, and the structures and services in the immediate vicinity designed accordingly.

Services that cross active faults such as gas, water, sewer, power, and telecommunications need to be designed to accept such movements, e.g. through the use of flexible pipelines. Likewise, structures such as bridges, tunnels, etc. need to be designed to tolerate the expected movements.

6.2 Excavatability

The nature of the geology across the Istanbul area has resulted in sedimentary rocks at or near the surface. An initial assessment of excavatability is based on the available findings of the geotechnical report [17].

The project potentially includes the construction of a number of high rise buildings, basements, tunnels and underground railway stations. The available methodologies to excavate through the underlying rocks should be considered at the earliest opportunity.

6.2.1 Method of assessment

There are several different methods which may be used to estimate the excavatability of rock. A widely used approach, which forms the basis of guidance given in excavator manufacturers' handbooks, is based on seismic compression wave (P-wave) velocity. The charts given in the Caterpillar handbook are reproduced in Figure 25.

Previous attempts to correlate P-wave (also known as the primary wave) velocity and standard rock mass descriptors such as the rock quality designation (RQD) have met with limited success. The P-wave values provided by the geotechnical report [17] are reproduced in Table 5.

Table 5: Indicative P-wave velocities [17]

Formation type	P-wave velocity (m/s)
Kartal formation	Not detailed
Dolayoba formation	1000 - 2048
Godzag formation	800 - 1172
Aydos formation	930 - 2300

Other methods have been developed based on rock strength and fracture spacing or the rock mass rating assessments. The method of Pettifer and Fookes (1994) [41] based on rock strength and fracture spacing is believed to be widely used in the industry and the design chart is reproduced in Figure 25.

6.3 Tunnels

Proposals for the current scheme include tunnels, including two underground railway tunnels with a third tunnel carrying the coastal highway beneath the proposed site. Section 3.3 provides additional information relating the requirements of the tunnels.

Dalgiç (2003) [15] suggests that the presence of faults zones along the line of the tunnels will affect the selection of the tunnelling methodology used. Extensive mapping of fault zones along the path of the proposed tunnels should be undertaken to mitigate risks and provide additional assurance that the appropriate tunnelling techniques are used.

BS 6164:2001 "Code of practice for safety in tunnelling in the construction industry" [42] states that tunnelling works "depend critically on adequate pre-construction investigation of the ground and site, and proper interpretation of the information obtained". As previously indicated in Section 4.6 the depths and thicknesses of the various stratums have not been confirmed at this stage in the project (August 2007).

Depending upon the depth of tunnels and the final route selection, from the limited geological and soils information available at present, the Light Railway Transit (LRT) tunnel adjacent to the E-5 intercity motorway would appear to pass through the Dolayoba formation. The proposed second railway tunnel for the East Suburb rail system to the south of the site is likely to be constructed through the Kartal formation.

As indicated by Greater Istanbul Municipality Design Brief [1] much of the current coastal highway would appear to be located on the sections of reclaimed land, and this has "cut off" the traditional town centres of Kartal and Pendik from the sea. Based on the bathymetric map of the area (see Figure14) it is anticipated that the depth of fill material will be approximately 10m.

All routes for railway and road tunnels are required to include a degree of redundancy to allow for the future expansion of the transportation system as the development area expands. This issue will affect the required land corridor.

There are numerous techniques for excavating and the ground support of tunnels. BS 6164:2001 suggests that the essence of a safe excavation is to maintain the stability of the ground at all times. This is achieved by either:

- Continuous ground support during excavation (closed face), or
- Excavating as much ground as is safely self supporting until a temporary or permanent support can be provided (open face).

The amount of ground which can be opened varies from running sand and soft clay which may requires immediate support to an excavated surface in sound hard rock which may remain unlined for many weeks. A comprehensive risk assessment based on the detailed ground investigation should be developed and implemented at all times.

BS 6164:2001 states the major factors which should be taken into account when determining the ground support system for the tunnel include:

- Size and depth of the tunnel
- Shape of the tunnel
- Method and speed of excavation and lining
- Stiffness and water tightness of the lining system
- Groundwater regime
- Structural geology, including seismic activity
- Proximity of other underground structures
- Construction of adjacent tunnel
- Vibration from construction

6.3.1 Settlements from tunnelling

During the construction of any tunnel, whether bored or cut and cover, the potential impact of any resulting ground movements on adjacent structures must be carefully considered. The proximity of the proposed LRT tunnel adjacent to the E-5 intercity motorway should be carefully considered when proposing the method of ground support, the route, depth and size of the tunnel. The main interchange from the highway to the development site indicates an elevated road passing over the E-5 motorway.

Regardless of the type of tunnel construction, there are likely to be associated ground movements experienced at the existing ground surface. Ground movements must be estimated and calculated as part of the tunnel design process. Movements should be carefully monitored during the construction process to ensure their impact on adjacent structures and properties is fully assessed and controlled.

6.3.2 Existing quarry

The proximity of the existing 65m deep quarry to the proposed underground LRT tunnel should be fully considered. The area should be mapped and surveyed in detail to provide information to the design team related but not limited to its plan location, profile of the quarr wall, depth, stratigraphy, ground water levels, soil and rock properties and faults.

The methodology used for extracting the limestone from the quarry is currently unknown. The material may have been excavated using mechanical diggers, rock drilling and splitting or the use of explosives, all of which may potentially impact on the stability of the existing quarry walls.

6.4 Slope stability

6.4.1 Landslide hazard zones

The site slopes from approximately +120m height above sea level in the north, and falling t sea level (0m) over approximately 4 kilometres. Any assessment of the slope stability mus be considered in terms of the seismic activity associated with the Istanbul area.

It is recommended that any evidence of earlier slope instability should be identified from field work, aerial photographs and IKONOS satellite imagery. Following the August 17th 1999 earthquake, Lubkowski (et al) [43] produced a landslide hazard map for Yalova, Turkey based on the following criteria:

- Presence or absence of landslide features, old or recent
- Type of slope failure, shallow or deep seated
- Density of distribution of landslides
- General slope angle

A site specific hazard map developed for the project would then allow the proposed development area to be categorised in following landslide hazards zones:

- Low – no landslide or isolated shallow landslide features
- Moderate – shallow landslide features, widely dispersed on moderate to steep slopes
- High – deep seated rotational and/or high frequency shallow landslides

The landslide hazard zones can then be used to provide a qualitative assessment of the instability landforms in the area. This will form an integral part of a wider consideration for the foundation and superstructure costs associated with seismic hazards.

Lubkowski (et al) recommends that for "all new developments, the stability of slopes in the vicinity should be assessed".

6.4.2 Landscaping of parks and quarry
Depending on the final proposals for the park areas and the existing quarry, landscaping of these regions of the development site is anticipated.

Where steep rock slopes are required it will be important to ensure that the excavated rock faces are excavated to the specified batter, with acceptable tolerances to ensure that:

- no significant overhangs are created
- rock in the excavated face is not shattered or loosened
- anchors and facing can be properly constructed

Generally a tolerance of +100mm and -200mm would be applied to excavated slopes in rock. Techniques that may be used to achieve these tolerances include pre splitting, line drilling and possibly the use of excavators.

6.5 Existing foundations

The industrial nature of the existing site may potentially result in significant building foundations to be cleared and removed prior to and during the development of the site.

The existing foundations will be dependent on the founding conditions of the underlying soils, and the magnitude and extent of the loads from the historical structures. A detailed assessment of the remaining foundations must be undertaken to confirm their depth and location relative to the proposed buildings and tunnels.

Although information relating to the nature of the existing industries is currently limited, they are believed to include:

- Construction materials
- Aerospace
- Chemicals and textiles
- Machine manufacturing

The nature of these industries would suggest that loading and settlement criteria for the associated plant and machinery would have possibly required substantial foundations.

The assessment of the existing foundations should be based on the following:

- Detailed desk study encompassing the entire development area
- Obtaining historical records (where available) relating to the existing buildings
- Where appropriate intrusive investigations works to supplement the level of available information

6.5.1 Ground contamination
Due previous industrial use of the site, the land may have been polluted as a result of past waste disposal practices and or spills and leaks. The extent of any potential ground contamination is impossible to determine at the masterplanning stage.

An overview of potential contamination and its possible implications for the development are discussed elsewhere within the Arup submissions.

This is an important issue which should be addressed at the earliest opportunity as it may have implications on the cost and planning of the development.

Mitigation Strategies

7.1 Seismic

Mitigation strategies for dealing with the seismic hazards indicated in this report are based on identifying the vulnerability of the proposed infrastructure and building developments. This is required in order to categorise the risk posed by the seismic hazards considered. The second phase is to engineer appropriate solutions to either avoid the hazard (such as not placing key infrastructure in tsunami run up zone for example), or to develop solutions to reduce the vulnerability of the infrastructure to the imposed hazard. It is important that key "lifelines" are identified and receive special attention during the planning and design phases of the development. A strategy which involves emergency services and infrastructure service providers (transport, telecommunications (fibre, cable, cellphone, wireless, water, wastewater, gas, and power) should be developed.

7.1.1 Buildings
Turkey has a recognised well developed building code in terms of earthquake provision. It is recommended that the design and construction of all developments follow the provisions in the Turkish building code. It is imperative that structural design complies with the code to ensure good performance during the expected high intensity "shaking" in the region. The main mitigation strategy to reduce the risk of damage to buildings from seismic activity is for structural and foundation design to follow the relevant codes. A suitable quality assurance system should be adopted to ensure the designs to this standard are followed through to construction which complies with international best practice.

7.1.2 Marina & Shoreline development
The proposed marina and shoreline developments are in a zone of increased susceptibility to high intensity shaking, due to proximity to the North Anatolean Fault. The expected presence of weaker soils will also potentially amplify ground motion, and be susceptible to liquefaction phenomena. This coastal area is also has a high risk of tsunami inundation caused by seismic activity within the Marmara Sea. Mitigation strategies include the possibility of ground improvement to prevent widespread liquefaction (particularly in manmade and recent alluvial and marine soils), the use of breakwaters and deflecting barriers, and planting of trees along to shoreline to inhibit inundation during a tsunami. A detailed study to assess the effects of tsunami on the coastline should be completed so that mitigation strategies can be assessed for their suitability to minimise the risk to vulnerable infrastructure.

7.1.3 General
Where soils are susceptible to liquefaction – the use of ground improvement of deep foundation are options that may be considered by designers.

In zones of close proximity to active faults, developments and key lifeline infrastructure should avoid being placed with +/- 15 m (or more) from these identified zones. If this is not possible, suitable engineering strategies to reduce the vulnerability of infrastructure to the effects of fault displacement must be implemented –such as foundations that are tolerable to movements expected, and flexible pipelines where they cross the fault.

Slope stability assessments and cut faces in soil and rock (including cut and cover and tunnel boring construction) should consider the effects of seismic loading, including the effect of ground motion, and the potential build up of excess pore water pressure due to cyclic loading. Developments should avoid areas where deep slips may develop, or use deep foundations, and slope stabilisation strategies to prevent large movements under earthquake loading.

7.2 Excavatability

The excavation of material will be of consideration for the construction of the foundations, underground stations, basements and tunnels associated with the development.

7.2.1 Assessment of bulk excavation
Figure 25 indicates that for the largest Caterpillar dozer (a D11 excavator fitted with shanks) he limit of rippability is given by a P-wave velocity of about 2500m/s, with marginal rippability up to about 2800m/s. The sedimentary rocks (see Section 6.2.1) at the site indicate a range of P-wave velocities of 600 m/s to 2300 m/s. Thus based on this approach a large proportion of the sedimentary rock is anticipated to be rippable.

The D11 is a heavy machine (operating weight 100 tons) and machine availability will be restricted. The limiting P-wave velocties for the smaller D10 excavator are about 200m/s lower and Pettifer and Fookes [19] report that breaking with a hydraulic hammer followed by ripping with a D9 excavator is broadly similar in effectiveness to ripping with a D11.

Additional site specific testing and interpretation should be undertaken in those areas of the development where significant excavations are proposed. It should be noted however that the interpretation of velocity-depth profiles obtained from seismic refraction surveys has limitations for the following reasons as indicated by ASTM D5777-00 (2000) [43]:

- The seismic velocity of the 'layers' in the ground are assumed to be homogeneous and isotropic
- Blind zones can arise when there is insufficient contrast between the overlying material and the refractor, for the refractor to be detected
- A layer must have sufficient thickness to be detected
- If the velocity of a deeper layer is lower than that overlying it, the lower velocity layer and other deeper layers cannot be detected
- The refraction method is sensitive to ground vibration noise (e.g. traffic noise)
- The resolution of the method decreases with depth

Consideration should also be given to the assessment of excavatability based on rock strength and fracture spacing or rock mass rating assessments.

The likely costs and programme implications of very difficult excavation will need to be considered. If construction of the proposed underground station structures or building basements are required to be completed in areas of moderately strong to strong rock with significant P-wave values then their production with heavy hydraulic breakers and/or the use of expensive specialised breaking techniques should be anticipated. In extreme cases excavation may result in the used of blasting techniques which will provide their own regulatory, environmental and health and safety issues.

7.2.2 Assessment of embedded wall construction
Depending upon the relative depth of basements or the proposed underground stations, and their proximity to adjacent structures the retention of vertical sided excavations may require the construction of embedded retaining walls around the perimeter of the individual building sites. There are two principal methods of excavation that can be adopted for constructing vertical retaining walls in rock:

- Secant or contiguous piles
- Diaphragm wall

Secant or contiguous piles
This type of retaining wall consists of a series of secanted (overlapping) piles or contiguous (individual) piles installed around the perimeter of the basement structure.

One method of construction makes use of rotary drilling rigs that apply torque and downwards pressure to the cutting tools. These are usually a combination of augers fitted with rock bits and rock buckets. The tools break the rock into fragments which are then removed from the bore using a cleaning bucket. Boring relies on the ability of the tools to break the rock into fragments, and in hard rocks this will depend on the fracture spacing and interlock. Where the rock cannot be broken up coring tools can be used. This is believed to be the most common type of bored pile construction in Istanbul.

An alternative means of forming the piles is by reverse circulation drilling which utilises a rotating bit which chips the rock into very small fragments which are removed from the bore suspended in circulating drilling fluid. This type of drilling will bore through most rocks, but the rate of progress can be very slow, leading to significant cost and programme risk.

Diaphragm wall
Diaphragm walls consist of interlocking vertical reinforced concrete panels, and are generally considered to be the most expensive variety of embedded retaining wall.

As an approximate guide RQDs of the sedimentary rock in the range of 30% to 70% will mean relatively slow production. Wall production rates would reduce further as RQD values increase. This would involve either breaking the rock with heavy chisels for removal by grab or the use of a cutter such as a hydrofraise. The construction of a diaphragm wall would require the use of a drilling fluid to support the trench and will require the provision of mixing plant and associated lagoons.

Trial bores
In order to establish the feasibility of boring into any rock with high P-wave velocities and the likely rates of progress of drilling, trial bores and panels are recommended. Trials will confirm the feasible penetration into the rock mass and will highlight any risk to programme or cost. Following trial bores, the need to consider alternative solutions will be highlighted at a relatively early stage in the construction process.

7.3 Tunnels

Current scheme proposals include up to three tunnels; two underground railway tunnels and a third tunnel carrying the coastal highway beneath the site. These consist of the following:

- Light Railway Transit (LRT) project parallel to the existing E-5 intercity motorway, forming part of a wider rail system between Kadiköy to Kartal.
- The existing overland East Suburb rail system to the south of the area will be located underground for the width of the site.

- The existing coastal highway will be located underground for the width of the development.

7.3.1 Method of excavation

During the construction of the Tuzla tunnel (which has an external diameter of 5m at depths of approximately 15m to 20m; see Section 4.4.3) to the east of the development, Dalgiç (2003) [15] discussed three methods of tunnel construction through the fault zones found in Kartal formation:

- Conventional system (steel arch and shotcrete)
- Tunnel boring machine (TBM)
- Cut and cover

These provide a basis for three possible methods of tunnel construction which have previously been used in Instanbul, Turkey.

Conventional system

According to Dalgiç (2003), the convention system included the use of steel arches in conjunction with a shotcrete (sprayed concrete) facing. Although the paper does not detail the method of excavation used to form the tunnel, BS 6164:2001 notes that the steel arch ribs are normally used to provide immediate support to the tunnel as "soon as practicable after excavation".

The British Standard [42] suggests that sprayed concrete linings are normally used in open face tunnelling where the ground is self supporting until temporary or permanent support can be provided. Open faced shields provide initial support and protection during the excavation and erection of the lining.

Dalgiç (2003) states that "rock bolts" were also used to support the tunnel excavation. Whilst rock bolts can be used to tie back loose rock slabs which would otherwise fail, they can also prevent separation across rock discontinuities such as fissures and joints ensuring the integrity of the exposed rock mass are maintained.

Through fault zones containing clay, jet grouting was used to prevent softening of the material.

Tunnel Boring Machine (TBM)

A TBM has a rotary wheel excavator capable of cutting the whole tunnel face at each revolution of the wheel.

In some ground conditions, unless continuous support is erected behind the cutting head falls in the ground are to be anticipated. Due to the fissured nature of the likely rock strata, sudden changes in rock conditions are anticipated, which should be considered as part of the risk assessment and selection of tunnelling technique. Probing provision should be made ahead of the face of the TBM to assess the presence of faults, fissures and other possible variations in the ground conditions.

Dalgiç (2003) [15] indicates that for the Tuzla Tunnel a shielded TBM was proposed to excavate through the shale and limestone of poor to fair quality. Steel supports with wire mesh and sprayed concrete were used to support the tunnel in the temporary and permanent case.

The use of the TBM as indicated by Dalgiç has several advantages and disadvantages:

- Advantages
  - increase rate of advance (as a function of rock strength);
  - more stable and smooth excavations;
  - requiring less support;
  - reduced damage to ground surface;
  - safer working conditions.
- Disadvantages
  - High capital cost;
  - longer lead time for construction of TBM;
  - lack of versatility related to variable ground conditions;
  - expensive replacement of consumable tools;
  - low advance rate in very strong rock or very poor rock.

In faulted rock zones, Dalgiç (2003) suggests that the use of the TBM was not considered successful due to jamming of the cutter and shield, and deviations of the tunnel alignment.

Cut and Cover

Where the geology along the route of the Tulza tunnel indicated significant depths of alluvium, cut and cover structures were used to form the tunnel.

This would typically involve the construction of an embedded retaining wall to support the retained soil and groundwater over depth of the excavation. Once the tunnel, or road or railway has been constructed, the retaining structure is covered to allow the land directly above the route to be used and developed.

Unlike the conventional system or the TBM approach to tunnel construction, which are both subterranean, the construction works for the cut and cover solution is completed from the existing ground level. Surface access is therefore required along the route of the tunnel to allow for the retaining structure to be installed and the soils and rock between the retaining walls to be excavated. In areas where there is significant existing infrastructure including roads and rail or adjacent buildings this can place substantial programming and logistical risks on the development.

The cut and cover solution can be appropriate for tunnels of a limited length at shallow depths (typically less than 5m to 10m). The depth and width of the cut and cover option is dependent on the sequence of excavation and the propping applied to wall in the temporary and permanent case.

Shafts

Depending upon the methodology of tunnel installation chosen, the construction of vertical shafts may be required before the tunnelling can commence. This could be either a permanent shaft developed for use and inclusion as part of the final scheme, or a temporary shaft provided for the construction of the underground works and finally filled in.

The formation of the shaft can be constructed by a variety of means depending on the size, depth of the shaft and the ground conditions and can include the following:

- underpinning
- caisson
- sprayed concrete
- bored pile
- diaphragm wall
- drill and blast

7.3.2 Site constraints

As indicated in Section 6.3, there are several major factors which must be taken into account when determining the ground support system for a tunnel, which include but is not limited to the depth and shape of the tunnel, the route, ground water levels, geology and proximity of adjacent structures.

The proposed Light Railway Transit tunnel adjacent to the E-5 intercity highway will form part of a larger infrastructure development. The chosen methodology for the excavation of the tunnel is therefore also dependent upon the needs of the wider LRT infrastructure project. It is anticipated that a cut and cover solution would not be suitable for the construction of the tunnel due to the proximity of the highway and the existing quarry. In selecting an appropriate methodology for excavating and supporting the tunnel, consideration should also be given to the presence of an existing fault zone (See Section 4.4.2) adjacent to the proposed route of the LRT tunnel.

Depending upon the covered length and depth of East Suburb rail system and coastal highway tunnels to the south of the development area, the use of a cut and cover solution may be appropriate. The current scheme layout indicates the railway and highway occupying different routes. During scheme development, if the depth and route of the tunnels can be converged, both sets of infrastructure could potentially be constructed through a single transportation corridor.

As indicated by the Design Brief [1] the existing coastal highway has acted to restrict access from the traditional centres of Kartal and Pendik to the coastal area. It is intended that the positioning of the proposed tunnel should therefore allow for the reinstatement of access to the coast. Careful consideration should be given to the proximity of any tunnels near to the area of reclaimed land along the coastline. Any design should carefully assess the effect of excavating through the existing fill material and the subsequent stability of the existing sea wall.

The positioning of the tunnels and their entrances should accommodate for the possibility of flooding from a tsunami surge. Historical and risk of potential tsunamis are discussed further in Section 6.1.4 of this report.

During the construction process, there will be interaction between the tunnels and those buildings and structures above the proposed routes (both current and existing). The scheme and detail design must fully consider and assess the impact and interference of one on the other and vice versa.

An informed assessment of the available tunnelling options can only be made following a detailed site specific ground investigation along the proposed routes under consideration.

7.4 Building foundations

The foundation types will depend on the design loadings for the proposed structures, the findings of the desk study, and the material properties for the underlying soil and rock stratum derived from the site specific ground investigation.

Depending on the ground investigation it is anticipated that shallow foundations bearing on the excavated rock surface could generally be adopted were possible, and that the foundation design will be governed by limiting settlement criteria. The stiffness of the rock below formation level will depend on the following:

- The methods used for and control of the rock excavation, where excavation may lead to significant loosening of the rock and a reduction in stiffness
- The presence of fault zones

As indicated in Section 4.6 the following geological areas and associated foundation proposal were identified in the Design Brief [1]:

- KF-YU and Df-YU: "suitable for all kinds of construction, the foundations of the buildings should go at least one basement deep into the soil in order to be able to resist horizontal movements originated by earthquakes."
- Yd-AJ and Qal-AJ: "suitable for low-rise buildings and low density" structures. "Special importance should be given to the drainage of the surface and underground waters".

7.4.1 Typical foundation types

Typical foundation types for the structures will include following:

- Pad foundations – these are usually provided to support modestly loaded structural columns, and may consist of square, rectangular or circular slabs of uniform thickness.
- Strip foundations – typically these will provide foundations for load bearing walls or closely spaced rows of columns where pad foundations would be touching.
- Raft foundations – these are required where structural columns or other loaded areas are in close proximity in both directions, and where the building is founded or soils of low bearing pressure.
- Bearing piles – these are used where the soil at the proposed foundation level is unable to support required loads on pad, strip or raft foundations; or where the structures are positioned on a compressible stratum where building loads must be transferred to a more competent underlying stratum.

Careful assessment and design of the building foundations is required for all of the proposed structures accounting for variability in the strength and stiffness properties of the soils and rocks. Consideration will also be given to the ground water levels and the rate of loading and unloading of the soils.

Consideration of the fault zones in the area should include an assessment of whether they are active of inactive faults.

As part of any pre-contract or pre-construction scheme development, preliminary piling installation and testing should be considered to confirm the viability of pile construction in rock in addition to an assessment of the piles' working capacities.

7.4.2 Towers

A careful assessment of the fault zones must be undertaken with particular focus placed on identifying faults beneath the more sensitive structures. Where fault zones are identified a more detailed investigation will be required to establish the fault zone geometry and stiffness of these zones.

If the fault zones are steeply dipping and relatively narrow, they will potentially have little impact on a raft foundation, but if they are relatively wide any foundations may need to be increased in size and/or designed to span the fault zones.

If the identified faults are low angle features extending under much of the building footprint with significantly lower stiffness than the rock mass in general, they could lead to differentia settlement. If the magnitude of differential settlement were found to be unacceptable consideration would need to be given to measures to reduce the differential settlement sucl as increasing the size of the raft foundation or installing piles to transfer the load to below the fault zones.

Depending on the stratigraphy, soil strengths, and settlement criteria piles may be required to transfer building loads to deeper underlying materials.

7.4.3 Other structures

In areas were competent rock outcrops at or near the surface an allowable bearing pressure for pad or strip foundations should be selected on the basis of the permitted total and differential settlement which should be checked by settlement calculations. A preliminary estimate of allowable bearing pressure for rock can be obtained from Figure 1 of BS8004:1986 [45].

Following completion of the excavation to formation level, the formation should be inspected. Where foundations are underlain by fault zones or zones of significant weathering an assessment of the founding material should be made, and if necessary, the sizing or type of foundations modified.

Even for low rise structures of less than 5 storeys, the stratigraphy and soil strengths across the site may require the installation of piles to transfer building loads to deeper underlying material.

7.4.4 Basements – uplift

Depending on the depth of the basement (or underground station) and the existing ground water levels, uplift pressures should be considered. The options for accommodating for the buoyancy effect within a basement design are typically:

- Design to resist the uplift forces (tension piles)
- Provide a drainage system to relieve the uplift pressure, with a reduced number off uplift piles

7.4.5 Seismic considerations

Lubkowski (et al) suggests that new structures should be located to avoid active fault zones.

With proper and appropriate appreciation of earthquake hazards, all new structures can be designed to mitigate or avoid the effects of earthquake. However, there may be an associated increase in costs of both design and construction.

All structures associated with the proposed development must be designed and constructed in accordance with accepted national (Turkish) and international best practice.

Recommendations for Future Work

This report has presented a preliminary assessment at the masterplanning stage on the geotechnical and seismic hazards and issues related to the proposed development at Kartal Pendik. The following is a summary of the recommendations required to facilitate a more detailed assessment of the geotechnical issues.

This report contains an initial assessment of the stratigraphy and the material properties of the site based on the information available. At present, no fully translated copies of the geotechnical report [17] are available. The copy of the geotechnical report received by the project team does not include any of the referenced appendices which detail the borehole logs and information relating to laboratory testing. Whilst we have commissioned a limited translation for sections of the document, a full translation including the missing appendices is required to validate and expand on the soils information.

8.1 Desk study

It is recommended that a detailed geotechnical desk study be undertaken to fully assess the site and ground related hazards. The core of the desk study should include but not be limited to the following:

- Site – location, topography, present use and proposed use.
- Site history – review of historical maps, review prior usage, archaeology, possible obstructions, sources of contamination, unexploded ordnance, mining and mineral extraction etc. This would include the reclamation history of the fill area to the south of the proposed development.
- Site geology – review of geological maps, boreholes, stratigraphy, hydrogeology, data from previous GI's, seismology etc.
- Recommendations for site investigation – scale and scope of the proposed site investigation.
- Ground related site constraints – highlighting site specific factors that may affect the ground investigation, foundation options and foundation construction.
- Ground related hazards – converting the findings of the desk study into risk information by identifying ground related factors that may affect cost and programme.
- Detailed assessment of seismic activity in and around the proposed site, including tsunami and liquefaction hazards, particularly along coastal areas. Recent developments considering the increased risk of an earthquake along segments of the North Anatolian Fault close to Istanbul since the 1999 Izmit earthquake should be incorporated into any site specific seismic hazard study to provide design loading for the project.

The desk study would extend to incorporate all parts of the proposed development at Kartal Pendik.

8.2 Ground Investigation

Following the completion of the detailed desk study it is recommended that a site specific and project specific Ground Investigation (GI) is planned, specified and implemented. Given the size of the site, it may be appropriate to phase the GI works.

The Ground investigation will be tailored to the proposed works, and will require details relating to the extent and locations of buildings and structures. The GI should include but not be limited to the following:

- Boreholes (including rotary coring), trial pits and cone penetration testing across the site.
- Detailed mapping of the stratigraphy.
- In situ testing, including standard penetration testing (SPT) to be undertaken above the rock head, permeability testing, total core recovery, rock quality designation etc to be undertaken.
- Recovered samples for laboratory testing, including triaxial compression tests, unit weight, particle size distribution, Attenburg Limits, uniaxial compressive strength, point load tests etc.
- Mapping of rock discontinuity inclinations and orientations using in-hole optical acoustic televiewer.
- Standpipe and piezometer installations and monitoring ground water levels.
- Chemical testing of soils and groundwater samples.
- Trial pits to assess the extent of existing foundations to be removed.
- Field surveys to locate, map and assess fault zones.

In addition to providing geotechnical information across the site, the ground investigation will focus on those areas associated with structures and the proposed tunnels corridors.

8.3 Interpretative Report

It is recommended the factual information obtained from the ground investigation is analysed, assessed and interpreted to determine the following:

- The engineering properties of the in situ soils and rock for the geotechnical design of the proposed development.
- Chemical properties of the ground and groundwater.
- Explore the ground hazards identified in the detailed desk study, including seismic assessment of the development area.

The information provided from the interpretive report will enable numerical analyses of the design to be undertaken. The results of the ground investigation will be used to carry out the geotechnical design.

As the project develops it is possible that on-site construction trials will be required to verify some aspects of the geotechnical design and site specific constructability issues. Depending on the findings of the report additional investigation works may be required to further develop detailed design solutions.

Site contamination and remediation

The proposed development presents a clear opportunity to bring disused former industrial land back into beneficial use. However, contamination issues are likely to exist at the site and these need to be dealt with as part of the planning process and beyond. Depending on the ground conditions and the nature of relevant receptors (eg. proposed human occupants, groundwater) the costs for dealing with these issues could be minimal or could be large. Additional information is needed to begin the process of assessing this issue further.

Because of the potential for significant contamination liabilities to exist at sites such as those included within the Project Area, potential investors and funders will likely require studies of this issue as part of their due diligence process. These studies may be funded by the seller or the buyer/investor, depending on the nature of the transaction. Warranties and indemnities may also be required, so that any remediation costs are borne by the seller. The negotiation of such instruments typically requires a certain amount of site-specific information, as does the seeking of insurance cover for remediation costs. From this perspective, therefore, the undertaking of more detailed studies of the contamination issues will be useful from a commercial perspective.

As a result of the above, it is recommended that the project team consider appointing relevant specialists to undertake a desk study and possibly the intrusive investigations outlined above. Alternatively, this could be a requirement on the current site owners/occupiers looking to release their land into the scheme, as a part of the recipient's due diligence.

References

[1] Greater Istanbul Municipality, "Urban Regeneration Project for Kartal Sub-Center and Kartal-Pendik Waterfront: Design Brief", Metropolitan Planning and Urban Design Center

[2] Geomar Ltd, "Fault Hazard and Geology Report of the Zincirlikuyu – Ciftciler Site", January 2006 – Job No 116218

[3] Boğaziçi University, "Earthquake Risk Assessment for Istanbul Metropolitan Area – Final Report, May 2002

[4] Kaya and Birenheide, "Contribution to the Stratigrphy of the Middle Devoniam in the Surrounding of Adapazari, Northwest Turkey", *Mineral Res. Expl. Bull.*, 108, pages 57-63, 1988

[5] Westaway, R. (2003) "Kinematics of the Middle East and Eastern Mediterranean Updated", *Turkish Journal of Earth Sciences.* Vol 12., 2003, pp 5-46

[6] Ambraseys, N.N., (2002), The seismic activity of the Marmara Sea region over the last 2000 years, *Bulletin of the Seismological Society of America, 92*, 1-18.

[7] EERI. Kocaeli, Turkey, Earthquake of August 17, 1999 Reconnaissance Report, Earthquake Spectra 2000; Supplement A to Volume 16.

[8] Pasons T. (2004) Recalculated probablity of M≥7 earthquakes beneath the Sea of Marmara, Turkey. Journal of Geophysical Research, Vol 109.

[9] Ketin I. (1969), Uber die nordanatolischeh Horizontalverschiebung. *Bull. Min. Res. Explor. Inst. Turkey, 72*, 1-28

[10] Barka, A.A., (1996), Slip distribution along the North Anatolean fault associated with large earthquakes of the period 1939 to 1967, *Bulletin of the Seismological Society of America, 86*, 1234-1238

[11] Toksoz, M. N., Shakal, A. F., and Michael A. J., (1979) Space-time migration of earthquakes along the North Anatolean fault zone and seismic gaps, *Pure and Applied Geophysics* 117, 1258-1270

[12] Stein, R. S., Barka, A. A., and Dietrich J. H. (1997). Progressive failure on the North Anatolian fault since 1939 by earthquake stress triggering, *Geophys. J. Int. 128*, 594-604

[13] Okay, Kaşlilar-Özcan, İmren, Boztepe-Güney, Demirbağ and Kuşçu, "Active faults and evolving strike-slip basins in the Maramara Sea, northwest Turkey: a multichannel seismic reflection study", *Tectophysics* 321 (2000) pages 189-218

[14] Zarif and Turğal, "Aggregate properties of Devonian limestones for use in concrete in Istanbul, Turkey", *Bull Eng Geol Env* (2003) 62: 379-388

[15] Dalgiç, "Tunneling in fault zones, Tuzla tunnel, Turkey", *Tunneling and Underground Space Technology* 18 (2003) pages 453 – 465.

[16] Technical University, Environmental Engineering Section, "Environmental Impact Evaluation – Kartal Marina", December 2005

[17] EMA, "Geologic/ Geotechnical Report to be the Basis for Revised Zoning Plan of Kartal-Soğanlık and Dolayoba Regions of Kartal District", 2001

[18] Ustaömer and Kipman "An example of a pre-early Ordovician arc magnetism from North Turkey", *Mineral Res. Expl. Bull.* 120, pages 37 to 53, 1998

[19] BECT (2000) Yalova *Province*. Vol.1. British Earthquake Consortium for Turkey.

[20] Cornell, C. A., "Engineering Seismic Risk Analysis," *Bulletin of the Seismological Society of America*, Vol. 58, No. 5, pp. 1583-1606, 1968.

[21] Gutenberg, B. and Richter, C.F. (1965) *Seismicity of the Earth and Associated Phenomena*. New York: Hafner.

[22] Wells, D.L., and Coppersmith, K. J., (1994). New Empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement, *Bulletin of the Seismological Society of America, 84*, 974-1002

[23] *Specification for Structures to be Built in Disaster Areas. Part III: Earthquake Disaster Prevention*. Ministry of Public Works and Settlement. Government of the Republic of Turkey. 1998

[24] GSHAP (1999) Global Seismic Hazard Assessment Program. [Online] http://www.seismo.ethz.ch/GSHAP/

[25] Giardini, D. and P. Basham, "The Global Seismic Hazard Program", *Annali di Geofisica*, Vol. XXXVI. N.3-4, June-July 1993.

[26] Erdik M., Alpay Biro Y., Onur T., Sesetyan K., Birgoren G., (1999) Assessment of Earthquake Hazards in Turkey and Neighbouring Regions. [Online] http://www.seismo.ethz.ch/gshap/turkey/papergshap71.htm

[27] Erdik et al. (2002), *Earthquake Risk Assessment for Istanbul Metropolitan Area*. Department of Earthquake Engineering, Boğaziçi University,Kandilli Observatory and Earthquake Research Institute. May 2002. Istanbul.

[28] BSSC (2003) *NEHRP Recommended Provisions and Commentary for Seismic Regulations for New Buildings and Other Structures*. FEMA 450. National Earthquake Hazards Reduction Programme. Building Seismic Safety Council.

[29] Omori, F., (1894), On aftershocks, *Rep. Imp. Earthquake Invest. Comm., 2*, 103-109.

[30] Dutton, C. E. (1904) *Earthquakes in the Light of the New Seismology*, 314 pp., G. P. Putnam, New York.

[31] Dieterich, J. H., (1994), A constitutive law for rate of earthquake production and its application to earthquake clustering, *J. Geophys. Res.*, 99, 2601-2618

[32] Kagan, Y. Y., and Jackson D.D., (1991), Long-term earthquake clustering, *Geophys. J. Int. 104*, 117-133.

[33] Kagan Y.Y., (1994) Incremental stress and earthquakes, *Geophys. J. Int. 117*, 345-364.

[34] Parsons, T. (2002)Global Omori law decay of triggered earthquakes : large aftershocjs outside the classical aftershock zone, *J. Geophys. Res., 107*(B9), 2199.

[35] Ito, A. et. al. (1999), Precise distribution of aftershocks of the Izmit earthquake of August 17, 1999, Turkey, *Eos Trans AGU, 80*(46), Fall Meet. Suppl.

[36] Nalbant, S.S., Herbert, A., and King G.C.P, (1998), Stress coupling between earthquakes in northwest Turkey and the north Aegean Sea, *J. Geophys. Res.*, 103, 24,469-24,486.

Ove Arup_Engineering consultants
UTILITIES & TELECOMS

Executive summary

1.1 Demand estimates

The estimated demands for the development are as follows:

- Peak power demand: 280MW
- Peak heating demand: 390MW
- Daily water demand: 18,000 m3/day
- Daily foul production: 17,000 m3/day
- Daily irrigation demand (max): 3,000m3/day

1.2 General objectives

The following principles generally apply for all of the utility strategies considered.

- **Satisfy the demands**
- **Minimise the network**: The network should be designed so that the overall amount of pipe work or cabling is minimized while offering the necessary infrastructural coverage.
- **Renewable + low carbon generation**: Systems for on site energy generation such as ground source cooling, solar, wind power and re use of waste heat for heating / cooling (CHP + absorption chillers) are suggested where appropriate.
- **Reduce demands**: Buildings should be designed in such a way that energy demand is reduced to a minimum (see Sustainability Report).

1.3 Utilities strategies (general)

The following sections outline the strategies proposed for each of the different utilities considered in the development. Telecoms strategy is dealt with in a separate report. For each utility the following stages have been considered:

- Estimate demands for each utility generated within in the development
- Analyse the existing network against proposed street layout.
- Check for potential diversions / upgrades
- Identification of options and assessment of these options for supply strategy, if applicable.
- Proposal of outline distribution strategy and connections to existing network

Figure 14 shows the overall design of the infrastructure strategy for the development.

1.4 Power strategy (Figure 8)

- **Existing network**: There is an insufficient network on site which will need to be entirely re laid in order to supply the proposed development. However, there are several 35KV lines crossing the site which are constraints for the location of buildings.
- **Upgrades / Impact**: There are ongoing conversations with the different statutory bodies in order to assess the need for reinforcement s outside of the development.
- **Supply**: The following strategy is being proposed for the supply of energy into the site::
  - **Direct connection to grid**
    - Supply 2/3 of peak demand)
  - **De centralised CHP production**:
    - Supply of 1/3 of total peak demand (90MW)
    - 7x13MW CHP plants (number indicative) serving 650,000m2 GFA
    - District cooling distribution from plants
    - Cooling provided by absorption chillers in individual plots
  - **Renewable sources**: Combination of PV + Solar + micro wind
  - **High efficiency thermal systems**: Combination of seawater + Groundwater + energy piles
- **Distribution**: The distribution system can be described as follows:
  - Main HV ring connected to grid
  - 3 substations 35KV – 10KV (location in plan just indicative)
  - Local 10KV distribution

1.5 Gas supply (Figure 9)

- **Existing network**: There are several main pipes crossing the site connecting the districts of Kartal and Pendik.
- **Upgrades / Impact**: There are ongoing conversations with the different statutory bodies in order to assess the need for reinforcements outside of the development. Pipes crossing the site and connecting Kartal to Pendik are likely to be affected. Diameters are unknown at the moment and therefore it is difficult to assess the implications of diverting the pipes
- **Supply / Distribution**: A set of primary and secondary distribution rings are proposed as shown in Figure 9.

1.6 Potable water (Figure 10)

- **Existing network**: There are two strategic mains crossing the site which may be a constraint for the location of buildings.
- **Upgrades / Impact**: There are ongoing conversations with the different statutory bodies in order to assess the need for reinforcements outside of the development. Two strategic mains (900mm and 2,100mm diameter) are likely to be affected. Moving the building footprint to avoid the main is recommended. However, it is understood that there are political pressures to maintain blocks free of constraints. This might imply that the main needs to be diverted.
- **Supply / Distribution**: A set of primary and secondary distribution rings are proposed as shown in Figure 10.

1.7 Waste Water (Figure 11)

- **Existing network**: There is a large interceptor to the south taking water from Kartal to pumping station to the south east which then takes the foul to Tuzla WWTP.
- **Upgrades / Impact**: There are ongoing conversations with the water treatment company in order to assess spare capacity of pumping station to the south and Tuzla WWTP. The interceptor along the coast is likely to require replacement as it might coincide in plan with the layout of the expressway tunnel.
- **Layout strategy**: A gravity system is proposed discharging into the main pumping station. A set of primary sewers is designed to take foul water to the pumping station coming south by the east side of the development. This has been proposed in order to avoid potential conflict with the proposed rail and road tunnels along the coast.

1.8 Storm water (Figure 12)

- **Existing network**: There is a storm water system to the east of the site discharges directly into the sea. No data has been made available for the west side.
- **Layout strategy**: A gravity system is proposed. Inverted siphons may be required to avoid potential conflict with the proposed rail and road tunnels along the coast.
- **Sustainable Drainage**: A set of strategies are proposed in order to reduce potential contamination to the sea.

1.9 Water saving strategies (Figure 13)

A set of strategies has been put forward in order to save water potentially recycling it for irrigation (3,000m3/day maximum). The following strategy is put forward in order to reduce demand

Grey water recycling:

- Grey water is taken from part of residential parts of development. It then receives a light treatment and gets re utilised for irrigation.
- Storage of 3,000m3 (one day max. irrigation) across the site would be required.
- Grey water would be in excess during winter time. A connection to the foul system would be required during these periods.
- Storm water harvesting has been considered and although is not the preferred option, can act locally as a supplement.

Introduction

On 2006 Zaha Hadid Architects (ZHL) was appointed to design Kartal - Pendik Masterplan in Istanbul. The project comprises a mixed used development of approximately 4,500,000m2 of development in a 340Ha site situated to the east of the city of Istanbul, along the coast of the Marmara Sea .

On March 2007 Arup were asked to provide engineering input for the Masterplan design to be submitted in 2007. This report outlines the input of utilities and infrastructure engineering into the Masterplan. It covers the following points:

- Power supply
- Gas supply
- Potable water supply
- Foul water drainage
- Storm water drainage

2.1 Proposed masterplan

The site is an elongated strip of land typically 600m wide (roughly east to west) and 3Km long (roughly south to north). It is framed by the Marmara Sea, the railway line linking to Ankara and the coastal expressway to the south, the M5 highway to the north and the districts of Kartal to the west and Pendik to the east .

The development can be described as follows:

- 4,500,000 m2 of mixed development (3,500,000 private + 1,000,000 public)
    - 2,300,000m2 residential (60%)
    - 620,000m2 office (16%)
    - 500,000m2 retail (12.5%)
    - 1,980,000m2 other (11.5%)
- 80,000 residents
- 80,000 workers
- 120,000 daytime population
- 1,000 berth marina facilities on the Marmara Sea
- Upgrade of transportation systems: There is a set of projects already on board within the municipality which will impact the Masterplan. The Masterplan needs to address them in different degrees as explained in the following points:
    - An underground line connecting the Bosphorus to the airport has been planned to have station to the north of the site
    - New tram line crossing the site north-south.
    - The coastal expressway to the south is being planned to cross the site in a tunnel.
    - The railway line connecting to Ankara to the south is being planned to cross the site in a tunnel .
    - A railway station for the train to Ankara is proposed for the site.

2.2 Current use of site

The development site is currently made up as follows (see Figure 4):

- Combination of the occupied and vacant industrial facilities covering approximately 25% of the available area.
- Commercial, housing and residential constitute in the region of 12.5% of the area (See Figure… for location).
- A disused quarry and associated land occupying as further 8.5% of the available space.
- Nearly 20% of the overall area is currently vacant, with a further 13.5% occupied by parks and playgrounds.

2.3 Site constraints and opportunities

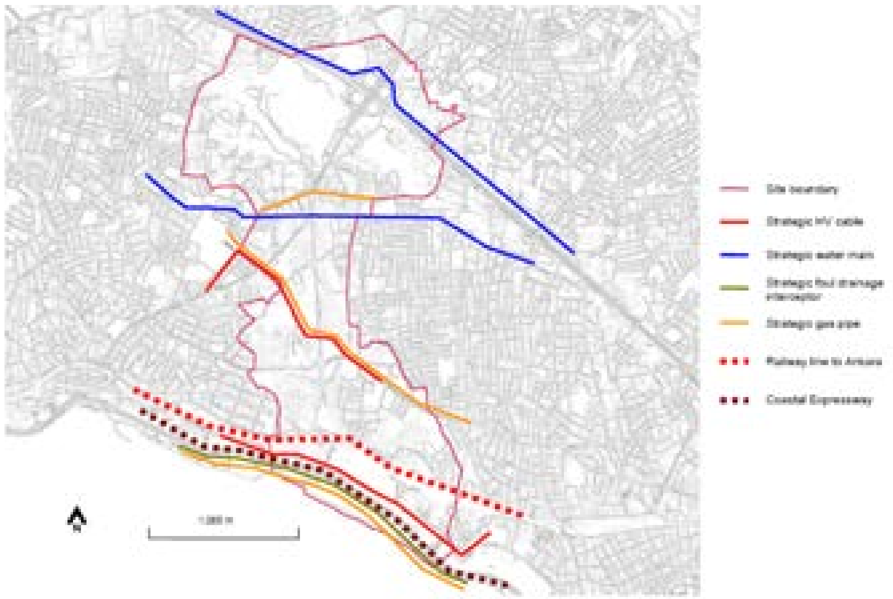
2.3.1 Constraints for the Development

Figure 3 shows the different constrains for the development. These constrains are of different nature and are treated in different sections of the infrastructure report (indicated in brackets)

- **Water main:** There is a 900mm main crossing the site in the middle area. This can be an expensive piece of infrastructure to move and / or divert. There is also a 2,000mm diameter main which is not so likely to be intercepted by building footprints.
- **Highway + Road burial:** The burial of highway + railway might imply a constraint in terms of location of footprints and finished floor levels of the adjacent developments in depth of excavation is restricted for geotechnical reasons. They might also bring problems for the utilities layout.

2.3.2 Opportunities for the Development

- **Good public transport links:** Public transport provision to the site is expected to be quite good with the following projects being currently proposed:
    - The future underground station to the north
    - Railway station to the south with line capacity being improved
    - Ferry terminal to the south
    - Bus terminal to the south
    - North to south tram connecting previously mentioned transport nodes
- **Sloped site:** The site drops with a typical slope of 5% from +120m OD beside the M5 in the north to sea level in the south. This is likely to give the opportunities to provide south facing facades with views to the sea (See Figure 5).



Power supply strategy

3.1 Existing demands

The estimated demands for the development are as follows:

- Total power demand: 280MW
- Total heating demand: 390MW

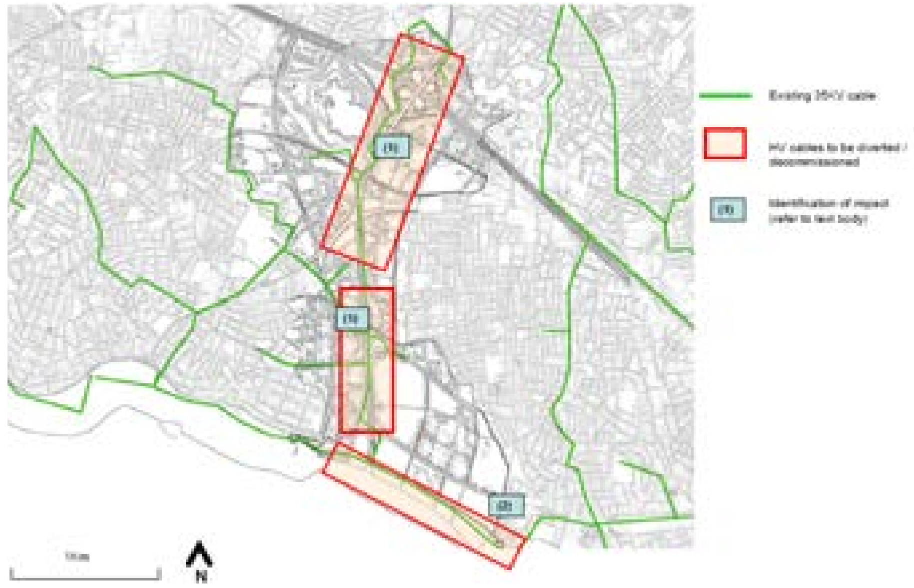
3.2 Existing network / Assessment of capacity

There is an existing network on site the servicing the existing light industry and residential developments (See Figure 6). The network is composed of HV lines (35KV) medium voltage lines (10KV not shown in the drawing for simplicity) and low voltage lines. The type of demands likely to be on site will imply that most of the exiting infrastructure would be inadequate or need to be removed when the development gets in place.

There are two high voltage lines currently on the site:

- There is a high voltage (35KV) line crossing the site to the middle, direction NW-SE and N-S along the future main boulevard (Number (1) in Figure 6)
- Two high voltage (35KV) lines running along the railway (one to the north and one to the south) which connect Kartal with Pendik. These can be some of the infrastructures where tapping into can be feasible. (Number (2) in Figure 6)

Talks are currently being undertaken with the electricity company in order to assess the spare capacity in the network and potentials for upgrading.



3.3 Diversions / Upgrades

The proposed development will impact on the layout of two HV lines currently on site (marked and numbered in Figure 6). At the time of writing this report, there is no information as to what is the voltage of these lines or the spare capacity in the network. However, the following points give an idea of the likely effects of the impacts of the development:

(1) – This branches seem to be a spur servicing the industrial states currently on site. If this is the case, the line is likely to be decommissioned before the development starts.

(2) – This branch shows a connection between Kartal and Pendik. This is likely to be of a more strategic character than the number (1). This branch will be affected by the burial of railway + highway. A diversion in order to keep service is likely to be required.

Talks are currently being undertaken with the electricity company in order to assess the potential impact of the development in the previously mentioned lines, as well as the strategy in case diversions are required.

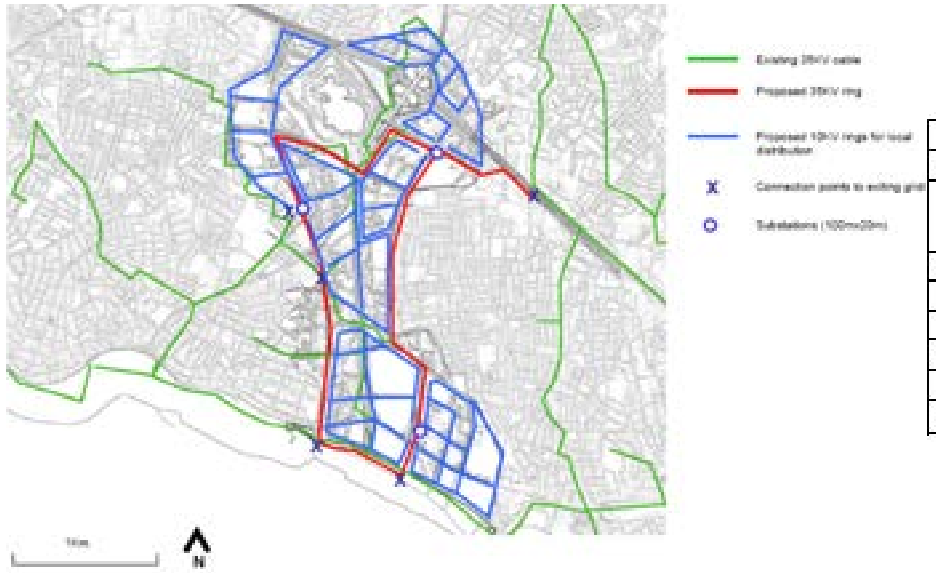
3.4 Supply strategy options

The power strategy has been developed in order to incorporate options that supply the demand from alternative sources. The options have been divided into primary supply and auxiliary supply.

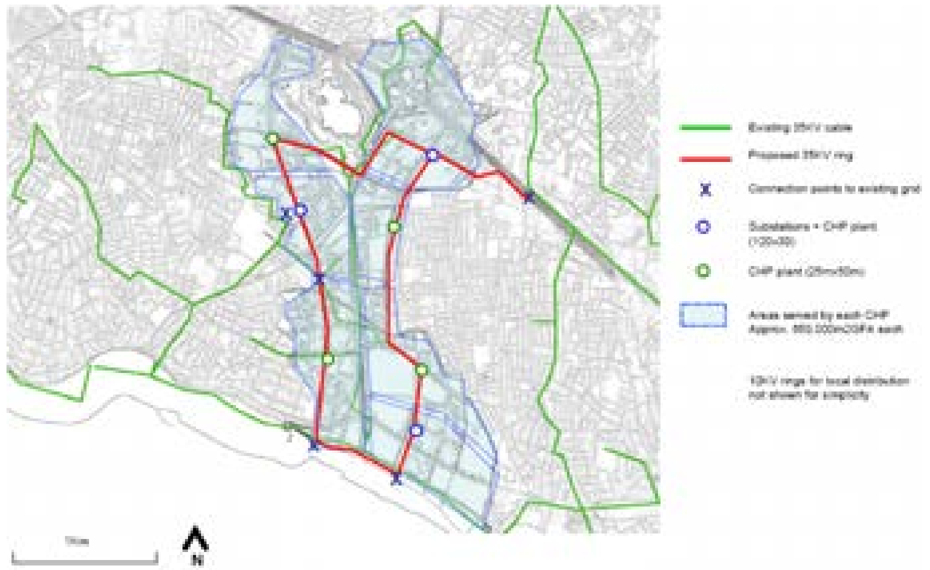
3.4.1 Primary supply

These options include sources which are likely to produce large and reliable proportion of energy for the site.

- **Option 1: Full connection to the network**: this options sources of the power fully from the existing network (Figure 7).



- **Option 2: CHP on site**: This option sources part of the power from small scale gas fired power stations (CHP) and a pipe system which uses the waste heat to provide heating during winter (See figure 8). A set of absorption chillers distributed locally can also turn the heat into cooling during summer. (See Appendix B, for detailed description + assessment). Connection to existing grid is still required.



3.5 Objectives

The supply options have been assessed against the following objectives:

- **Reduce capital cost per KWh**
- **Reduce operational cost per KWh**
- **CO2 Emissions per KWh**
- **Land take**: This evaluates the need for substations (common for both) + occupation of CHP
- **Impact on the urban landscape**: Some of the options might have negative influence on the environment such as noise pollution and visual intrusion.

It has to be noted that, in order to reach the next level of definition in the Masterplan, a full feasibility study on the usage of CHP might be required in order to assess if this option is to be taken forward. Careful considerations on user profiles and environmental conditions are key for a more accurate approach to the issues.

3.6 Option assessment

In order to evaluate the relative merits of the 2 sets of options discussed we have assessed them against specific criteria and scored them from 1 to 5 where '1' is very poor '3' is average and '5' excellent. The specific criteria and assessment are summarised in the table below:

	Primary supply		Auxiliary supply	
	Option 1	Option 2	Option 3	Option 4
	Full connection to the network	CHP on site	Renewable sources	High efficiency thermal systems
Capital Cost (per KWh)	4	3	3	2
Operation cost (Per KWh)	2	5	3	4
Land take	3	2	4	4
CO2 emissions per KWh	3	5	5	4
Impact on the urban landscape	3	2	3	5
TOTAL	15	17	18	19

- **Primary supply**: Option 2 (CHP) is the preferred option.
- **Auxiliary Supply**: At the moment, scoring of both options is rather similar, meaning that both seem equally feasible and should be investigated further.

3.7 Supply strategy description

- **Connection to existing grid**: Connection to the existing grid is still required, as the CHP only provides approximately 1/3 of maximum demand (see next section Distribution Strategy for details)
- **CHP system on site**
  - A de - centralized system of CHP (several units) is chosen as the preferred option given the phased character of the development (see Annex B3)
  - A number of 7 CHP is chosen for the site as an indication of occupation of infrastructure on site (see Annex B3 for details). A detail feasibility study would be required in order to asses the real requirements of space and optimum distribution of plants.
  - 3 of the CHP plants can be integrated with the substations (see next section on Distribution Strategy)
  - Closed loops for hot water – warm water return should be installed to feed development from each of the CHP plants.
  - Optional cooling provided by absorption chillers on individual plots.
- **Renewable energy sources**: These are recommended to be installed within the built fabric including the following:
  - PV cells on the roof tops
  - Micro wing turbines on the rooftops
  - Solar panels for hot water are only recommended in those blocks where CHP option is not taken forward
- **High efficiency thermal systems for buildings**: These will be supporting the overall strategy. Seawater cooling is proposed for dense developments close to the sea and linked into energy centres. Groundwater cooling (if applicable) linked to CHP plants or energy piles for groups of buildings are optimal for areas to the north (see section Appendix C, section C2.5)

3.8 Distribution strategy

A distribution system has been designed for the development. This can be described as follows:

Electrical distribution

- Main 35KV ring connected to the city wide grid
- 3x35KV-10KV substations distributed close to main consumption points in order to minimise power losses. (Location in Figure 8 just indicative)
- 10KV distribution locally to transformer within blocks
- This system in principle applies for all generation options. In case that load from CHP + renewables is substantial, the number of substations could potentially be reduced to two.

Centralised heating distribution

- Loops connecting the CHP plants to local.
- Gas boilers located beside the CHP plants covering the heating demand in excess over the baseline.
- Loops are to be two of pipes: Hot + Return
- Pipe work for this technology tends to be have large diameters (order of 600mm) as flows tend to be large and pipes require insulation

3.9 Energy efficient buildings

Detailed design of the buildings can actually have great impact on energy consumption. The section on Energy efficient buildings within the Sustainability Report outlines some of the main strategies which can be taken when dealing with the detailed building massing in further design stages.

Gas supply strategy

4.1 Existing demands

The estimated demands for the development are as follows (see Annex A):

- Total peak gas demand (kitchen supply): 66MW
- Total peak heating demand: 390MW

The heating demand is assumed to be provided by CHP or gas boilers adjacent to the CHP. In case that the CHP option is not taken on board, the demand will need to be taken by the gas.

4.2 Existing network / Assessment of capacity

There is an existing limited network on site servicing the existing light industry and residential developments (See Figure 9).

There is a set of gas pipes crossing the site connecting the networks in Kartal and Pendik. This network is likely to be of larger hierarchy and potentially be the connecting point for the site. (Indicative location in Figure 9)

4.3 Diversions / Upgrades

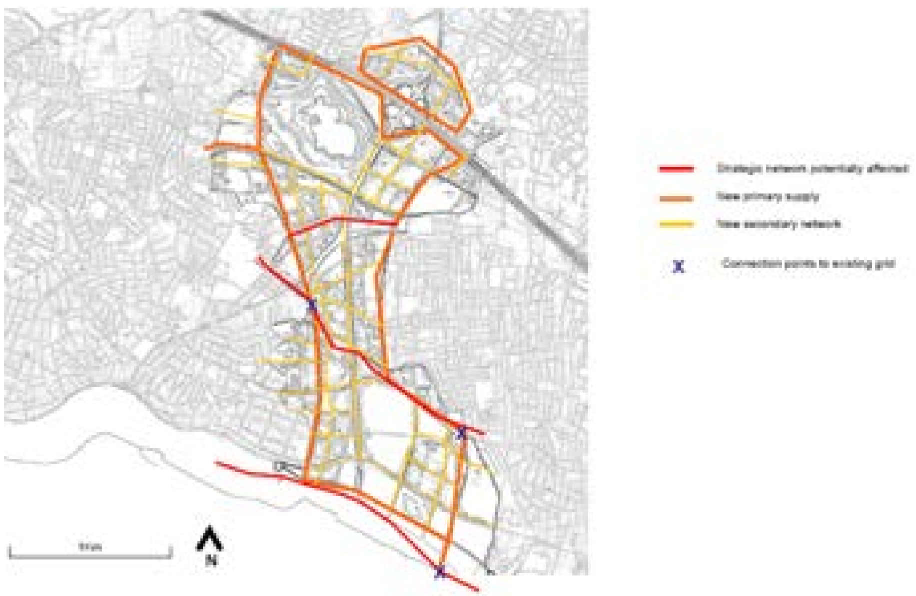
There are ongoing conversations with IGDAS (Istanbul Natural Gas Distribution Company) in order to assess spare capacity on the network.

To date, no detailed drawings of piping layout have been made available. Based on the information received to date, the pipes connecting the districts of Kartal Pendik are likely to impact on plan with the final footprints of the buildings.

Diversion of the pipes is likely to be required or the layout of the buildings may need to be adjusted depending on cost and timescale of the diversion

4.4 Distribution strategy

The proposed strategy for supply is connection into the existing system as shown in Figure... A set of primary loops would need to be located and secondary ones feeding locally into the internal blocks.



Potable water supply strategy

5.1 Estimated demands

The estimated demands for the development are as follows (see Annex A):

- Potable water demand of 18,000m3/day

5.2 Assessment of existing network

There is an existing network on site with a low coverage in comparison to the networks in place in Kartal and Pendik. The majority of the mains on site are of small size (100mm to 200mm diameter shown in light blue in Figure 10). These mains are not likely to be able to cope with the demands calculated above and will need replacement, with the exception of the network serving the housing development in the south.

There are two strategic mains crossing the site

- 900mm diameter main crossing the site connecting Kartal to Pendik. This main crosses the site both under the sidewalk of the road (See Figure 10) but also enters some private property. In certain parts there is consolidated development and buildings which appear to be on top of it.
- 2,000mm strategic main bordering the E5 motorway to the north.

These two strategic mains are the only pieces of infrastructure likely to be capable of dealing with the demands of the order of the ones generated by this development. There are current conversations being held with the relevant statutory bodies in order to evaluate spare capacity along these mains.

5.3 Diversions / Upgrades

Any diversions to minor mains (light blue in Figure 10) are not likely to imply large cost and / or risk and therefore do not represent an constraint at this stage of design. There are two main impacts which need to be considered individually:

5.3.1 1: 900mm main

The 900mm main crossing the site is likely to imply larger costs and / or risks if it coincides with the footprint of a building or any structure which digs into the ground. In order to deal with this issue, our recommendations are as follows:

- Try to modify the footprint of buildings so that they avoid the actual location of the main.
- Negotiations between the relevant statutory bodies and the property owner regarding rights of way for potential maintenance will need to be considered.
- A detailed study about the actual location of the pipe would be required, as the drawing obtained up to date might be indicative only
- However, it is understood that there are political pressures to maintain blocks free of constraints. This might imply that the main needs to be diverted.

5.3.2 2: 2,000mmm main

Any works which imply excavation around the highway (underground station or underpasses to M5 motorway) should consider the implications of diverting this main.

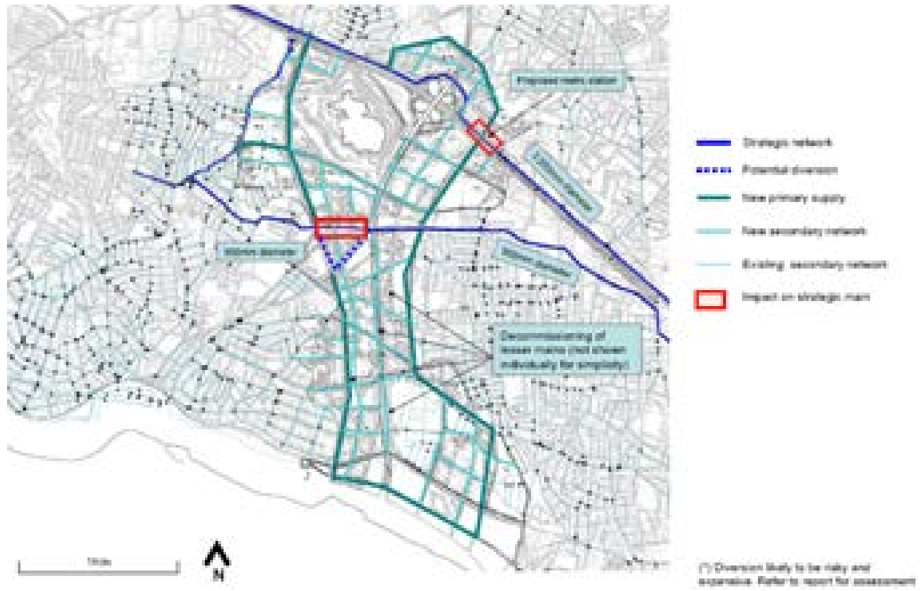
5.4 Supply strategy

There are current discussions with the water company in order to assess the impact of the development in their network. In the unlikely event that the network would need to be reinforced, negotiations about the funding of these works may need to take place.

5.5 Distribution strategy

The proposed strategy for supply is tapping into the existing system as shown in Figure 10 A set of primary loops would need to be located and secondary ones feeding locally into the internal blocks.

Figure 13 shows the location of the pipes within the section of the street. Primary loops are likely to be of 200mm to 400mm diameter while secondary network will have diameters down to 150mm. these diameters are indicative only and are valid for giving an idea of space requirements within the walkways.



Waste water collection strategy

6.1 Estimated foul production

The estimated demands for the development are as follows (see Annex A)

- Potable water demand of 18,000m3/day
- Foul production: 17,000m3/day

6.2 Site levels / Proposed levels

The site slopes down (average of 6%) from +120m OD to the north to sea level on the south (See Figure 5). The Masterplan levels are broadly respecting the existing levels.

The tunnels for the expressway + railway are likely to impact on the layout of the gravity systems as they might impose a barrier to elements coming down the site in the subsurface. This issue is dealt with in Layout Strategy section.

6.3 Assessment of existing network

There is a very limited foul water drainage system within the project area. The system is likely to be insufficient in terms of diameters and position in relation to the proposed streets. With the exception of the residential area to the south of the site, the existing sewers will need to be decommissioned.

The system to the west (Kartal) and east (Pendik) works by gravity, taking the foul to an interceptor running parallel to the coast. This collector discharges to Eastern Tuzla (X5) Waste Water Treatment Plant, by means of a Pump Station to the east project site (See Figure 11).

The existing pump station has inlet diameter of 2,800mm and outlet pipe diameter is 3,000mm. Capacity of the pump station is about 50,000 cu. m/day. The Tuzla Waste Water Treatment Plant has waste water treatment capacity of 150,000cu. m/day. It has been planned that the treatment plant serves 4.5 million people.

There are ongoing conversations with the waste water treatment plant order to assess whether there is spare capacity both in the pumping station and the Tuzla Waste Water Treatment Plant.

6.4 Diversions / Upgrades

The interceptor running along the coast is likely to require a diversion due to the tunnel from the highway / railway (see Figure 11).

Careful analysis should be placed with levels in order to assess whether the pumping station gets affected by the tunnel layout

6.5 Design Objectives

- Make use of difference in levels in order to avoid impacting the coastal tunnels
- Minimise capital cost
- Minimise Operation costs.

6.6 Design Layout

Given the difference in levels in the site, gravity system is clearly the most cost effective option for draining foul water from the site. The system proposed for the development can be described as follows:

- **Primary mains:** These mains take foul drainage to the east boundary of the site as quickly as possible. This is done in order to avoid the conflict with the tunnels along the coast (Figure…). Diameter for these mains is likely to be in the region of 500mm. this value is indicative only and useful in order to have an idea of layout occupation on sidewalks.
- **Secondary mains:** These take the foul drainage from the developments into the primary mains.
- **Connections to existing network:** The main proportion of the foul production will be connecting to the existing grid in the vicinity of the pumping station to the south of the site (See Figure 11). Other minor connections have been outlined when areas of development are adjacent to the existing network.
- **Minor pumping stations:** some underground pumping stations (10mx10m occupation of land) are likely to be required in the vicinity of the tunnels in order to extract foul that cannot be taken to the east. Final number TBC in detail design stages

6.7 Grey water harvesting

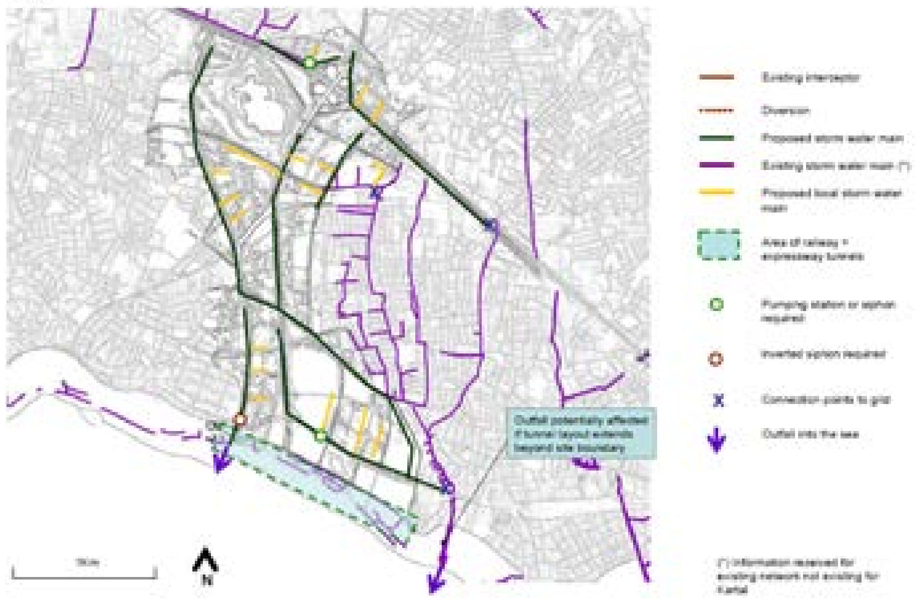
The section on Water Saving Strategies comments on the option of collecting grey water to be re used in irrigation.

Storm water strategy

7.1 Assessment of existing network

There is no existing stormwater drainage available in the project area. In the southern side of the project area, there is a line of stormwater drainage pipeline system, which has been locally laid in order to drain some parts of the area. This is mainly provided for the coastal area.

The storm water system in Pendik currently discharges into the sea via an outlet (see Figure 12).



7.2 Design Objectives

- Make use of difference in levels in order to avoid impacting the coastal tunnels
- Minimise capital cost.
- Minimise Operation costs.
- Minimise environmental impact of discharges

7.3 Design Layout

Given the difference in levels in the site, gravity system is clearly the most cost effective option for draining foul water from the site.

Attenuation of storm water discharge is not likely to be required as the site is right beside the outfall to the sea and the impact of storm water flows can be ignored.

The system proposed for the development can be described as follows:

- **Primary mains:** These mains take stormwater and direct it to the east boundary of the site as quickly as possible. This is done in order to avoid the conflict with the tunnels along the coast. Diameter for these mains is likely to be in the region of 500mm. this value is indicative only and useful in order to have an idea of layout occupation on sidewalks.
- **Secondary mains:** These take locally the surface water drainage from the developments into the primary mains.
- **Connections to existing network:** The main proportion of the storm water will be connecting to the existing grid in the vicinity of the outlet to the south of the site (See Figure 12). Other minor connections have been outlined when areas of development become surrounded by existing network.
- **Minor pumping stations:** some underground pumping stations (10mx10m occupation of land) are likely to be required in the vicinity of the. Final number TBC in detail design stages. Alternatively, it might be possible to cross the tunnels with inverted syphons.

7.4 Sustainable techniques for drainage

Stormwater can carry pollutants of different kinds which might need to be intercepted before they reach sensitive areas. In order to reduce the potential impact of the water discharged, the following strategies can be adopted on site:

- **Petrol interceptors:** These may be applied in areas where the water enters the network or just before it is discharged into a sensitive area. In the case of this project, it has to be made sure that these measures have been applied before the discharge into the outfall
- **Landscape strategies:** These strategies try to reduce the flows and pollutants which enter the site at source. Annex D outliners these strategies, commonly denominated Sustainable Urban Design Systems (SUDS).
  - Infiltration trenches
  - Green swales
  - Permeable surfacing
  - Green roofs

7.5 Storm water harvesting

The section on Water Saving Strategies comments the option of collecting storm water to be re use in irrigation.

Water saving strategies

This section outlines a set of strategies which can reduce water demands by reutilising water for irrigation, improving the sustainability record of the overall system.

8.1 Demands and sources

Annexes 1 and 5 of this report outline the irrigation demands, as well as the sources of water which are likely to be used for this purpose. These values can be summarised as follows:

- Irrigations requirements are in the region of 3,000m3/day for the hottest day, while they come down to 300m3/day during winter.
- Grey water production on site could be as high as 5,200m3/day if a collection system is placed in all the households.
- Rainwater harvested is likely to be in excess during winter months and would only supply with 50% of demand in summer if all rainfall is stored.
- Rain can fall in a quite concentrated manner in the summer in Istanbul. In order to collect effectively storm water, the storage tank would need to be able to harvest water from up to two weeks.

8.2 Options

- Option 1: Rainwater harvesting
  - Storage tanks to hold typically 2 weeks of rainfall during summer (23,00m3)
  - Additional demand from potable supply (average 10,000m3 week) during summer months
- Option 2: Grey water harvesting
  - Grey water collection network.
  - The network of grey water collection could be partial, as there is potentially more grey water to be collected than irrigation demand.
  - Storage tank: 2 Day irrigation requirements storage tank (6,000m3) + primary treatment (filtration)
  - During winter time, when irrigation demand is low, excess of grey water should be discharged into the Foul system

8.3 Objectives

The following objectives are set for the strategy

- Reduce the water demand required for irrigation purposes during the maximum amount of time.
- Reliability of supply
- Minimise the amount of pipe work required upfront
- Minimise the amount of storage required on the site.

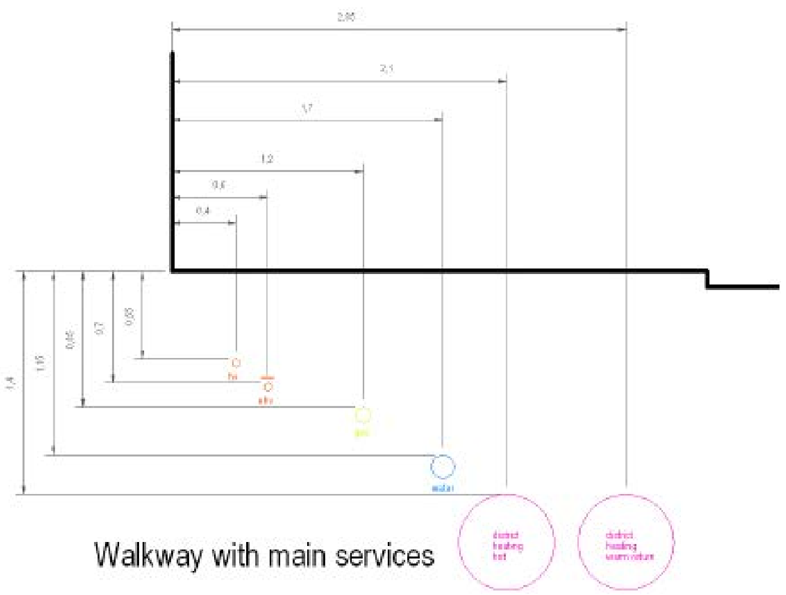
8.4 Option assessment and proposed strategy

In order to evaluate the relative merits of the 2 options discussed we have assessed them against specific criteria and scored them from 1 to 5 where '1' is very poor '3' is average and '5' excellent. The specific criteria and assessment are summarised in the table below:

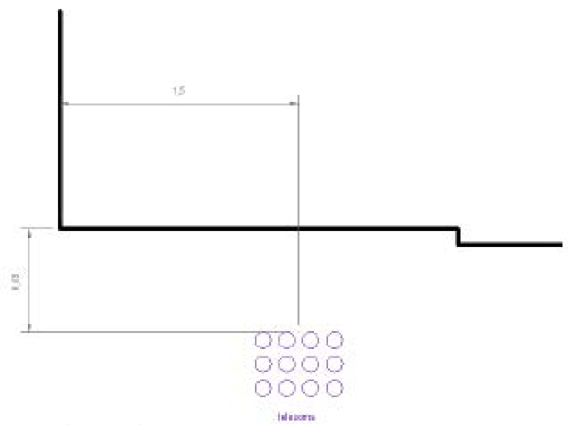
	Option 1	Option 2
	Rainwater harvesting	Grey water harvesting
Reduce irrigation demands	3	5
Reliability	3	5
Need for pipe work	4	2
Need for storage	3	4
Total	13	16

Option 2 (grey water harvesting) is the preferred option

The options are not mutually exclusive, therefore, the final solution should consist on an optimal combination of the options taking into account a more detailed analysis.



Walkway with main services



Oposite walkway

Utility demands

A1.1 Introduction

This annex includes the different design assumptions taken in order to evaluate the utility demands for the development. The following points summarise the key drivers of the whole calculation:

- Power consumption has been calculated on the basis of flats having central boiler + gas cooking (which reduces the values greatly)
- In order to calculate potential demand of district heating (option 2), the values for gas have been transposed into the heating.
- If Option 2 would not to be taken forward, the gas demands would be equal to the ones calculated in this report plus the demands for heating included in district heating.
- District cooling (HC for the summer) is assumed to be equivalent to the demand of heating during the winter.

A1.2 Unitary values:

ASSUMPTIONS

	Power		District heating		Gas		Potable water		Foul water	
	Peak	Yearly	Peak	Yearly	Peak	Yearly	Peak	Daily	Peak	Daily
Units	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Residential	36	24	114	34	36	29	8 hour period calculation, peak factor 2.5	200	foul / potable = 0.95	8 hour period calculation, peak factor 6
Office	82	177	88	177	0	0		23		
Retail	151	379	116	379	0	0		28		
Education	231	496	131	496	0	0		28		
Entertainment	86	174	116	174	0	0		10		
Culture	40	168	116	168	0	0		5		
Parking	12	6	0	6	0	0		0		
Hotel	68	110	117	110	0	0		140		

A1.3 Total values

TOTAL VALUES

	Power		District heating		Gas		Potable water		Foul water	
	Peak	Yearly	Peak	Yearly	Peak	Yearly	Peak	Daily	Peak	Daily
Units	MW	MWh/year	MW	MWh/year	MW	MWh/year	l/s	m3/day	l/s	m3/day
Residential	65.5	55,897	210.4	206,896	65.6	65,762	1377.9	15,874	2618.6	15,080
Office	40.9	110,450	43.9	86,825	0.0	0	55.4	638	105.2	606
Retail	60.3	169,251	46.3	68,410	0.0	0	36.3	380	57.6	332
Education	24.7	66,191	14.0	21,352	0.0	0	8.1	93	15.4	89
Entertainment	7.2	16,527	9.7	9,274	0.0	0	15.2	176	29.0	167
Culture	15.6	62,556	53.6	91,598	0.0	0	45.1	520	85.7	494
Parking	9.3	5,374	0.0	0	0.0	0	0.0	0	0.0	0
Hotel	8.1	16,327	13.9	46,920	0.0	0	36.0	415	68.5	394
TOTAL	234.6	524,419	391.8	534,175	65.6	65,762	1568.1	18,068	2979.3	17,162

Grey water is estimated to be 30% of residential demand: 5,200m3/day

A1.4 Irrigation demands

The following assumptions have been made in order to evaluate the potential demand of water for irrigations.

- The percentage of the site which is to be irrigated is 20%
- There are different types of vegetation with different requirements ranging from lush (grass) to crease and low water demanding species. (see demand in chart below).
- At the moment of writing this report, there is no landscape plan with detailed breakdown of areas and vegetation types.
- The values in the chart below refer to hottest day in summer. Values for winter will be much lower (down to 10% of maximum demands)

			Evapotranspiration		Demand	
	%	Area	Summer	Winter	Summer	Winter
		m2	mm/day	mm/day	m3/day	m3/day
Lush	30%	204,000	8	1	1632	204
Medium	30%	204,000	4	0.5	816	102
Dry	40%	272,000	2	0	544	0
Total		680,000			2,992	306

Combined Heat and Power

B1.1 Combined Heat and Power – The Concept

The basic concept of CHP plant technology (Figure 1) is both the generation of electricity, and the utilisation of waste heat, through the combustion of fuel (typically natural gas, but alternatively biomass, biofuel or oil). This is a more sustainable approach than the conventional means of electrical generation in which the generation of heat and power occur separately. Fuel is burnt in the CHP plant, and this turns a generator which produces electricity. As a part of this process heat is generated, and this is recovered from the engine cooling systems via a heat exchanger.

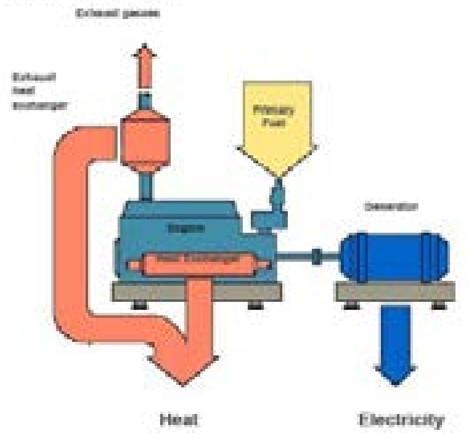


Figure 1 Principle of CHP

This heat is then used to heat water, and this hot water would be pumped around the site through a district heating network. The network would provide hot water for instantaneous use, and for the heating of buildings through radiators or warm air heating.

Flow and return pipes will be required in order to supply buildings with hot water, and then take this water back to the energy centre to be re-heated. The CHP engines in the plant will be connected to a series of circuit breakers, which will allow the electricity produced to be fed back in to the site-wide electrical distribution network(s).

CHP plants are housed within Energy Centres, which usually also contain supplementary gas or biomass fuelled boilers to provide top-up heat supply. In the event that the CHP plant is non-operational full electrical grid back-up will be required to ensure peak electrical demands can be met. Each CHP plant will consist of a number of gas engines, the capacity of which will typically have been designed to optimise the electrical and heat output to meet the baseline demands. In the event that more electricity is required it would be obtained from the grid. In the event that more heating is required it would be obtained from the supplementary boilers.

Figure 2 District Heating Network Pipes (size will vary)

B.4.1 Tri-Generation

In addition to producing heat and electricity, CHP plants can also be designed to incorporate cooling, thus becoming Combined Cooling and Heat Plants (CCHP). Heat exchangers are used to convert heat into cooling, typically by means of an absorption chiller. This allows the CCHP plant to be used year-round (not just during the cooler months when heating is required). Cooling units can either be located centrally within the Energy Centre, or on a building-by-building basis.

The latter option reduces the need for additional plant on building rooftops, and can make metering and maintenance more straightforward when a building has multiple tenants. The former option (centralised cooling units) requires additional pipe work (flow and return pipes) in order to allow routing of the chilled water through the development. This leads to increased space requirements within utilities corridors.

Stand-by electrical chillers would be required either centrally within the Energy Centre, or locally on building roofs, to allow cooling of buildings in the event that the CHP plant is non-operational, or is not able to meet the full cooling demand of the site. It is inefficient to use heat generated by supplementary gas boilers within Energy Centres for cooling.

B1.2 CHP in Turkey

The first CHP plant in Turkey was opened in 1992. Cogeneration has been developing steadily and accounts for 17.6% of the country's electricity production, a share that is set to increase, as more industrial companies become auto-producers (Source: Turkey Cogeneration Association, 2006). CHP electrical generation capacity is in the region of 6,000MW.

B1.3 Sustainability

CHP technology offers a more sustainable alternative to conventional power generation, as it makes use of the heat that is usually wasted by a large oil or gas-fired power station. Experience gained from previous Arup projects indicates that a reduction in carbon emissions in the region of 30% can be achieved when benchmarked against 2002 emissions. The use of biofuels (e.g. wood chippings) can further reduce carbon emissions when they are used in the supplementary boilers, or even the CHP engines. Biofuels represent a carbon neutral fuel source and are becoming increasingly common; availability of this fuel source should be considered during any Energy Assessment or CHP Feasibility Study. The use of efficient fixtures and fittings within buildings, and improvements on insulation, shading, climate control features such as brise soleils etc., will serve to reduce the demands placed on the CHP plant and further reduce the carbon footprint of the development.

There is the potential to incorporate further technologies (such as thermal stores or fuel cells) to further reduce the carbon footprint of a development.

An Energy Assessment and/or CHP Feasibility Study will indicate more accurately the potential reductions CO_2 emissions that can be achieved through the use of CHP and other technologies.

B1.4 Plant Distribution Strategy

There are three possible Energy Centre distribution strategies:

1. Centralised

A single, large scale energy centre. Plant contained within a dedicated building/boundary with plant capacity to serve total site thermal demand/consumption. Optimised electrical generation capacity paralleled by electricity network connections.

Advantages	Disadvantages
Easy connection to community scheme	Large single spatial requirements
High efficiency and emissions reduction	Not the most flexible to phasing demands
Economies of scale	May require additional pumping of flows through large district networks
Low operation and maintenance costs	
Simplified fuel delivery logistics and storage	

Table 1 Centralised Distribution Strategy - Advantages and Disadvantages

2. De-centralised

A small number of medium and small scale energy generation centres located at strategic points within the development with plant contained within both dedicated buildings and integrated with development plots. Individual energy centre capacity designed for total site thermal demand/consumption. Optimised electrical generation capacity paralleled by electricity network connections.

Advantages	Disadvantages
Easy connection to community scheme	Higher capital costs than centralised
Economies of scale	More complex fuel delivery logistics and storage
High efficiency and emissions reduction	Increased operation and maintenance costs
Flexible to phasing	More complex energy infrastructure routing
Reduced individual energy centre footprint	
Easier to integrate into a high density environment	

Table 2 De-centralised Distribution Strategy - Advantages and Disadvantages

3. Distributed

Multiple small energy centres integrated within individual buildings. Each energy centre to serve building demand as a minimum with potential to serve small fraction of the total site demand. Electrical generation capacity paralleled by electricity network connections.

Advantages	Disadvantages
Small individual spatial requirements – easily integrated into build basements	Greater overall capital expense
Very flexible to phasing and numerous land owners	Lower overall efficiency
	Lower overall emissions savings
	High operation and maintenance costs
	More complex and expensive to connect to community scheme
	Complex fuel logistics and storage
	Higher overall spatial requirement

Table 3 Distributed Distribution Strategy - Advantages and Disadvantages

B1.5 Procurement

Typically an Energy Supply Company (ESCo) will run the Energy Centre, district heating/cooling networks and the on-site electricity network under a design, build, finance, operate and maintain (DBFOM) contract. They may also own and operate primary electrical substations and building transformers. The ESCo would take the risk of ensuring sufficient supplies of electricity and heat to consumers throughout the site and would gain revenue from consumers. In addition, the ESCo would be responsible for attracting and retaining customers to utilise the district heating network. The ESCo would need to have a distribution license, which would also allow them to generate electricity through the CHP plant.

Such an ESCo is usually appointed following a competitive tendering process, having been selected as the most suitable bidder. In the case of Kartal-Pendik a number of different ESCos could be appointed, with each one responsible for running one (or a number of) Energy Centres, district heating/cooling networks, and power networks. Alternatively one single ESCo could be appointed for the whole site, offering benefit from scales of economy, and ease of network interconnectivity.

In order to facilitate the ESCo tender process a CHP Feasibility Study is often produced, in order to explain the development to the ESCo, outline the parameters within which they must work, highlight the business case for CHP technology on the site, and offer a possible reference design.

Depending upon their expertise, business model and typical markets, ESCos may choose to adopt the reference design provided within the Feasibility Study, or propose their own alternate design. For instance, an ESCo may choose to operate as a net exporter of electricity, i.e. they size the CHP plant to produce more electricity than that required by the development itself, and sell the surplus back to the grid.

The ESCo will consider the security of its business, i.e. the number of consumers that will require its services. In order to ensure that a robust business case is presented to the

Case Studies

Two case studies of proposed CHP schemes in the UK are presented to provide background information.

B2.1 Case Study 1 – Brownfield Regeneration Project, Central London

Development size (GFA): 700,000m²

Development type: Mixed use development comprising office, residential, retail, leisure, food & drink, education.

Energy Centre distribution strategy: Decentralised. Two Energy Centres are proposed. It is yet to be confirmed whether the district heating network each supplies will be connected to form one complete network. Both centres link into the same electrical grid.

Energy Centre	Capacity (Electrical Generation)	GFA Supplied	Estimated Dimensions (LxWxH)
1	7 MWe	467,500m²	35m x 25m x 10m
2	4.6 MWe	237,000m²	30m x 25m x 10m

Table 4 Distribution Strategy, Case Study 1

Tri-generation: Yes. Absorption chillers situated locally on building roof tops provide cooling. Electrical chillers are also to be provided. Residential buildings are not supplied with absorption chillers.

B2.2 Case Study 2 – Brownfield Regeneration Project, East London

Development size (GFA): 2,900,000m²

Development type: Mixed use development comprising office, residential, retail, leisure, food & drink, education.

Energy Centre distribution strategy: Decentralised. Two Energy Centres are proposed. Each Energy Centre provides electricity and heat, however their distribution areas for each are different, hence the split between electricity and heat in Table 5.

Energy Centre	Capacity (Electrical Generation)	GFA Supplied	Estimated Dimensions (LxWxH)
1	15MWe	Electricity 1,430,000m²	70m x 18m x 10m
		Heat/cooling 715,100m²	
2	10MWe	Electricity 1,480,000m²	60m x 17m x 10m
		Heat only 2,185,000m²	

Table 5 Distribution Strategy, Case Study 2

Tri-generation: Yes (partial). Energy Centre 1 provides heating and chilling centrally, with absorption chillers located within the Energy Centre to meet base cooling demands. Electrical chillers (also centrally located) provide top up for peak loads. Energy Centre 2 provides heating but not cooling, as the area it supplies is predominantly residential. There are some commercial buildings however, and cooling in the from of absorption chillers or electrical chillers could be provided on building roofs if required.

Application to Kartal Pendik

An initial estimation of number and size of plants has been done in order to have an understanding of the potential impact of the scheme in terms of size requirements and land allocation. It has to be noted that in order to properly define a CHP scheme, a detail study of considering consumer profiles, climatic conditions, therefore, the number and sizes of the plants given might change.

It is also important to note that the proposed system allows for certain parts of the development to implement a CHP strategy, while other might still stick to the conventional option.

The following sections outline the decision making process behind the selection of type and size of plants.

B3.1 Plant distribution strategy

Kartal Pendik development will occur in Phases. This fact rules out the possibility of a centralised option, given the fact that it would mean that the system is oversized for large part of its design life.

Phases are likely to be relatively large (greater than 500,000m2), which means that De-centralised system (Option 2) is likely to be optimal.

De-Centralised option has been taken forward.

B3.2 Demands supplied by CHP

CHP power output is likely to be of the baseline type. This means that not all the power can be provided by this system. For the purposes of this exercise an indicative value of 1/3 of total power has been assumed:

- Total power demand: 280MW
- Supplied by CHP: 90MW (Approx)

B3.3 Indicative plant number / sizes

In order to evaluate the number of plants, Case study 2 from section B2.2 has been taken as an example (same type of De-Centralised development).

- Plant production: 13MW (Case study 2). Total of 7 plants
- Plat size: (Case study 2) 70mx18mx10m

Renewable energy sources

C1.1 Photo-voltaic (PV) panels

- High capital and operating costs per kWh of power supplied.
- High performance.
- Highest sun incidence tends also to coincide with highest power demand.
- Current evolution of technology is improving performance and lowering production costs.

C1.2 Wind turbines

- Given the reportedly reliable pattern of winds on the site, wind power could also be beneficial in terms of reducing demands from non-renewable sources. However, the site is located on the leeward side of Nevis, hence the wind potential may not be great.
- Current evolution of technology is improving performance and lowering production costs.
- There can be a potential negative aesthetic impact if not correctly integrated into the landscape. However, wind turbines incorporating aesthetic design are available on the market which could satisfy these requirements (see image to the right below).

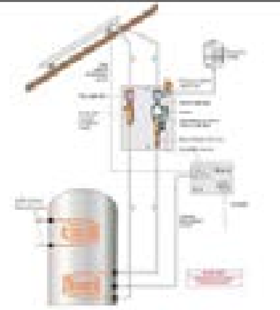
Small-scale wind turbines located on buildings. Some (e.g. right-hand image) are designed incorporating aesthetic criteria.

Large-scale wind turbine familiar from wind farms

C1.3 Solar thermal water heating

- Relatively low cost for water heating purposes.
- Potential visual impact of water heating panels on the site.

A solar water heating panel. Solar heating panels can also be installed on building roofs.



A schematic of a solar thermal water heating system

C1.4 Option assessment

In order to evaluate the relative merits of the 4 options discussed we have assessed them against specific criteria and scored them from 1 to 5 where '1' is very poor '3' is average and '5' excellent. The specific criteria and assessment are summarised in the table below:

	Photo-voltaic panels	Wind turbine	Solar thermal
Minimise capital cost (per kWh)	2	2	4
Minimise operating cost (per kWh)	2	4	4
Reduction in CO_2 emissions (kg CO_2 per kWh) (taking into account manufacture and construction)	2	3	2
Minimise other environmental impact e.g. noise and aesthetics	3	2	3
Minimise area requirements	3	4	5
Reliability of supply	4	2	4
TOTAL	16	17	22

C1.5 Proposed strategy

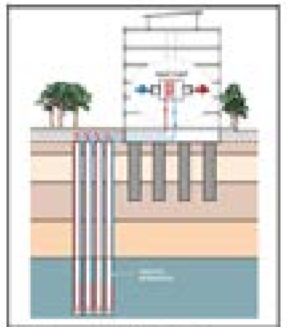
- **Solar thermal:** This is the preferred option. However there are some remarks on its adoption:
  - If the CHP option of is put forward, the supply of hot water is likely not to be such an advantage.
  - In parts of the development where CHP might not be available this options is still the recommended one
- A combination of wind + PV cells is recommended to be located upon rooftops.
- Given that the current trends in the development of sun and wind power we suggest that, even though they are not installed initially, provision in terms of space and architectural configuration of the buildings in order to allow for future provision of this sort of energies.

High efficiency thermal systems

This section outlines the different options available for using high efficiency thermal systems within the buildings. The basic principle of the technology is the usage of a certain element with high thermal mass as a heat sink with relatively constant temperature thus improving the efficiency of heat pumps for acclimatizing.

C2.1 Energy piles

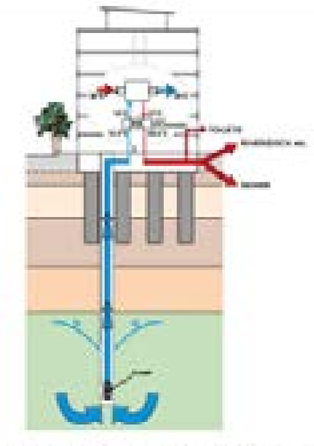
- Sealed loops of pipe are installed into the ground and heat exchange fluids circulated through them.
- The fluid circulates along the loops of pipe, exchanging heat with the ground and is connected to a number of reversible heat pumps.
- The system uses the ground as a heat sink to dissipate waste heat, thus providing cooling to buildings.
- Attention should be paid to the potential heating of the ground in the long term which would hamper overall efficiency.
- These systems potentially have minimal environmental impact and enable a reduction in energy demands from external sources.
- Piping systems for upper areas of the development might be quite expensive given the low density and large distances between units.



Energy piles functional diagram

C2.2 Centralised groundwater cooling / heating

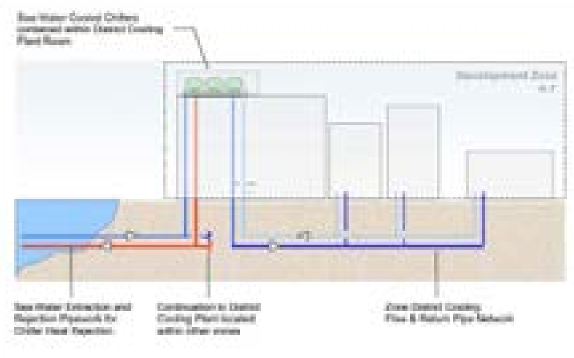
- Groundwater is typically abstracted from an aquifer at a temperature of around 15-17°C (but see note below).
- A centralised heat pump passes cooling water in a closed loop in close proximity to the abstracted groundwater, transferring heat into groundwater.
- The heated groundwater water is then either discharged to waste or re-injected back into the aquifer.
- The cooling water is used to provide cooling to buildings.
- Centralised systems improve efficiency of heat pumps with minimal land requirements.
- The attached figure is indicative of the heat exchange process but does not show the centralised process.
- Piping systems for upper areas of the development might be quite expensive given the low density and large distances between units.
- Groundwater cooling would depend on the existence of enough groundwater available on site.



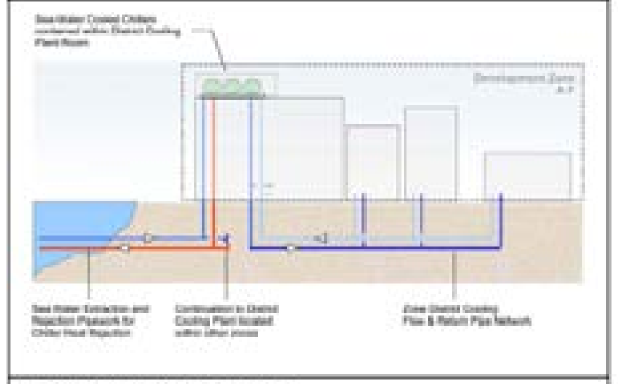
Centralized groundwater cooling functional diagram

C2.3 Centralised sea water cooling / heating

- Water is pumped from the sea from sufficient depth to obtain cool water. A borehole in the sea-bed is an option in order to access water at the correct temperature.
- A centralised heat pump passes cooling water in a closed loop in close proximity to the abstracted seawater, transferring heat into the seawater.
- The warm seawater is then discharged back into the sea. There might be a need to mitigate the impact of this on the marine environment.
- Centralised systems improve efficiency of heat pumps with minimal land requirements.
- Seawater abstraction system can be integrated with seawater abstraction for desalination.
- Piping systems for upper areas of the development might be quite expensive given the low density and large distances between units.



Centralized seawater cooling functional diagram



Centralized seawater cooling functional diagram

C2.4 Option assessment

	Cooling piles	Centralised groundwater cooling	Centralised seawater cooling
Minimise capital cost (per kWh)	2	3	3
Minimise operating cost (per kWh)	3	3	3
Reduction in CO_2 emissions (kg CO_2 per kWh) (taking into account manufacture and construction)	3	3	3
Minimise other environmental impact e.g. noise, air pollution and aesthetics (taking into account on and off-site issues)	5	4	2
Minimise area requirements	4	3	3
Reliability of supply	3	3	5
TOTAL	20	19	19

Note: Cooling piles and groundwater cooling may not be feasible if the ground or groundwater at the depth of interest is not due to geothermal activity.

C2.5 Proposed strategy

All three options are equally attractive at the moment. However, there might be particular issues with each of them that make them more or less attractive:

- Centralised systems will be optimal if linked to the generation of hot water for the site (CHP plants)
- Energy piles can work for individual buildings.
- Centralised sea water cooling is likely to be feasible if combined with CHP centres close to the sea.
- Areas to the north of the development are likely to be using either energy piles or centralised groundwater heating / cooling (is available).

Sustainable Urban Design systems

The proposed stormwater drainage strategy includes aspects of Sustainable Urban Drainage Systems (SuDS), primarily related to issues of water quality. The other common areas of sustainable drainage related to attenuation of flows and infiltration of runoff have limited application at on the site.

D1.1 Permeable Surfacing

Permeable car parks and surfacing are a means of reducing surface runoff volume and improving water quality. They work by allowing stormwater to filter through open paving joints, into a permeable strata beneath. The filtration slows the time of entry of the storm water into the nearby watercourses and also cleans the water. They have been shown to break down oils, preventing pollution of a local water course without the requirements for oil interceptors.

The application of this type of surfacing at Kartal Pendik may be limited by the residual contamination that could be present and the extent of basement car parking which will reduce the benefit of permeable surfacing. However, in conjunction with the provision of granular fill below the surfacing it could provide some limited storage and would delay the peak run-off from the area. When the extent of hard landscaping is better understood in conjunction with the types of surfacing being considered, a further study should be undertaken to investigate the feasibility of utilising permeable surfacing.

D1.2 Green Roofs

Although this technology has been around in some from for a very long time it has in recent years moved forward considerably and now offers many benefits. Where rainfall is significant and regular the insulation against solar gain and the protection of the waterproof membrane as well as rainwater flow attenuation make this technology attractive. At the same time when large areas of land are becoming urbanised providing green roofs or even gardens replace some of the lost amenity and habitat.

However, a green roof need not be literally green due to vegetation but other technologies can be considered. Providing a canopy at roof level that shades the roof will reduce solar gain and prolong the life of water proof membranes. If the shading device were PhotoVoltaic arrays then they could at the same time be harnessing the solar energy. Other forms of solar panel could be used to simply generate hot water for domestic use.

Where there may be benefits to the establishment of local ecology the provision of green roofs should be considered.

Example of green roof

Introduction

As part of its overall strategy for the Kartal & Pendik urban regeneration project, Information and Communications Technology (ICT) will be used as a key differentiator to make the development attractive to its future tenants. The ICT strategy for the development is thus a central component of the overall strategy of the development.

This section is intended to describe the ICT aspects of the Kartal & Pendik urban development master plan. It identifies key issues related to information and communications technology (ICT) in this development and delineates potential implementation solutions. It is in six parts:

- Project background
- ICT in urban regeneration
- ICT in a service-based economy
- ICT services in the development
- ICT infrastructure
- Implementing the ICT infrastructure

Project background

Greater Istanbul Municipality has planned a number of urban regeneration projects. One of these projects is the regeneration of the industrial areas in Kartal and Pendik. The project area is located within the boundaries of Istanbul Metropolitan Area and in the east bank of the city. The total project area is 555 Ha.

The Kartal-Pendik regeneration and transformation project aims to improve the quality of urban life and create innovative, unique urban centres that are sensitive to the environment. One of the key objectives of the project is to create an alternative new urban area with business centres, theatres, concert halls, congress halls and marinas. Within the project area there are four religious facilities, two elementary schools, two training schools, and five social and cultural facilities

The Kartal & Pendik urban regeneration project will therefore result in a mixed development comprising residential, retail, corporate, industrial and government tenants. Both the tenants as well as the Kartal & Pendik Estate Management will need to be served by a broad spectrum of ICT services including for example telephony, cable and satellite TV, the Internet, Intercom, CCTV and access control security, private mobile radio, public wireless local area network, cellular radio, utilities metering and alarms, and microwave data links.

ICT services are supplied in Turkey by a number of public and private service providers. Among the public service providers are Turk Telecom, Internet Service Providers, cellular radio operators, and cable and satellite TV services providers. Other 'third party' service providers, including Kartal & Pendik Estate Management itself or its partner(s), are in principle able to lease/buy ICT wholesale services from public service providers and manage the sale and distribution of these services within the development.

ICT in urban regeneration

Physical regeneration will enhance the existing area as a location for people and investment by providing facilities that are lacking currently, such as offices and other commercial premises, housing and amenities such as parks, green space, community and cultural buildings. Physical regeneration will be married with social and economic schemes. Thus, the property-led regeneration scheme will provide locations for investment and employment in an area that previously lacked employment opportunities.

The development will focus among others on two key objectives.

- enhance the existing area as a location for people and investment. This will involve property development, urban design and transport infrastructure.
- increase accessibility to jobs and infrastructure for residents of the area. The particular importance of linking physical, economic and social initiatives to achieve the best outcomes is often underscored.

In today's economy in Turkey, the types of employment that attract new investment are typically service-based or knowledge work that has infrastructural requirements such as broadband telecommunications as well as a need for trained staff. The challenge for a new urban development is to enable the transformation or evolution of this area into a connected community: a place where skills, infrastructure, and the value chains of local businesses take full advantage of the opportunities ICT can offer.

ICT in a service-based economy

4.1 Broadband

It is generally recognised that a broadband ICT infrastructure is now key to economic development. It is increasingly clear that having a good broadband infrastructure is not so much a competitive advantage but a pre-requisite for moving up the value chain. The availability of broadband in an area enhances that area as a location for investment, and increasingly will be a pre-requisite for many kinds of investment. Broadband as a piece of infrastructure improves residents' access to work, education and training, as well as services. The application of ICT to support regeneration depends almost entirely on the vibrancy of local actors, their effort, commitment and opportunity to shape development.

Broadband is the term used describe a wide range of ICT that allows high-speed, always-on access to the Internet. Broadband allows a wide range of applications which are not feasible using a dial-up connection, such as streaming video, gaming, multimedia applications such as telemedicine, and so on. An increasing range of services is becoming available on the Internet. Broadband makes it easier to tap into these resources.

For Small to Medium Enterprises (SMEs) particularly, of the type that would take a tenancy in this development, broadband will allow them to enjoy levels of connectivity that have been standard for larger organisations in Turkey for some time. They can capitalise on this connectivity to move up the value chain with improved processes and e-business tools, gaining time and cost savings as well as increased customer reach.

The availability of broadband in Turkey varies widely. The difficulty for some areas is that the major telecommunications supplier is unwilling to invest in the necessary network upgrades in the absence of proven demand. Also techno fear, cost and confusion cluster to create hurdles to the adoption of broadband. Thus, micro-drivers such as the cost of dial-up access, children's education and increasing internet use could drive adoption of broadband.

There will be opportunities to use ICT in this regeneration area to gain competitive advantage. Firstly, at the area level, broadband infrastructure may be needed to achieve the economic and social aims of the project. Secondly, at the level of the property development itself, there is an opportunity to provide ICT services as part of an overall offering. Business relocation decisions are typically made on the basis of price and location. Differentiation can then occur on the basis of facilities and amenities. It is here that the level of ICT provision can impact on the marketability of property in the development.

The provision of good quality ICT services will play a part in reversing preconceived notions held about this particular area of Istanbul. As developments start to be differentiated by the range of ICT services provided to tenants, branding will focus increasingly on the contribution that the range of ICT services makes to the overall brand of the development rather than the other infrastructure capabilities.

In addition to the above differentiated benefits, ICT solutions will increasingly be used to generate revenues and reduce construction and operation costs for development stakeholders. For example, wireless connectivity added here will be an innovative approach to neighbourhood renewal.

4.2 E- Business, E-Learning, and Knowledge Management

E-business is the conduct of business on the internet, not only buying and selling, but also servicing customers and collaborating with business partners. This broad definition covers everything from a simple brochure-ware website to complex supply chain integration between suppliers and their partners.

Increasingly, organisations are seeking to tie in their partners, i.e. suppliers, strategic partners, and customers, through business to business integration platforms including marketplace, middleware, logistic networks and EDI. Greater integration across the supply and demand chain in this development will allows these organisations to feed more accurate and timely management information into their reporting systems allowing them to perform better forecasting, reducing inventory and overheads.

There will be an opportunity here for regeneration and economic development by helping SMEs to reap the benefits of e-business. There may be a case for aggregating demand in such a way that applications could be provided to SMEs through an Application Service Provider (ASP) model. Here, applications will be delivered over the internet through a dedicated website or portal. The user will be able to access the application through a browser. This will reduce maintenance and licence costs of software. Another application would be e-procurement where groups of SMEs could access online marketplaces which aggregate goods to reduce costs.

These solutions underline the importance of broadband availability. Over time this type of infrastructure will gain in importance as a source of competitive advantage, and eventually it will be as common as roads or utility provision.

The shift to more knowledge-intensive industries will make education and training even more important in enabling people to take up employment opportunities. Accordingly, e-learning will become a mainstream application across all learning and disciplines. E-learning in the development will involve the provision of training and education on-line. This will involve a wide range of learning activities: from highly tailored business-focussed applications to university degrees. To take advantage of these resources, IT literacy will be a pre-requisite. This will underline the importance of IT training as a tool in projects aimed at social inclusion and economic advantage.

Knowledge management and collaboration initiatives will be aimed at organisations to make them more effective in reusing and leveraging intellectual capital. Knowledge management refers to the collection, storage and presentation of information within and outside an organisation. Applications will include portals, databases, newsletters, and other information tools. Collaboration will involve working with partners or employees located in different sites. Tools will include portals, email, and other specialised applications that facilitate design processes and the exchange of ideas.

Turkey's communications market holds much potential given the size of its population and its growing economy due to the country's integration with the European Union (EU). The telecommunications market has been liberalised with a number of licences awarded to alternative operators and a 55% stake in the incumbent fixed-line operator, Turk Telecom, privatised. The country's telecoms regulatory framework has been amended to conform to the EU's regulatory framework for communications.

ICT services in the development

Based on the demand for and supply of ICT services in the Kartal & Pendik development, key objectives of an ICT strategy will be:

- future-proofing for both technology as well as customer growth.
- flexibility for changes in technology and customer requirements.
- commercial astuteness for the best return on investment for Kartal & Pendik Estate Management and its ICT partners.

The development project will be carried out in a number of phases. The requirement for ICT services will commence at different times in different parts of the development. Hence, whilst planning on a site-wide basis is needed to achieve a modular, scalable, coherent, and consistent approach that can result in clear commercial benefits, planning the phased piecemeal development, and the resulting gradual penetration, of ICT services over a longer period of time is of equal importance.

The plan for a site-wide ICT infrastructure will therefore include the plan for the permanent infrastructure that will need to be designed and implemented initially, and the plan for extending this permanent infrastructure into each new development area.

ICT infrastructure in the development

6.1 ICT analytical model

ICT equipment and services can be analysed into a hierarchical model based on five layers:

- Infrastructure, based on commercial and domestic transmission cables and ducts.
- Networks, including wireless and fixed network equipment.
- Systems, supporting particular services.
- Services, based on voice, data and image communications.
- Terminals and interfaces, providing users with access to voice, data and image Information.

6.2 Site-wide ICT infrastructures

ICT Services will be brought into development either through wired or wireless connections. Whilst Turk Telecom and cable TV suppliers are likely to provide their services almost exclusively via wired connections both into and inside the development, cellular operators will bring their services into the development via wireless connections. Cellular operators are likely to provide their services inside the development via wired connections up to the transmitting antennae and then via wireless connections to mobile customer terminals. Satellite services providers are likely to provide their services to customer TV terminals inside the development via wireless connections only.

6.3 Site-wide wired ICT infrastructure

For routing wired connections inside the development, a permanent cable routing infrastructure, i.e. a duct infrastructure, will be required. The duct infrastructure will be designed in such a way that all existing and future ICT service providers including the present incumbent, Turk Telecom, can:

- route their services cables to all parts of the development.
- have sufficient duct space to route their service cables.
- maintain secure services by avoiding a single point of duct/cable failure, by using for example duplicated routes, e.g. employing duplicated ring network topologies.
- extend their services cables in accordance with the phased development programme.

The duct infrastructure will provide highly secure wired connections to the Telco/Carrier and cable TV supplier networks. Hence, to avoid a single point of failure of external services, there will be a minimum of two geographically well-separated connections from the duct infrastructure to the service provider networks, i.e. service providers will be provided with the ability to connect into the duct infrastructure at a minimum of two geographically separate points of entry into the duct network infrastructure. The points of entry will be located such that the service providers can connect their networks conveniently, i.e. routing cables along the shortest distance along for example major roadways, ideally from two separate switching nodes on their networks.

Whilst the other utilities, i.e. gas, electricity, water and sewage, will have their own site-wide permanent infrastructures inside the development using for example common roadways, the design of the duct infrastructure for ICT services will be coordinated with the design of the duct infrastructures for these other utilities.

6.4 Site-wide wireless ICT infrastructure

The need for particular cellular operators to have their own radio transmission infrastructure inside the development, for providing mobile cellular services in the development, will depend on their existing radio transmission infrastructure and coverage in the area of the development. Hence, a dialogue will be initiated with cellular operators to identify the need for space for their own radio transmission infrastructure inside the development.

If some cellular operators require their own radio transmission infrastructure inside the development, cellular receiving antennae (used by a cellular operator to receive services into the development from its back-haul network) will need to be located either on a dedicated antenna mast (or masts) or at the top of buildings, with sufficient space nearby for housing associated transmitter/receiver equipment. Similarly, cellular transmitting antennae (used by a cellular operator to provide services inside the development in areas occupied by its customers, e.g. in corporate offices, retail premises, open spaces and roadways, and residences) will need to be located either on a dedicated antenna mast (or masts) or at the top of buildings, with sufficient space nearby for housing associated transmitter/receiver equipment.

Even with a dedicated mast or masts inside the development for cellular operators, there may still be a requirement for some transmitting radio antennae (and associated radio transmission equipment) to be located closer to the target area of radio coverage. This equipment will be located on some buildings in the development. Network connections will be installed between the dedicated mast area and this equipment. These connections may be either wireless or wired: wireless connections will use line of sight radio transmission and wired connections will use the site-wide duct infrastructure.

The overall architectural and commercial strategy for the development will determine whether it is advisable to reserve one or more special areas for a dedicated antenna mast and for building space for mounting cellular antennae and associated equipment. A dedicated mast or masts will avoid the mushrooming of antennae on buildings throughout the development and may also provide Kartal & Pendik Estate Management and its ICT partner(s) with commercial opportunities.

Implementing the ICT infrastructure

7.1 Designing

Preliminary deliverables based on an ICT infrastructure strategy for the development will include:

- the design of a site-wide duct infrastructure, in liaison with Turk Telecom, cable TV suppliers in the area, satellite TV providers, and the designers of an infrastructure for the other utilities.
- an outline plan for a wireless infrastructure, drawn in liaison with cellular operators and satellite TV services providers.

7.2 Procuring, owning, operating and maintaining

The overall commercial strategy for the development will determine whether it is advisable either for Kartal & Pendik Estate Management or its chosen partner(s), or one or more of the major Telcos/Carriers that will provide their services in the development, to carry out one or more of the following tasks with respect to the site wide duct infrastructure:

- supply and install.
- operate and maintain.
- own.

Similarly, the overall commercial strategy for the development will determine whether it is advisable either for Kartal & Pendik Estate Management or its appointed partners, or one or more of the cellular operators that will provide their services in the development, to carry out one or more of the following tasks with respect to the site-wide wireless infrastructure:

- design.
- supply and install.
- operate and maintain.
- own.

7.3 Extending in the phased development

The site-wide wired (i.e. duct) and wireless infrastructures will need to be extended when the phased developments take place. Generic commercial and technical strategies for extending the ICT infrastructures in the phased developments will need to be drawn up and agreed with the sub-contractor developers.

The generic technical strategy for extending the ICT infrastructures will address:

- the guidelines for the design of a duct infrastructure.
- the planning of a wireless infrastructure in the phased developments.

7.4 Programme for implementing and extending

An indicative programme of actions, in sequential order according to their commencement, with respect to the ICT infrastructures in the development is:

- Liaise with Turk Telecom, cable and satellite TV operators and cellular operators, to inform them of the Kartal & Pendik project development plan and the commercial opportunities in the development, to obtain feedback on the wired and wireless infrastructure they require for providing their services in the phased development and their potential responsibilities for planning, implementing, operating, maintaining and owning them.
- Design a site-wide duct infrastructure, in liaison with the Turk Telecom, cable TV suppliers in the area, satellite TV providers, and the designers of an infrastructure for the other utilities.
- Draw an outline plan for a site-wide wireless infrastructure, in liaison with cellular operators and satellite TV providers.
- Determine the commercial strategy for designing, installing, operating and maintaining and owning the permanent duct infrastructure in the development and extending it in a phased development programme.
- Determine the commercial strategy for designing, installing, operating and maintaining and owning the permanent wireless infrastructure in the development and extending it in a phased development programme.
- Based on the commercial strategies, agree responsibilities for designing, installing, operating, maintaining, and owning the site-wide wired and wireless infrastructures.
- Install, operate and maintain the site-wide duct infrastructure in the development.
- Design, install, operate and maintain the site-wide wireless infrastructure in the development.
- Draw up generic commercial and technical strategies for extending the ICT infrastructures in the phased development.
- Agree with the sub-contractor developers the generic commercial and technical strategies for extending the ICT infrastructures in the phased development.