4.4.3. Hazardous Facilities

A possibility of fire outbreaks from facilities where inflammable liquids or gases materials are handled was estimated. The facilities are classified as follows:

(1) Petrol stations

(2) Refuelling stations

(3) Gas refilling workshops

(4) Kerosene distributors

(5) Oil distributors

The concepts of the estimation are as follows:

- The offices of the facilities will suffer damages caused by earthquake motion, and the damage functions for residential buildings were applied in the estimation of damages to office buildings.
- At facilities that are seriously damaged or collapsed, inflammable liquids or gases will leak from the storage tanks.
- The leaking liquids or gases ignite to fire according to the following probability:

Petrol stations, refuelling stations: 2.55%

Others: 3.66%.

(Kanagawa Prefecture 1986)

- The above values are estimated based on Japanese experience. No case information on fire occurrences in Iran was available. Consequently, the results show only a relative possibility of fire occurrence.
- The number of fire outbreaks is summed up in each district and then expressed as rating of fire hazard.

The distribution for the hazardous facilities is not uniform in the Study Area and it is considered that the database was not prepared based upon a uniform criterion. Therefore, fire outbreak was calculated for the municipal districts in which more than 5 hazardous facilities were located within the district. There are only 11 such districts among the 22 districts considered in the Study.

Results of the analysis are shown in Table 4.4.14. Distribution of the vulnerability rating for districts under the Ray Fault Model are shown in Figure 4.4.17.

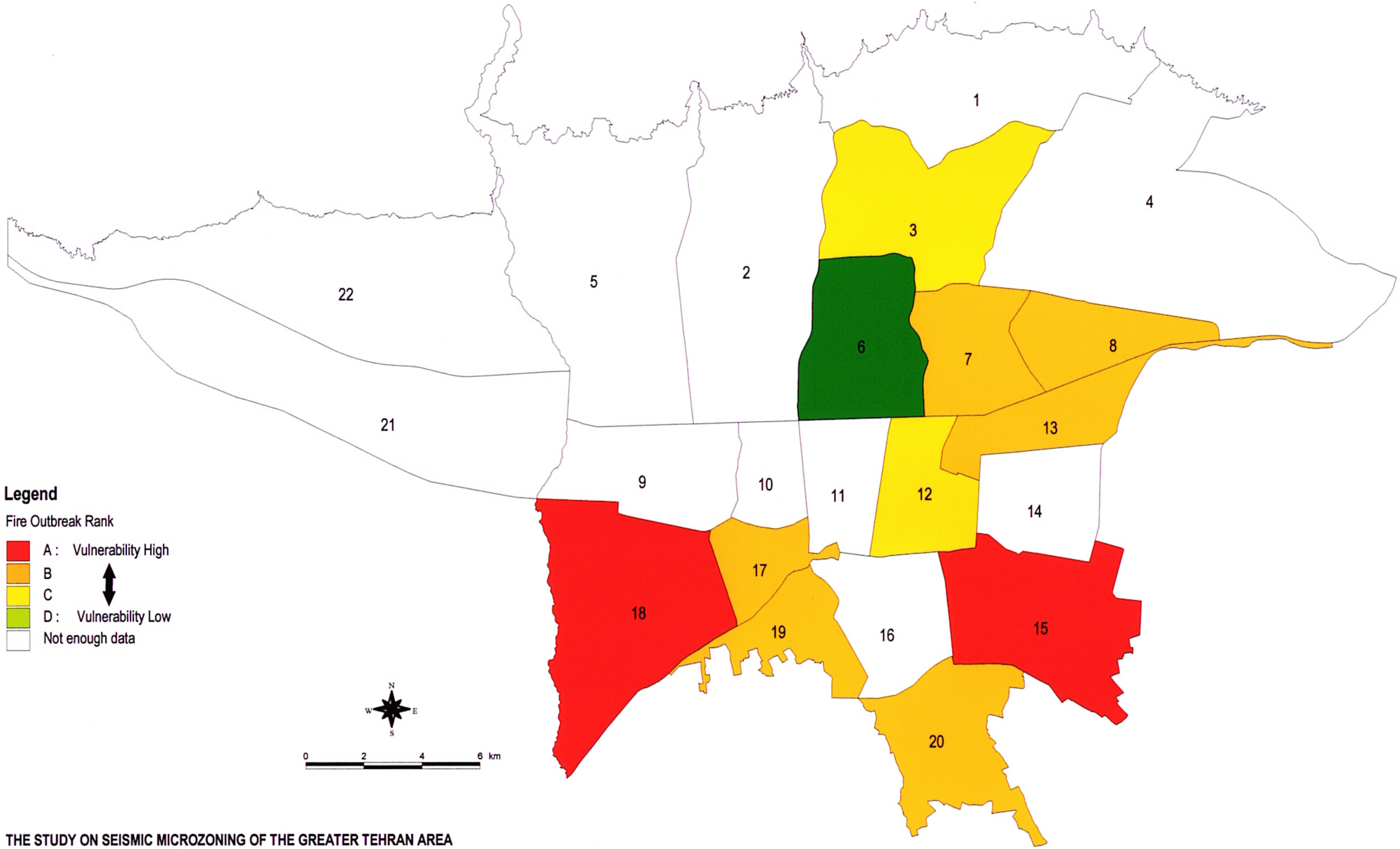
Table 4.4.14 Vulnerability Rating of Fire Outbreaks from Hazardous Facilities

District	Petrol Station	Other Types of Stores	Vulnerability Rating			
			Ray Fault Model	NTF Model	Mosha Fault Model	Floating Model
1	2	0				
2	3	0				
3	8	0	C	C	D	C
4	1	0				
5	1	0				
6	6	0	D	D	D	D
7	10	8	B	C	D	B
8	4	7	B	B	C	B
9	3	0				
10	2	0				
11	4	0				
12	7	1	C	D	D	C
13	10	8	B	C	D	B
14	3	0				
15	2	17	A	C	D	B
16	2	0				
17	3	6	B	C	D	B
18	2	32	A	B	C	A
19	0	9	B	D	D	C
20	5	8	B	D	D	B
21	0	0				
22	0	0				
Sum	78	96				

Vulnerability Rating	Possibility of Fire Outbreak
A:	High
B:	↑
C:	↓
D:	Low
Blank:	Inadequate Data

Figure 4.4.17

Fire Outbreak Rank from Hazardous Facility(Ray Fault model)



THE STUDY ON SEISMIC MICROZONING OF THE GREATER TEHRAN AREA IN THE ISLAMIC REPUBLIC OF IRAN

Centre for Earthquake and Environmental Studies of Tehran (CEST)
Japan International Cooperation Agency (JICA)

4.4.4. Liquefaction

(1) General

The following three grades are indicated as the liquefaction potential estimation in the " Manual for Zonation on Seismic Geotechnical Hazards" by TC4, ISSMFE(1993).

Method Grade 1: simple and synthetic analysis by using geological maps, topographical maps and histories of disaster

Method Grade 2: a rather detailed analysis using site reconnaissance results, interviewing the local residents, etc.

Method Grade 3: a detailed analysis using geological investigation results and numerical analyses

It is considered that Method Grade 3 is appropriate in quality and content, compared to other estimation items of the Study. The main content of the evaluation of the liquefaction potential is the comparison of the soil strength with the seismic motion. Various procedures exist to determine these values. Soil properties are determined by simple physical property tests or detailed dynamic laboratory tests. Seismic motion is determined using only information on ground type of the area or an estimated waveform for target earthquakes. In the latter case, the waveform is used to obtain the maximum value of acceleration during an earthquake or time-dependent change of acceleration. The procedure should be determined considering the objective of the estimation. In cases where critical situations are estimated in designing important facilities, a point base analysis is to be used with detailed procedures. In this seismic microzoning study, soil strength and seismic motion are to be determined at the same levels of quality in the whole Study Area. Therefore, using some statistical method is appropriate.

The following information on soil properties and seismic motion was available in the Study:

- Borehole logs with results of Standard Penetration Tests (SPT)
- Statistically compiled physical properties of soil.
- Peak ground acceleration for scenario earthquakes

Considering the above, a combination of the F_L method and the P_L method was used in the Study. This method is commonly used in Japan for practical purposes. The result of the analysis was expressed as a point base, because the quantity of available borehole data was limited. The flowchart of the liquefaction analysis used in this project is shown in Figure 4.4.18.

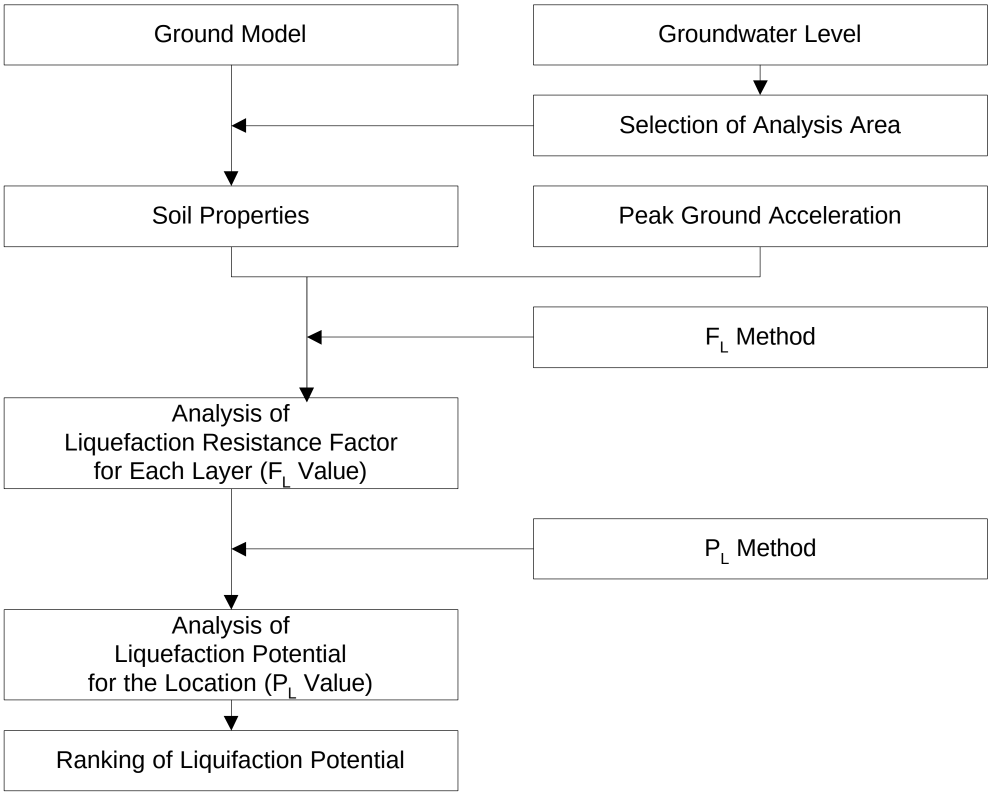


Figure 4.4.18 Flowchart of Liquefaction Analysis

(2) Method of the Liquefaction Potential Evaluation

The liquefaction potential for individual layers is analysed by the F_L method. The whole liquefaction potential at the analysed point is evaluated by the P_L method based upon the results of the F_L method.

<u>FL Method (Japanese Design Specification of Highway Bridge, revised 1996)</u>

Ground condition to be evaluated

Quaternary sandy soil from ground surface to depth of 20 m
Groundwater table less than 10 m from ground surface

$F_L = R/L$

F_L: liquefaction resistance factor

$F_L \leq 1.0$: Judged as liquefied
$F_L > 1.0$: Judged as not liquefied

R: cyclic shear strength at effective overburden pressure

$R = C_w \times R_L$

C_w: correlation coefficient for earthquake type

Type 1 earthquake (plate boundary type, large scale)

$C_w = 1.0$

Type 2 earthquake (inland type)

$C_w = 1.0$ $(R_L \leq 1.0)$
$= 3.3R_L+0.67$ $(0.1<R_L \leq 0.4)$
$= 2.0$ $(0.4 < R_L)$

R_L: cyclic resistance ratio obtained by laboratory test

$R_L = 0.0882\ (Na/1.7)^{0.5}$ (Na<14)

$= 0.0882\ (Na/1.7)^{0.5} + 1.6\times10^{-6}(Na-14)^{4.5}$ (14 ≤Na)

Sandy Soil

$Na = c_1 N + c_2$

$c_1 = 1$ (0% ≤ Fc < 10%),

$= (Fc + 40)/50$ (10% ≤ Fc < 60%)

$= Fc/20 - 1$ (60% ≤ Fc)

$c_2 = 0$ (0% ≤ Fc < 10%)

$= (F-10)/18$ (10% ≤ Fc)

Fc : fine contents

Gravelly Soil

$Na = \{1-0.36\log_{10}(D_{50}/2.0)\}N_l$

N: SPT blow count

Na: N value correlated for grain size

N_l: $1.7N/(\sigma_v' + 0.7)$

D_{50}: grain diameter of 50% passing (mm)

L: shear stress to the effective overburden pressure

$L = \alpha / g \times \sigma_v/\sigma_v' \times r_d$

r_d : stress reduction factor

$r_d = 1.0 - 0.015x$

x : depth in meters below the ground surface

α: peak ground acceleration (gal)

g: acceleration of gravity (= 980 gal)

σ_v: total overburden pressure

σ_v' : effective overburden pressure

<u>P_L Method (Iwasaki et al. 1982)</u>

$$P_L = \int_0^{20} F \cdot w(z)dz$$

$15 < P_L$	Very high potential
$5 < P_L \le 15$	Relatively high potential
$0 < P_L \le 5$	Relatively low potential
$P_L = 0$	Very low potential

$F = 1-F_L$ ($F_L<1.0$)

$= 0$ ($F_L\ge1.0$)

$w(z) = 10 - 0.5z$

P_L: liquefaction potential index

F_L: liquefaction resistance factor

w(z): weight function for depth

z: depth in meters below the ground surface

(3) Precondition for the Analysis

<u>Groundwater level and analysed area</u>

The F_L method defines that groundwater level to be considered as less than 10 m from the ground surface. The area with groundwater level less than GL-15 m was considered in the Study, considering the fluctuation of the groundwater level. The data on groundwater level was based upon CEST (1998). Details are explained in the section 2.2.4, Groundwater. The area selected corresponds to southeastern part of Tehran, the entire areas of Districts 15, 16, 20, the southern areas of Districts 11, 12, 14 and the eastern areas of District 19. In the calculations, the groundwater level was modelled as the actual groundwater level minus 5 m. This lead to over-calculated and safe results.

Peak ground acceleration

The Ray Fault Model presented the biggest peak ground acceleration value in the selected area. The acceleration value for each borehole location was used.

Soil parameters

Collected soil property data was statistically analysed and is shown in the Appendix. The following soil parameters were determined:

Table 4.4.15 Soil Parameters for Liquefaction Analysis

Soil Type	Fine Contents Fc (%)	Grain Diameter of 50% passing D_{50} (mm)	Grain Diameter of 10% Passing D_{10} (mm)	Unit Weight γ_t (g/cm^3)
Gravelly Soil	2.3	5	0.1	2.2
Sandy Soil	14.2	2.1	-	2.1
Clayey Soil	no possibility of liquefaction, because clay content (Cc) is 20% or over			

(4) Liquefaction Potential

The results of the analysis for each borehole are also shown in the Appendix. These results are summarised in Table 4.4.16 and Figure 4.4.19.

Table 4.4.16 Summary of the Liquefaction Analysis

Liquefaction Potential	Criterion	Explanation	No. of Boreholes
Very high	$15<P_L$	Ground improvement is indispensable	0
Relatively high	$5<P_L\leq15$	Ground improvement is required Investigation of important structures is indispensable	1
Relatively low	$0<P_L\leq5$	Investigation of important structures is required	12
Very low	$P_L=0$	No measure required	39

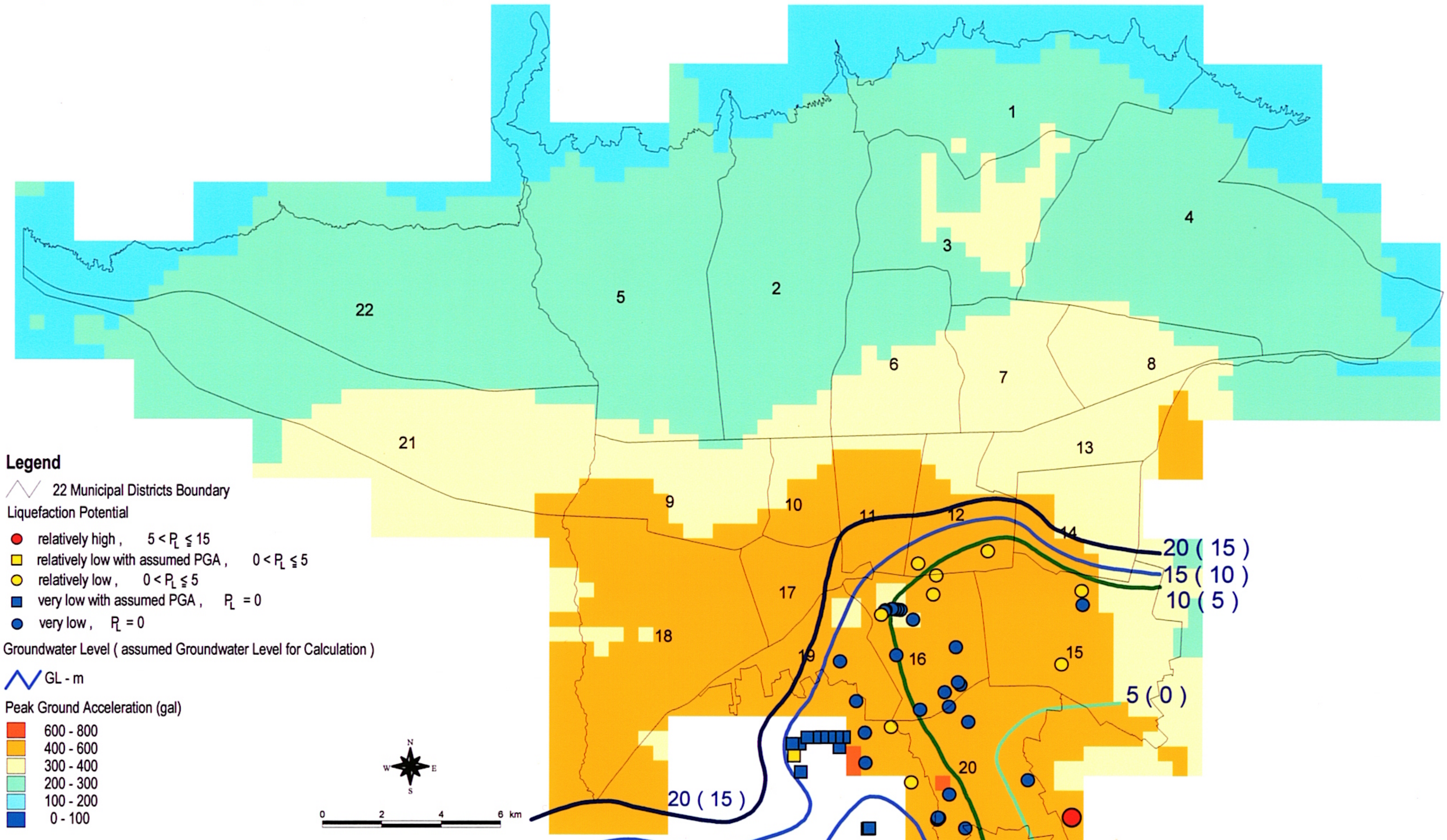
Almost the entire area is rated as having ‘ very low’ or ‘ relatively low’ liquefaction potential. Stiff cohesive clayey soil is predominantly deposited in the analysed area. Some sand or gravel layers are interbedded the clayey soil.

Only one borehole location was judged as having ‘ relatively high’ liquefaction potential. This borehole is located in the eastern area of District 20. The geological circumstances indicate that the distribution of high-potential liquefable soil in this area is relatively limited.

It is concluded that the risk of liquefaction in the Study Area, with some exceptions, is low. Detailed soil investigation should be carried out to confirm the distribution of such liquefable soils.

Figure 4.4.19

Liquefaction Potential (Ray Fault model)



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