Environmental and Social Impact Assessment Final Report: Annexes (Part 1)

Project Number: 51090-001
March 2018

ARM: Yerevan Gas-Fired Combined-Cycle Power Project

Prepared by Fichtner, Stuttgart, Germany

12. Annexes

12.1 Communication from Yerevan Municipality - illegal dwellings

ԵՐԵՎԱՆԻ ՔԱՂԱՔԱՊԵՏԱՐԱՆ

ԵՐԵՎԱՆ ՔԱՂԱՔԻ ԳԼԽԱՎՈՐ ՃԱՐՏԱՐԱՊԵՏ

ՀՀ, 0015, ք. Երևան, Արգիշտիի 1

№ 50/2-#1827 «10» 11 2017 թ.

«ԱՐՄՓԱՐՈՒԵՐ» ՍՊԸ ԳԼԽԱՎՈՐ ՏՆՕՐԵՆ

ՊԱՐՈՆ Ք.ԿՈՒԿՈՒՐԱԿԻՒՆ

Հարգելի պարոն Կուկուրակի

Ի պատասխան Երևանի քաղաքապետին հասցեագրված Ձեր 07.11.2017թ. գրության Երևանի Շենգավիթ վարչական շրջանում նախատեսվող ՀՇԳՑ-2 էլեկտրակայանի կառուցման կապակցությամբ բարձրացված հարցերի վերաբերյալ տեղեկացնում ենք, որ նախատեսվող ՀՇԳՑ-2 էլեկտրակայանից դեպի հյուսիս-արևելք ընկած հարակից տարածքներում Շենգավիթ վարչական շրջանի համար մշակված գոտիավորման նախագծով քաղաքաշինական ծրագրային գործունեություն չի նախատեսվում: ՀՇԳՑ-2 էլեկտրակայանի շինարարությունը որևէ սոցիալական բացասական ազդեցություն չի կարող ունենալ շինարարական հրապարակից նշված հեռավորության վրա գտնվող կացարանների հետագա ճակատագրի վրա: Միաժամանակ այդ կացարանների և դրանց բնակիչների հետ կապված հետագա գործողությունները որևէ գույքային,սոցիալական և ֆինանսական հետևանքներ չեն կարող առաջացնել ՀՇԳՑ-2 էլեկտրակայանի շինարարության ծրագրի համար:

Տ.ՓԱՐՍԵՂՅԱՆ

Կատ. 011 514 358

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YEREVAN MUNICIPALITY

MAIN ARCHITECTURE OF YEREVAN

10.11.2017

№ 50/2-71827

To the general director

Of "ArmPower" CJSC

Mr. C. Cucurachi

Dear Mr. Cucurachi,

In response to Your letter of 07.11.2017 addressed to the Yerevan Mayor, on the questions arisen for the planned CCPP-2 construction in the Shengavit administrative area, we inform, that in the adjacent areas situated to the north-east of the CCPP-2, a planned action of urban development is not foreseen by the project of the developed zoning for the Shengavit administrative area. The CCPP-2 construction cannot have any social negative impact on the further destiny of dwellings situated in the indicated distance from the construction site. At the same time, the further actions regarding those dwellings and their inhabitants cannot cause any property, social and financial consequences for the CCPP-2 construction project.

T. Barseghyan

12.2 Communication from Veolia Djur CJSC on water supply

VEOLIA
Ջուր

«Արմիաուէր» ՓԲԸ
Ք. Կուկուրեկինին
/հասցեն՝ ք. Երևան, Վ. Սարգսյան 10/

Ելից/ԳԳ/15193/2017.11.17 Երևան 24 նոյեմբերի 2017թ.

Առարկան՝ Պարզաբանում դիմումի վերաբերյալ

Հարգելի պարոն Կուկուրեկի,

Ի պատասխան Ձեր 17.11.2017թ. դիմումի՝ հայտնում եմ, որ տեխնիկական պայմանը տրված է տեխնիկական լուծումների հաշվառմամբ:
Տեղեկացնում եմ նաև, որ սահմանված կարգով աշխատանքները սկսելուց առաջ անհրաժեշտ է ԿՕ/574 տեխնիկական պայմանի հիման վրա կազմված նախագծային փաստաթղթերը համաձայնեցնել «Վեոլիա Ջուր» ՓԲԸ-ի հետ:

Հարգանքով՝ Գործառնական տնօրեն
Գոռ Գրիգորյան

Պատասխանատու՝
Մ. Միրզոյան
Հեռ.՝ 011 59 03 86

15193
24 11 17

Հայաստանի Հանրապետություն
ք. Երևան, 375025
Սրվանձտյան փ. 66/1
Հեռ./Ֆաքս (+374 10) 56-93-57

66a St. Abovyan
375025 Yerevan
Republic of Armenia
Tel./fax (+374 10) 56-93-57

VEOLIA
Group

To the general director of "Armpower" CJSC C. Cucurachi,

/address: 10 V. Sargsyan str., Yerevan/

N 15193/24.11.17

Yerevan, 24 November, 2017

Subject: Clarification about the application letter

Dear Mr. Cucurachi,

As a reply to your application letter of 17.11.2017, I would like to inform you that the Technical specification has been provided taking into account all the technical norms and criteria.
I also inform you that before starting the works in accordance with the established procedure it is necessary to agree the design documents, compiled according to the technical specification N KO/574, with "Veolia Jur" CJSC.

Best regards,

Executive director

Gor Grigoryan

Responsible
M. Mirzoyan
Tel.: 011 59 03 86

66a St. Abovyan
375025, Yerevan,
Republic of Armenia
Tel./Fax (+374 10) 56-93-57

VEOLIA

«ԱՐՄՓԱՄԲԵՐ» ՓԲԸ գլխավոր տնօրեն
պարոն Ք. Կուկուրակինին

ԵլիցԳՕ/ 2076 / 07.12.2017թ. Երևան, 07 դեկտեմբեր, 2017թ.

Առարկա՝ Հարցում

Հարգելի պարոն Կուկուրակի,

Ի պատասխան հարցման՝ տեղեկացնում ենք, որ տրամադրված տեխնիկական պայմանով նախատեսված ջրաբանակը հաշվարկված է այն սկզբունքով, ինչը բացառում է այլ բաժանորդների հաշվին ջրաբանակի տրամադրումը մեկ այլ օբյեկտի և չի կարող հանգեցնել վերջիններիս ջրամատակարարման վատթարացմանը:

Հարգանքով, «Վեոլիա Ջուր» ՓԲԸ
«Արենիը» SS տնօրեն՝
Կարապետ Օհանյան

VEOLIA
Ջուր

VEOLIA

Armpower CJSC

To the general director C. Cucurachi

N KO/2076 / 07.12.2017

Yerevan, 07 December, 2017

Subject- Inquiry

Dear Mr. Cucurachi,

As a reply to your inquiry we would like to inform you that the water amount foreseen by the provided technical specification has been calculated according to the principle that excludes the water amount provision to another object at the expense of other subscribers and can't result in the latters' water supply deterioration.

Regards,

Karapet Ohanyan,

Technical Director of "Arevelk"
"Veolia jur" CJSC

12.3 Record of Meetings

Date	Agency/ Institution	Place	Name of Person consulted	Reason for Visit
04.07.2017	RENCO SPA	Yerevan	Gegham Baklachev (RENCO), Vram Tevosyan (Consecoard LLC)	Discussion of technical and environmental issues of construction and operation of YCCPP-2
04.07.2017	Municipality of Kharberd village	Kharberd	Kamo Kakoyan (Mayor of Kharberd), Gegham Baklachev, Vram Tevosyan	Introducing the Project; discussing possible concerns
04.07.2017	Municipality of Ayntap village	Ayntap	Karen Sargsyan (Mayor of Ayntap), Gegham Baklachev, Vram Tevosyan	Introducing the Project; discussing possible concerns
05.07.2017	YCCPP-2 site	Yerevan	Gegham Baklachev, Vram Tevosyan	Visit of site and surrounding area
05.07.2017	RENCO SPA	Yerevan	Gabriele Colletta (RENCO engineer), Vram Tevosyan	Discussion of technical issues of construction and operation of YCCPP-2
06.07.2017	Municipality of Yerevan, Staff of Head of Erebuni Administrative District	Yerevan	Edgar Mkrtchyan (Head of Department), Gegham Baklachev, Vram Tevosyan	Introducing the Project; discussing possible concerns
06.07.2017	Aarhus Center	Yerevan	Silva Ayvazyan (Coordinator of Yerevan Aarhus Center), Gegham Baklachev, Vram Tevosyan	Introducing the Project; discussing environmental and social concerns
06.07.2017	Environmental Monitoring and Information Center	Yerevan	Shahnazaryan Gayane (Deputy Director), Gegham Baklachev, Vram Tevosyan	Discussing monitoring of stack emissions and of ambient air pollution
06.07.2017	YCCPP-1	Yerevan	Arkadi Gevorgyan (Chief Engineer), Gegham Baklachev, Vram Tevosyan	Discussing technical and environmental issues of operation of YCCPP-1
07.07.2017	Municipality of Yerevan, Environmental Department	Yerevan	Avet Martirosyan (Head of Environmental Department), Gegham Baklachev, Vram Tevosyan	Introducing the Project; discussing possible concerns
07.07.2017	Municipality of Yerevan, Staff of Head of Shengavit Administrative District	Yerevan	Armen Sargsyan (Head of Department), Gegham Baklachev, Vram Tevosyan	Introducing the Project; discussing possible concerns
07.07.2017	RENCO SPA	Yerevan	Avetik Horkannisyan (RENCO Engineer), Gegham Baklachev, Vram Tevosyan	Discussion of technical and environmental issues of construction and operation of YCCPP-2

12.4 Analysis of Oil in the Contaminated Soil from Construction Site

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WESSLING

WESSLING GmbH
Impexstraße 5 · 69190 Walldorf
www.wessling.de

WESSLING GmbH, Impexstraße 5, 69190 Walldorf

GefaÖ GmbH - Gesellschaft für angewandte
Ökologie und Umweltplanung
Herr Dr. Roland Marthaler
Impexstraße 5
69190 Walldorf

Geschäftsfeld: Umwelt
Ansprechpartner: J. Thomsen
Durchwahl: +49 6227 8 209 36
Fax: +49 6227 8 209 15
E-Mail: Julian.Thomsen@wessling.de

Prüfbericht

Jerevan CCPP-2

Prüfbericht Nr.	CWA17-016172-1	Auftrag Nr.	CWA-06752-17	Datum	18.07.2017

Probe Nr.	17-109040-01
Eingangsdatum	10.07.2017
Bezeichnung	Stelle1
Probenart	Feststoff allgemein
Probenahme	06.07.2017
Probenahme durch	Auftraggeber
Probenehmer	Jonas Martin
Probengefäß	Tüte
Anzahl Gefäße	1
Untersuchungsbeginn	11.07.2017
Untersuchungsende	18.07.2017

Probenvorbereitung

Probe Nr.		17-109040-01
Bezeichnung		Stelle1
Gesamtmasse der Originalprobe	g	200

Polychlorierte Biphenyle (PCB)

Probe Nr.			17-109040-01
Bezeichnung			Stelle1
PCB Nr. 28	mg/kg	OS	<0,05
PCB Nr. 52	mg/kg	OS	<0,05
PCB Nr. 101	mg/kg	OS	<0,05
PCB Nr. 118	mg/kg	OS	<0,05
PCB Nr. 138	mg/kg	OS	<0,05
PCB Nr. 153	mg/kg	OS	<0,05
PCB Nr. 180	mg/kg	OS	<0,05
Summe der 6 PCB	mg/kg	OS	-/-
PCB gesamt (Summe 6 PCB x 5)	mg/kg	OS	-/-

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Impexstraße 5 · 69190 Walldorf
www.wessling.de

Prüfbericht Nr.	CWA17-016172-1	Auftrag Nr.	CWA-06752-17		Datum 18.07.2017
Probe Nr.					17-109040-01
Summe der 7 PCB			mg/kg	OS	-/-

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Impexstraße 5 · 69190 Walldorf
www.wessling.de

Prüfbericht Nr.	CWA17-016172-1	Auftrag Nr.	CWA-06752-17	Datum	18.07.2017

Probe Nr.	17-109040-02
Eingangsdatum	10.07.2017
Bezeichnung	Stelle2
Probenart	Feststoff allgemein
Probenahme	06.07.2017
Probenahme durch	Auftraggeber
Probenehmer	Jonas Martin
Probengefäß	Tüte
Anzahl Gefäße	1
Untersuchungsbeginn	11.07.2017
Untersuchungsende	18.07.2017

Probenvorbereitung

Probe Nr.			17-109040-02
Bezeichnung			Stelle2
Gesamtmasse der Originalprobe	g		**200**

Polychlorierte Biphenyle (PCB)

Probe Nr.			17-109040-02
Bezeichnung			Stelle2
PCB Nr. 28	mg/kg	OS	**<0,05**
PCB Nr. 52	mg/kg	OS	**<0,05**
PCB Nr. 101	mg/kg	OS	**<0,05**
PCB Nr. 118	mg/kg	OS	**<0,05**
PCB Nr. 138	mg/kg	OS	**<0,05**
PCB Nr. 153	mg/kg	OS	**<0,05**
PCB Nr. 180	mg/kg	OS	**<0,05**
Summe der 6 PCB	mg/kg	OS	-/-
PCB gesamt (Summe 6 PCB x 5)	mg/kg	OS	-/-
Summe der 7 PCB	mg/kg	OS	-/-

Geschäftsführer:
Julia Wessling, Florian Wessling
AG Steinfurt HRB 1153

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WESSLING GmbH
Imexstraße 5 · 69150 Walldorf
www.wessling.de

Prüfbericht Nr.	CWA17-015172-1	Auftrag Nr.	CWA-06752-17	Datum	18.07.2017

Abkürzungen und Methoden		ausführender Standort
Polychlorierte Biphenyle (PCB)	DIN EN 15308[A]	Umweltanalytik Walldorf
		Umweltanalytik Walldorf
OS	Originalsubstanz	

Julian Thomsen
M. Sc. Biogeowissenschaften
Sachverständiger Umwelt und Wasser

12.5 Report on Groundwater Quality and Possible Soil Contamination from August 2017

12.6 Noise Propagation Study

12.7 Waste Water Temperature Study (steady state), ArmPower

12.8 Air Dispersion Calculation

12.9 Stakeholder Engagement Plan

12.10 Legal Framework of Earth Cover Pollution Standardization in Armenia and Results of the YCCPP-2 Territory Research, Consecoard 2018

12.11 Report on Soil Analysis, Groundwater and Hrazdan River Water Quality from February 2018

12.12 Legal Framework of Air Emissions Standardization in Armenia and Assessment of the planned YTPP-2 Emissions, Consecoard 2018

12.13 Public Consultation Meeting at Yerevan 10th February 2018

Report

On Monitoring Services

Yerevan, August 11, 2017

Based on the contract signed between "Renco Armestate" LLC and "Consecoard" LLC on 14.07.2017, the specialists of "Consecoard" LLC carry out monitoring of Yerevan TPP-2 construction site, which includes:

- topsoil, surface water and groundwater sampling according to the list submitted by the Client,
- organizing the tests in the appropriate licensed laboratory according to the List of Materials and Indicators Provided by the Client,
- analysis of results and comparison with sanitary norms in the Republic of Armenia.

Currently, "Consecoard" LLC specialists have conducted all samplings:

1. Land
   - from the central part of the area allocated for construction,
   - from the roadside,
   - near the pile of barrels of used oils existing in the area
2. Water
   - water leak during drilling of the area. Sampled water taken during drilling of a site for construction. The water was taken from the wells 7.9 m and 2.8 m, dug for sampling near the BH 1 (x – 457072.44, y – 4440369.06) and BH 17 (x – 457316.96, y – 4440491.54) wells for geological survey. Sampling was carried out 3 hours after the drilling works to ensure water simplicity.
   - water running through the pipe in the central part of the construction site,
   - outflow of canal water from the operating Yerevan TPP1

The sampling was conducted by the methodology of the Monitoring Center of the Ministry of Nature Protection of the Republic of Armenia with the participation of the representative of Renco company: Gegham Baklachev.

The collected samples have been moved to the “Laboratory of Environmental Monitoring and Information Center” SNCO of the Ministry of Nature Protection of the Republic of Armenia.

The results and data analysis are presented below.

Table 1. Water, common indicators:

№	Measured indicator	Unit of measurement	The results of analysis			The method of analysis
			Sample 1	Sample 2	Sample 3	
1	Hydrogen indicator (pH)	-	7.25	6.68	8.34	Electrochemical
2	Dissolved oxygen	mgO_2/l	1.34	7.37	6.61	Electrochemical
3	Mineralization	mg/l	1708	111	786	Electrochemical
4	BOD_5	mgO_2/l	1.50	1.19	6.80	Electrochemical
5	COD_5[1]	mgO_2/l	288	136	416	Oxidation by bichromate

[1] The COD value is high since the laboratory test was performed weeks after sampling.

Table 2. Water, Metals and Organic Compounds:

№	Measured indicator	Unit of measurement	The results of analysis			The method of analysis
			Sample 1	Sample 2	Sample 3	
6	Lithium	Mg/l	0.0340	0.0038	0.0212	ICP-MS[2]
7	Beryllium	Mg/l	$<10^{-6}$	$<10^{-6}$	$<10^{-6}$	ICP-MS
8	Boron	Mg/l	0.9258	0.0259	0.2678	ICP-MS
9	Natrium	Mg/l	269.5	6.8	95.5	ICP-MS
10	Magnesium	Mg/l	18.8	5.8	24.0	ICP-MS
11	Aluminum	Mg/l	0.0795	0.0052	0.0097	ICP-MS
12	Total phosphorus	Mg/l	0.0798	0.1148	0.2157	ICP-MS
13	Potassium	Mg/l	2.4	2.4	8.2	ICP-MS
14	Calcium	Mg/l	171.1	14.8	28.8	ICP-MS
15	Titan	Mg/l	0.0110	0.0037	0.0020	ICP-MS
16	Vanadium	Mg/l	0.3475	0.0213	0.0092	ICP-MS
17	Chrome	Mg/l	0.0079	0.0010	0.0063	ICP-MS
18	Iron	Mg/l	0.2262	0.0337	0.0828	ICP-MS
19	Manga	Mg/l	0.0818	0.0009	0.0020	ICP-MS
20	Cobalt	Mg/l	0.0017	0.0007	0.0002	ICP-MS
21	Nickel	Mg/l	0.0029	0.0003	0.0012	ICP-MS
22	Copper	Mg/l	0.0034	0.0006	0.0033	ICP-MS
23	Zinc	Mg/l	3.0628	0.0025	0.0038	ICP-MS
24	Arsen	Mg/l	0.0541	0.0011	0.0059	ICP-MS
25	Selen	Mg/l	0.0054	0.0002	0.0014	ICP-MS
26	Strontium	Mg/l	2.2267	0.0821	0.2446	ICP-MS
27	Molybdenum	Mg/l	0.0588	0.0009	0.0485	ICP-MS

[2] The applied method: Inductively coupled plasma mass spectrometry (ICP-MS)

28	Cadmium	Mg/l	0.00017	0.00001	0.00014	ICP-MS
29	Tuna	Mg/l	0.00109	0.00020	0.00041	ICP-MS
30	Antimony	Mg/l	0.00015	0.00010	0.00008	ICP-MS
31	Barium	Mg/l	0.0268	0.0070	0.0219	ICP-MS
32	Lead	Mg/l	0.0011	0.0002	0.0005	ICP-MS
33	Benzene	Mg/l	<0,0001	-	<0,0001	Gas chromatography
34	Toluene	Mg/l	<0,0001	-	0.001	Gas chromatography
35	Oktan	Mg/l	<0,0001	-	<0,0001	Gas chromatography
36	Ethylbenzene	Mg/l	<0,0001	-	<0,0001	Gas chromatography
37	Xylol	Mg/l	<0,0001	-	<0,0001	Gas chromatography
38	Nona	Mg/l	<0,0001	-	0.00014	Gas chromatography
39	Mixture of alkanes ($C_{10}H_{22}$-$C_{22}H_{46}$)	Mg/l	3.474	-	2.758	Gas chromatography

According to RA Government Decree " On defining water quality norms for each water basin management area taking into consideration the peculiarities of the Locality," (RA Government Decree N 75-N, dated on 27 January 2011,) the surface water quality assessment system in Armenia distinguishes five class statuses for each grade: "excellent" (1st grade), "good" (2nd grade), "mediocre" (3rd class); "Insufficient" (grade 4) and "bad" (5th grade).

The government's decision envisages maximum permissible concentrations for all classes, in case of exceeding them, the flow to water resources is prohibited.

Yerevan Thermal Power Plant territory is located in Hrazdan river basin(watershade) management area. According to "Armecomonitoring"'s reference outcomes on " Ecological Monitoring of the RA Environment" for 2015, the water in the lower stream of the Hrazdan River is "bad" (5th grade).

Below are the 5 th class limits for the Hrazdan River basin management, along with the results of the analysis.

Table 3. Water quality comparative data. General indicators

№	Comparable index	Unit of measurement	Norms by Water Quality Classes					The average result of the analysis
			I	II	III	IV	V	
1	2	3	4	5	6	7	8	9
1	Hydrogen indicator (pH)	-	6.5-9	6.5-9	6.5-9	6.5-9	<6.5 >9	7.25 - 8.34
2	Dissolved oxygen	mgO_2/l	>7	>6	>5	>4	<4	1.34 - 7.37
3	Mineralization	mg/l	74	148	1000	1500	>1500	111 - 1708

4	BOD_5	mgO_2/l	3	5	9	18	>18	1.19 - 6.80
5	Benzene	Mg/l	-	-	-	-	-	<0,0001
6	Toluene	Mg/l	-	-	-	-	-	0.001
7	Octane	Mg/l	-	-	-	-	-	<0,0001
8	Ethylbenzene	Mg/l	-	-	-	-	-	<0,0001
9	Xylol	Mg/l	-	-	-	-	-	<0,0001
10	Nona	Mg/l	-	-	-	-	-	0.00014
11	Mixture of alkanes ($C_{10}H_{22}$-$C_{22}H_{46}$)	Mg/l	-	-	-	-	-	2.758 – 3.474

Table 4. Water quality comparative data. Metals

№	Comparable index	Unit of measure ment	Norms by Water Quality Classes					The average result of the analysis
			I	II	III	IV	V	
1	Lithium	mkg/l	ֆԿ	ֆԿ	ֆԿ	<2500	>2500	3.8 – 34.0
2	Beryllium	mkg/l	0.014	0.028	0.056	100	>100	< 0.001
3	Boron	mkg/l	9	450	700	1000	>2000	25.9 – 925.8
4	Natrium	mg/l	5	10	20	40	>40	6.8 – 269.5
5	Magnesium	mg/l	2,8	50	100	200	>200	5.8 – 24.0
6	Aluminum	mkg/l	65	130	260	5000	>5000	5.2 – 79.5
7	Total phosphorus	mg/l	0,025	0,2	0,4	1	>1	0.08 – 0.2157
8	Potassium	mg/l	1,5	3,0	6,0	12,0	>12,0	2.4 – 8.2
9	Calcium	mg/l	9,7	100	200	300	>300	14.8 – 171.1
10	Titanium	mg/l	-	-	-	-	-	0.002 – 0.011
11	Vanadium	mkg/l	1	2	4	8	>8	9.2 – 34.79
12	Chrome	mkg/l	1.0	11.0	100	250	>250	1.0 – 7.9
13	Iron	mg/l	0,08	0,16	0,5	1	>1	0.0337 – 0.226
14	Manga	mkg/l	5	10	20	40	>40	0.9 – 81.8
15	Cobalt	mkg/l	0,14	0,28	0,56	1,12	>1,12	0.2 – 1.7
16	Nickel	mkg/l	1.0	11.0	50	100	>100	0.3 – 2.9
17	Copper	mkg/l	3.0	23.0	50	100	>100	0.6 – 3.4
18	Zinc	mkg/l	3.0	100	200	500	>500	2.5 – 3063.0
19	Arsen	mkg/l	0,13	20	50	100	>100	1.1 – 54.1
20	Selene	mkg/l	0,5	20	40	80	>80	0.2 – 5.4
21	Strontium	mg/l	-	-	-	-	-	0.081 – 2.2267
22	Molybdenum	mkg/l	7	14	28	56	>56	0.9 – 58.8
23	Cadmium	mkg/l	0,02	1,02	2,02	4,02	>4,02	0.01 – 0.17
24	Tin	mkg/l	0,09	0,18	0,36	0,72	>0,72	0.2 – 1.09
25	Antimony	mkg/l	0,2	0,38	0,76	1,52	>1,52	0.08 – 0.15
26	Barium	mkg/l	9	18	36	1000	>1000	7.0 – 26.8
27	Lead	mkg/l	0,3	10,3	25	50	>50	0.2 – 1.1

As can be seen from the table, the results of all sampling tests are within the limits of this class of water, and consequently, this quality water can be directed to the downstream of Hrazdan River, without additional cleaning.

2. Land

Based on the characteristics of soil analysis, preliminary analysis have been performed for some indicators, the results of which are given below.

External inspection: brown soil and ground, with the average content of rock material.

Vegetal and sub-vegetal layer, 13 -22 cm:

pH- in water extract ` 6.5 – 7.3

The sum of absorbed cations, m/eqv 100g in land: 28.5 – 32.2.

Table 5. Soil quality data. Metals

N	Measured index	Unit	Measured value			Method applied
			Sample 1	Sample 2	Sample 3	
6	Lithium	g/kg	0.0061	0.0175	0.0140	ICP-MS
7	Beryllium	g/kg	0.0004	0.0012	0.0010	ICP-MS
8	Boron	g/kg	0.0373	0.0435	0.0440	ICP-MS
9	Sodium	g/kg	6.0	15.7	10.3	ICP-MS
10	Magnesium	g/kg	2.4	14.8	8.7	ICP-MS
11	Aluminium	g/kg	9.17	73.24	45.77	ICP-MS
12	General Phosphorus	g/kg	0.28	0.84	0.64	ICP-MS
13	Potassium	g/kg	5.8	14.9	10.9	ICP-MS
14	Calcium	g/kg	18.2	83.4	44.4	ICP-MS
15	Titanium	g/kg	1.72	4.40	3.24	ICP-MS
16	Vanadium	g/kg	0.0633	0.1329	0.1010	ICP-MS
17	Chromium	g/kg	0.0174	0.0957	0.0518	ICP-MS
18	Iron	g/kg	5.77	41.04	22.07	ICP-MS
19	Manganese	g/kg	0.1579	0.8231	0.4255	ICP-MS
20	Cobalt	g/kg	0.0077	0.0179	0.0164	ICP-MS
21	Nickel	g/kg	0.0218	0.0549	0.0472	ICP-MS
22	Copper	g/kg	0.0167	0.0691	0.0354	ICP-MS
23	Zinc	g/kg	0.0454	0.1010	0.0588	ICP-MS
24	Arsenic	g/kg	0.0086	0.0118	0.0110	ICP-MS

25	Selenium	g/kg	0.0018	0.0012	0.0043	ICP-MS
26	Strontium	g/kg	0.1022	0.3144	0.1845	ICP-MS
27	Molybdenum	g/kg	0.0101	0.0049	0.0106	ICP-MS
28	Cadmium	g/kg	0.00008	0.00025	0.00016	ICP-MS
29	Tin	g/kg	0.00049	0.00206	0.00098	ICP-MS
30	Antimony	g/kg	0.00027	0.00086	0.00039	ICP-MS
31	Barium	g/kg	0.0779	0.4139	0.2195	ICP-MS
32	Lead	g/kg	0.0065	0.0369	0.0129	ICP-MS

The applied method: Inductively coupled plasma mass spectrometry (ICP-MS)

The results of soil survey and general indicators analysis indicate that soil quality is in line with the general characteristics of the region and is within the limits of permitted norms.

V. Tevosyan, director of "Consecoard" LLC

Final Report
March 2018

Yerevan 2 CC Power Plant
ArmPower CJSC

Noise Impact Study

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Rev No.	Rev-date	Contents /amendments	Prepared/revised	Checked/released
0	28/07/2017	Draft	E C Consulting /F.Sormani	
1	18/08/2017	First Emission	E C Consulting /F.Sormani	
2	05/10/2017	Draft Final Report	E C Consulting /F.Sormani	Sousa
3	20/11/2017	Draft Final Report	E C Consulting /F.Sormani	Sousa
4	19/03/2018	Final Report	E C Consulting /F.Sormani	Sousa
5	20/03/2018	Final Report - update	Sousa	Paulsch

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List of Figures

1. Scope of the Report

This Noise Propagation Study has been produced as part of the ESIA Report.

A Noise Calculation (NC) was produced for this purpose for the new power plant (YCCPP-2) site. The NC has been done by using the propagation model SoundPLAN (Braunstein + Berndt GmbH). The model determines sound propagation based on the provisions of ISO 9613 - 2. This model is widely used in EU noise mapping projects.

The application of the model allowed determining whether the noise levels emitted by the new plant will represent a nuisance to the surrounding areas, i.e., if the resulting ambient noise will be above the national and international standards.

2. Brief Project Description

To partially reduce the gap between the offer and demand of electric energy foreseen in the Republic of Armenia for the next years, the MOE has signed for the construction of a new 254 MW Combined Cycle type Power Plant, gas fired (the CCGT), in the surroundings of Yerevan city.

The electrical power shall be generated by means of a gas turbine driven generator and, at the same time, steam shall be produced from heat recovery from the GT exhausts. The steam will be fed to a steam turbine, driving an additional power generation unit.

The technology of the most modern gas turbine improving the overall efficiency of the thermal cycle joined with the low environmental impact makes the natural gas fired combined cycle technology, at present, an ideal solution in power sectors.

The Project is a combined cycle plant in a multi-shaft arrangement. The plant will consist of a Gas Turbine (GT) with generator, a Steam Turbine (ST) with generator, a Heat Recovery Steam Generator (HRSG) and other associated equipment and systems.

The plant will be designed for highly efficient operation and for high reliability and availability.

The multi-shaft arrangement is a proper solution with its high flexibility allowing different modes of operation and easy maintenance.

3. Methodology

The aims of this study are:

- calculation of noise emission contributions at the sensitive receptors determined by the CCGT operation;
- predictive definition of the acoustic pressure at the sensitive receptors during CCGT operation;
- predictive verification of the compliance with the applicable limits at sensitive receptors.

On the basis of the Project data, the sound contribution of the CCGT during operation at the most exposed sensors was calculated.
The values thus obtained were compared to the applicable limits.

The new 254 MW Yerevan Combined Cycle Power Plant ("CCPP") will be located in the vicinity of Yerevan city, in the area adjacent to the existing Yerevan CCPP, currently managed by the Yerevan TPP CJSC.

Figure 3-1: Geographic overview of the project

The following figure shows the location of the Power Plant.

Figure 3-2: Detailed geographic overview of the project

The first step of the Noise Calculations has been to state the area potentially most affected by the Project's noise emissions, defined as Assessment area.

4. Noise sources

The whole plant has been designed with particular attention to limit the noise emissions.

The most relevant noise sources will be located inside soundproofed cabin/buildings to minimize noise propagation.

The acoustic enclosure for Gas Turbine and Generator is located over the Gas Turbine thermal block and the generator. It includes the sidewalls for the exhaust gas diffuser area.

The acoustical enclosure is designed and suitable for indoor application, i.e. the thermal block compartment, the generator compartment and the exhaust gas diffuser area compartment are located inside a building.

The main purposes of the acoustic enclosure and the related installations are:

- To reduce the noise emissions generated by the Gas Turbine thermal block, the exhaust gas diffuser and the generator
- To cool down the Gas Turbine set environment during operation.

The acoustical enclosure is completely equipped with structural steel frame, acoustic panels (removable for maintenance), penetration elements for cabling and piping, fully automatic ventilation system, access stairs and ladders, industrial grade/self-closing access doors with panic bars and internal lighting, emergency lighting and small power outlets.

5. Noise Propagation Model

The calculation of the predictive noise propagation was performed in accordance with the ISO 9613-2.

The calculation was performed through SoundPlan (open field propagation simulation software) after setting the model parameters:

- contour setting (geomorphological-acoustic parameters of the propagation environment);
- calculation settings;
- characterization of sound emission sources.

5.1 Software used for simulation: Sound Plan

SOUND PLAN is an open-field sound propagation simulation program and is one of the most used software in environmental noise studies. Modeling of sound propagation is done through a numerical calculation model called 'search angle method'. Starting from every single point of reception considered in the simulation of sound propagation, SOUND PLAN simulates a series of search rays that propagate uniformly in all directions and, for each of them, the software analyzes the physical-geometric and acoustic characteristics of the propagation environment, determines the 'path' leading to the sound source by applying known properties on the direction of propagation of the sound rays.

Therefore, for each sound radius that reaches the source, it applies the attenuating factors related to the acoustic phenomena affected by the ray (the attenuating factors are evaluated quantitatively by means of the ISO 9613-2) and then, it sums, at the receiving point considered, all the contributions made by the sound rays that had reached at least one sound source.

For this numeric procedure to be executed in a reasonable time by the computer, using Sound Plan it is possible to make 'settings' on the accuracy of the calculation model and in particular on:

- the incremental value of the angle that identifies two contiguous rays of search;
- the maximum number of reflections to be considered for the search radius before its contribution is considered null;
- the circular width of the field of research.

Sound Plan is basically based on three modules:

- a 'geo-database'
- a calculation module
- a result display module

In the geo-database, the propagation environment is represented in the three dimensions and the surfaces of the same are acoustically characterized. Emission sources are also located, each of which must be associated with acoustic characterization (source spectrum or total source sound pressure level).

By the calculation module it's possible to select the calculation standard to be used and once selected, the standard can be 'set' in the values of the propagation environment conditions.

The result display module renders the calculation results according to the purpose of the calculation.

5.2 Model runs

The model has been set up and launched. The results have been collected and analyzed.

The Set up of the model has implied the input of all basic data into the software. This has included information regarding the location of sensitive receptors, the noise emission and the technical data of the new YCCPP-2 including terrain data, and dimensions of the nearby structures. The following aspects have been considered

- The soil use and occupation (including sensitive receptors)
- The terrain characteristics:
- The Plant's noise emissions and technical data.

5.1.1 Setting boundary conditions

The propagation area considered is the installation area of the Project Center and its immediate vicinity and is such as to include sensitive receptors identified.

The calculation of the contribution of the sound sources has been carried out on an area of the territory so that the effects of the sound can be considered as null.

In order to cover within the spatial scope of the study the sensitive receptors identified a computational area of about 3 km x 3 km was considered.

The geo-database was built through a detailed plan of the area.

Figure 5-1: The computational area

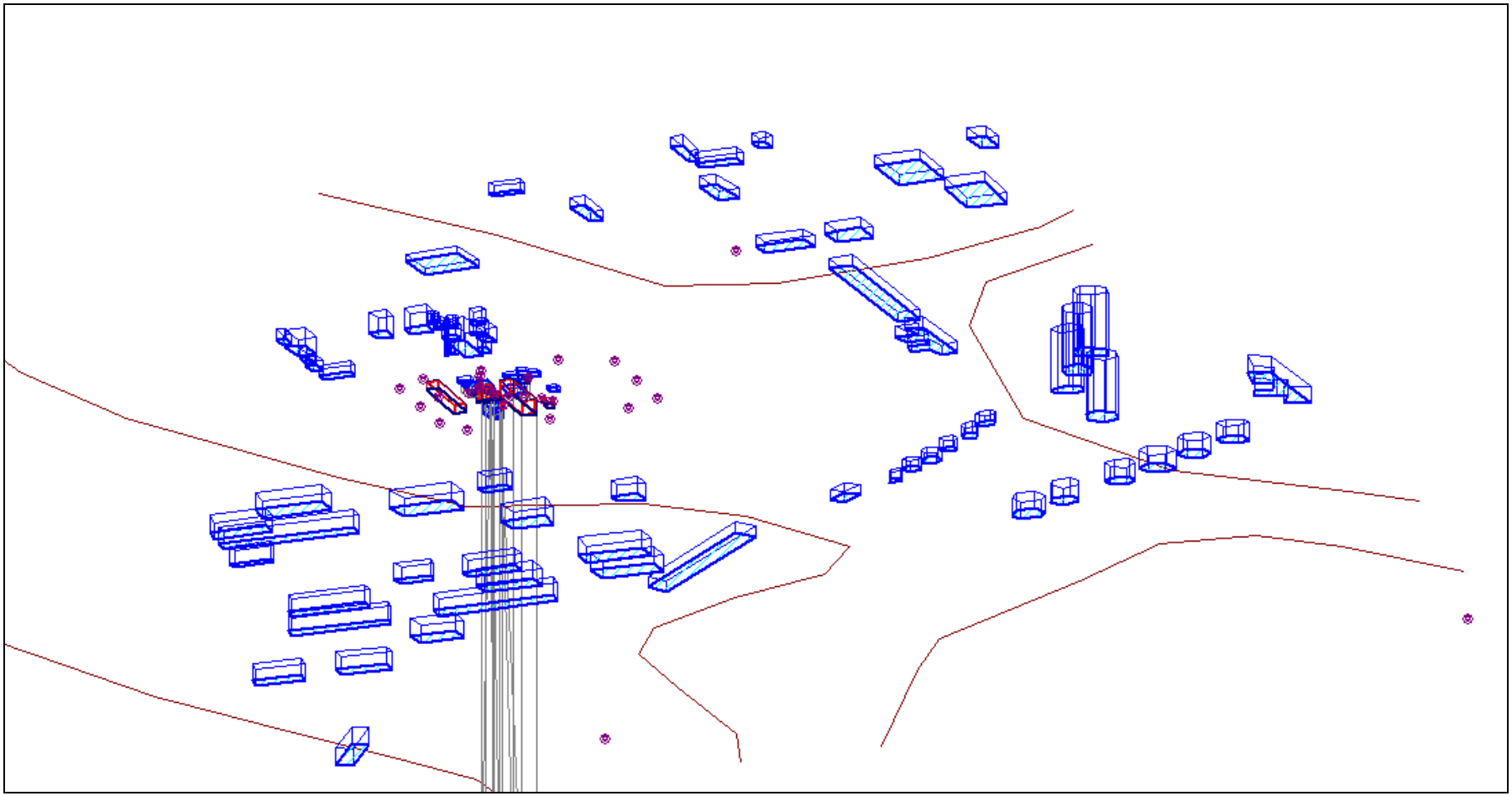


Figure 5-2: A geodatabase 3D view of the computational area

5.2 Setting the sound sources

The allocation of the sound emission to the various components of the plant was made in analogy to the technical specifications for the purchase of the various equipment, according to the designers' instructions according to the values reported in the Table 5-1.

Table 5-1: Sound pressure level of the most relevant sources considered in the model

Item	Source	Lp(A) (@1m) [dB(A)]
HRSG	Lateral Walls	71
	Roof	71
Air Intake GT	Intake	77
HRSG Diffusor	All surfaces	70
Main Machine Building (GT, ST)	All surfaces	60
Stack	External surfaces	75
	Mouth	80
Close cycle heat exchanger	All surfaces	75
Cooling Towers	All surfaces	80
Main Transformer	All surfaces	80
Units Transformer	All surfaces	75
Fuel Gas Booster Compressors Building	All surfaces	80
Auxiliary Boiler	All surfaces	60

Some sound sources have been modeled as areal sources and others as point sources.

The surfaces of buildings are acoustically considered as good reflectors (as is also indicated in ISO 9613-2). This is a typical assumption in the study of environmental noise propagation where 'natural screens' to be considered always have a significant thickness that, following the formulation proposed by ISO 9613-2 for the assessment of the sound pressure level loss at a reflection, is equivalent to the loss of 1 dB at every reflection.
The allocation of the sound power to the different components of the plant was made in analogy to the technical specifications for the purchase of the various equipment, according to the designers' instructions.

The following cautionary assumptions were made in the calculation model parameters setting:

- Continuous operation 24hours / day - 365 days / year (continuous operation both during the diurnal reference period and during the night reference period)
- Operating characteristics characterized by cautionary sound levels if compared to those guaranteed

5.2.1 Calculation settings

In order to obtain good accuracy results, the search angle method through which SOUND PLAN performs the calculation was set by initializing the relevant parameters with the following values:

- Incremental value of the search beam angle = 2º
- Maximum number of reflections (after which the contribution of the search radius is considered null) = 3

The settings made on the parameters of the calculation standard are as follows:

Table 5-2: Calculation settings

Environmental Conditions	Humidity	70%
	Temperature	10ºC
	Atmospheric pressure	1013,25 mbar
Diffractions Calculations	Contribution limits due to diffractions	Single diffraction=20dB
		Double diffraction=25dB
	Values assumed for the parameters in the formulations of ISO 9613 for calculating the diffractions	C1=3
		C2=20
		C3=0

5.2.2 Sound pressure levels "ante-operam"

Sensitive receptors that could potentially be more impacted by noise were detected through a site survey. They are reported in the Figure below.

Figure 5-3: Sensitive receptors potentially impacted

According to the Sanitary Norms N2-III-11.3:

- the applicable noise limits In the residential areas are 45 dBA during the Night time and 55 dBA during the Day time

In the industrial areas the limits fluctuate from 50 dBA to 80 dBA depending on the category of works.

The said limits are referred to the total environment noise (the power plant contribution including the current sound pressure ("ante operam" sound pressure).

The applicable national and international limits to the sensitive receptors potentially impacted are shown in the Tables below.

Table 5-3: Applicable limits to the sensitive receptors potentially impacted - National limits

Point of measurement	Time	TLV (equivalent to sound level), [dB(A)]
(Work-day and Weekend)		
R1	Day-time	55
	Night-time	45
R2	Day-time	55
	Night-time	45
R3	Day-time	55
	Night-time	45
R4	Day-time	70
	Night-time	70
R5	Day-time	55
	Night-time	45

Table 5-4: Limit values for noise regarding population - IFC/WB General EHS Guidelines

Receptor	One Hour $L_{Aeq\ (dB\ A)}$	
	Daytime 7:00 – 22:00	**Night-time 22:00 – 7:00**
Residential; institutional; educational	55	45
Industrial; commercial	70	70
Noise impacts should not exceed the levels given above, or result in a maximum increase in background levels of 3 dB (A) at the nearest receptor location off-site.		

In order to characterize the acoustic climate at the sensitive receptors, noise measurements were performed at each of them during the survey. For the measurement report, refer to the report "Noise and PM10 Baseline Study" rev.01 dated August 2017.

In the Table 5-5 the summary of the measurements outcome is reported.

Table 5-5: Current sound pressure ("ante operam") at the sensitive receptors

Point of measurement	Wind speed (m/s)	Time of measurement	Leq(A) [dB(A)]
Work-day			
R1	<1.7	Day-time	49.8
	<1.8	Night-time	47.1
R2	<1.9	Day-time	72.6
	<2.3	Night-time	62.4
R3	<1.8	Day-time	48.1
	<1.7	Night-time	40.0
R4	<1.6	Day-time	53.6
	<1.9	Night-time	57.3
R5	<1.7	Day-time	36.2
	<2.0	Night-time	39.4
Weekend			
R1	<1.5	Day-time	43.4
	<2.1	Night-time	49.0
R2	<1.8	Day-time	72.8
	<2.5	Night-time	59.2
R3	<1.9	Day-time	43.9
	<2.0	Night-time	33.9
R4	<1.8	Day-time	56.4
	<2.0	Night-time	57.2
R5	<1.5	Day-time	35.6
	<1.8	Night-time	34.2

"Ante operam" Day-time noise evaluation
Based on the noise measurement results conducted during work-days and weekend days, it can be concluded that noise equivalent levels in/near the residential areas were generally within the TLV except the point R2 (located in front of the highway), where the noise level exceeded the 55 dBA normative value. This can be explained by the movement of heavy vehicles and high traffic density along the highway

"Ante operam" Night-time noise evaluation
Equivalent noise levels during work-days and weekend days at measurement points R3 and R5 are within the 45 dBA TLV. Noise levels at point R1 during both work-days and weekend days were slightly exceeding the TLV (2.1 dBA and 4 dBA accordingly). This is due to the availability of background night noise from the facilities located in the vicinities. As a result of night-time measurements, the equivalent noise level at point R 2 (located in front of the highway) is above the 45 dBA TLV (see). The reason is high traffic density along the highway even at night-time.

5.2.3 Calculation of the sound contribution to the most exposed sensitive receptors

The calculation of the sound pressure level generated by the operation of the Power Plant towards the sensitive receptors has been performed by positioning the sensitive receptors in the model geodatabase. The calculation outcomes are reported in the Table below.

Table 5-6: Calculation outcomes: Sound Pressure generated by the Plant operation at the sensitive receivers

ID Receptor	Reference period (Work-day and Weekend)	Sensitive receptor applicability	Sound level contribution LAeq [dB(A)]
R1	*Day time*	Yes	32,5
	Night time	Yes	32,5
R2	*Day time*	Yes	38,0
	Night time	Yes	38,0
R3	*Day time*	Yes	34,9
	Night time	Yes	34,9
R4	*Day time*	Yes	42,7
	Night time	Yes	42,7
R5	*Day time*	Yes	31,8
	Night time	Yes	31,8

In addition calculation points along the Plant fence have been considered. The calculation outcomes are reported in the Table below.

Table 5-7: Calculation outcome: Sound Pressure generated by the Plant operation at the Plant fence.

ID Fence Point	Sound level contribution LAeq [dB(A)]
P East 1	51,3
P East 2	51,6
P East 3	51,5
P North 1	64,0
P North 2	57,3
P North 3	53,1
P South 1	54,2
P South 2	59,6
P South 3	60,2
P West 1	62,6
P West 2	67,9
P West 3	66,2

The calculation point along the fence have been positioned as shown in the Figure below.

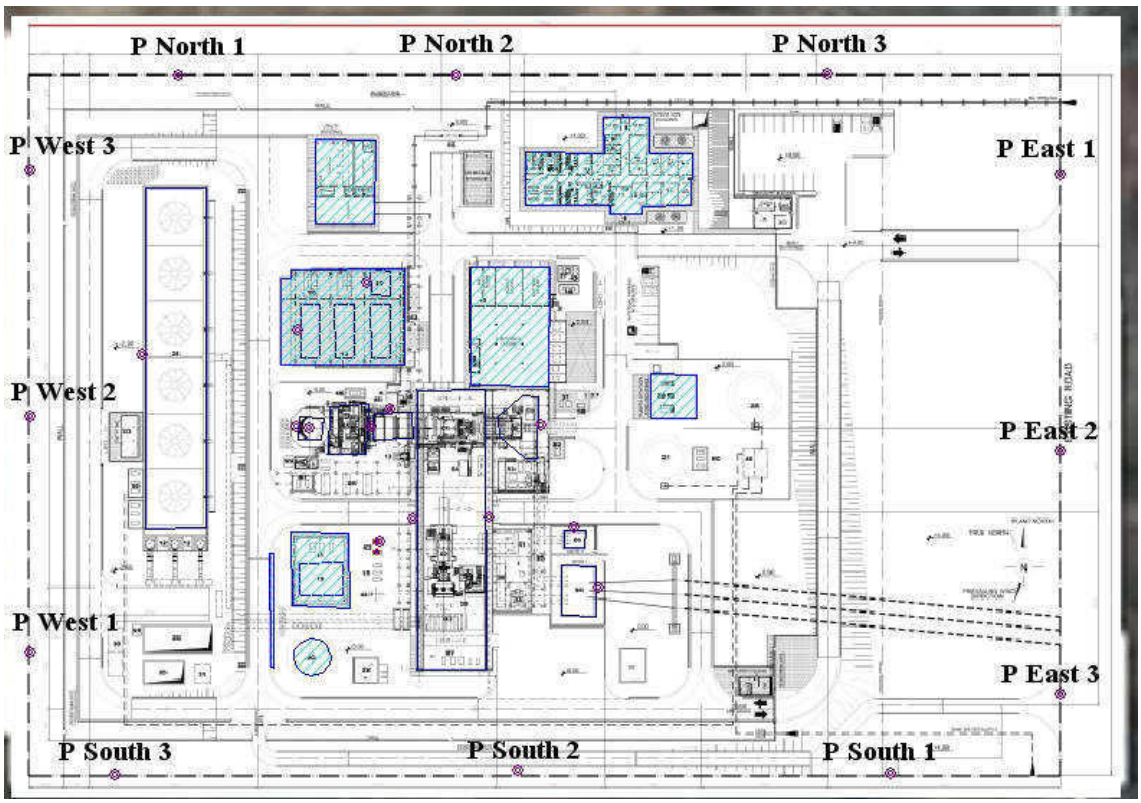


Figure 5-4: Position of the calculation points along the Plant fence

5.2.4 Calculation of noise maps

Through the calculation model also the noise maps have been generated.

The noise maps represent the sound pressure level curves, generated by the Plant during operation at the quotas of:

- +2 m from the ground level (Annex A)
- +10 m from the ground level (Annex B)

6. Predictive noise limit compliance check

The predictive noise pressure at the sensitive receptors has been calculated by adding the value of the background noise sound pressure to sound level contribution calculated by the model.
The formula used is the following:

$$Lpi_r = 10Log(10^{\frac{Lpe\_r}{10}} + 10^{\frac{Lpf}{10}})$$

Where:

- Lpi_r is the predicted noise pressure value at the 'r' sensitive receptor
- Lpe_r is the Sound level contribution of the Plant at the 'r' sensitive receptor
- Lpf is the current back ground sound level

The calculation outcomes are shown in the Table 6-1. As measurement point 'Noise 4' is located in an industrial area, limit values for industrial areas have been used for this point. However, as this measurement point is located near to the illegal housings northeast of YCCPP-1, Table 6-2 shows the relevant noise pressure at this point under consideration of limit values (international = national) for residential areas.

The results provide a comparison to the national and the international noise limit values. The international limit values (IFC EHS General Guidelines) have the particularity that, whenever the background levels are presently above the applicable limits, a maximum increase of 3 dB(A) due to a project is accepted. This is evaluated in the tables below.

As indicated in Table 6-1 and Table 6-2, where the predicted noise pressure is higher than the applicable limits, this is due to the high background 'ante operam' noise pressure. Contribution from the operation of YCCPP-2 in these cases will be negligible (0.00 – 0.18 dB(A)). This complies with the IFC standard of not exceeding an increase of 3 dB in the background levels.

Table 6-1: Predicted noise pressure at the sensitive receptors and "post – operam" noise limits compliance check

ID Receptor	Reference period	Applicable limit	"Ante operam" sound pressure LAeq [dB(A)]	"Ante operam" noise limits compliance check	Sound level contribution LAeq [dB(A)]	***Predicted noise ("post operam") pressure value LAeq [dB(A)]***	***Predicted ("post operam") noise limits compliance check***
Work-day							
R1	Day time	55	49,8	Compliant	32,5	49,88	Compliant
	Night time	45	47,1	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	32,5	47,25	Compliant: the maximum increase is of +0,15 dB (A)
R2	Day time	55	72,6	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	38,0	72,60	Compliant: the maximum increase is of +0,00 dB (A)
	Night time	45	62,4	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	38,0	62,42	Compliant: the maximum increase is of +0,02 dB (A)
R3	Day time	55	48,1	Compliant	34,9	48,30	Compliant
	Night time	45	40,0	Compliant	34,9	41,17	Compliant
R4	Day time	70	53,6	Compliant	42,7	53,94	Compliant
	Night time	70	57,3	Compliant	42,7	57,45	Compliant
R5	Day time	55	36,2	Compliant	31,8	37,55	Compliant
	Night time	45	39,4	Compliant	31,8	40,10	Compliant
Weekend							
R1	Day time	55	43,4	Compliant	32,5	43,74	Compliant
	Night time	45	49,0	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	32,5	49,10	Compliant : the maximum increase is of +0,10 dB (A)
R2	Day time	55	72,8	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	38,0	72,80	Compliant : the maximum increase is of +0,00 dB (A)
	Night time	45	59,2	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	38,0	59,23	Compliant : the maximum increase is of +0,03 dB (A)
R3	Day time	55	43,9	Compliant	34,9	44,41	Compliant

ID Receptor	Reference period	Applicable limit	"Ante operam" sound pressure LAeq [dB(A)]	"Ante operam" noise limits compliance check	Sound level contribution LAeq [dB(A)]	***Predicted noise ("post operam") pressure value LAeq [dB(A)]***	***Predicted ("post operam") noise limits compliance check***
	Night time	45	33,9	Compliant	34,9	37,44	Compliant
R4	Day time	70	56,4	Compliant	42,7	56,58	Compliant
	Night time	70	57,2	Compliant	42,7	57,35	Compliant
R5	Day time	55	35,6	Compliant	31,8	37,11	Compliant
	Night time	45	34,2	Compliant	31,8	36,17	Compliant

Table 6-2: Predicted noise pressure at the sensitive receptors and "post – operam" noise limits compliance check - measurement point 'Noise 4'

ID Receptor	Reference period	Applicable limit - *residential areas*	"Ante operam" sound pressure LAeq [dB(A)]	"Ante operam" noise limits compliance check	Sound level contribution LAeq [dB(A)]	***Predicted noise ("post operam") pressure value LAeq [dB(A)]***	***Predicted ("post operam") noise limits compliance check***
Work-day							
R4	Day time	55	53,6	Compliant	42,7	53,94	Compliant
	Night time	45	57,3	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	42,7	57,45	Compliant : the maximum increase is of + 0.15 dB (A)
Weekend							
R4	Day time	55	56,4	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	42,7	56,58	Compliant : the maximum increase is of + 0.18 dB (A)
	Night time	45	57,2	Not compliant: In this case, a max. increase of 3 dB (A) is allowed for „post operam"	42,7	57,35	Compliant : the maximum increase is of + 0.15 dB (A)

7. Conclusions

The assessment of the acoustic impact associated with the New CCGT has been carried out applying a predictive mathematic model to the actual project data.

The calculation has been performed in accordance with the calculation models defined in the ISO 9613-2 standard. The calculation was performed through the SoundPlan software after setting the model parameters.

The sensitive receivers that are more exposed to the new Power Plant operation noise have been detected. The current noise level pressure at the said sensitive receivers have been assessed by an acoustic survey.

The applicable reference noise limit are prescribed by The Sanitary Norms N2-III-11.3.

The final calculation outcomes have shown the compatibility of the New CCGT operation with the applicable noise limits.

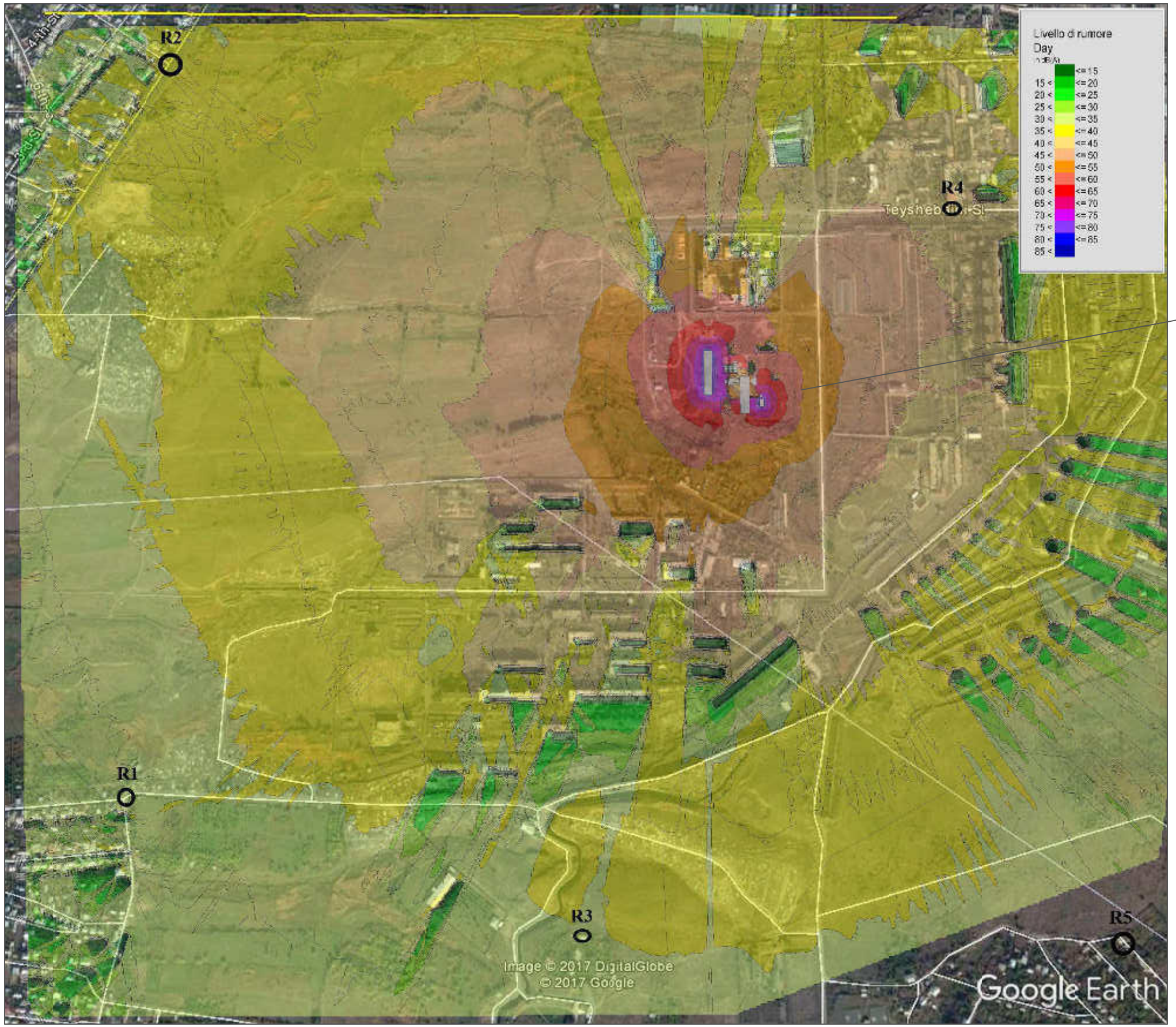
The New CCGT operation will not produce any significant increase of the noise pressure at the sensitive receptors. In particular:

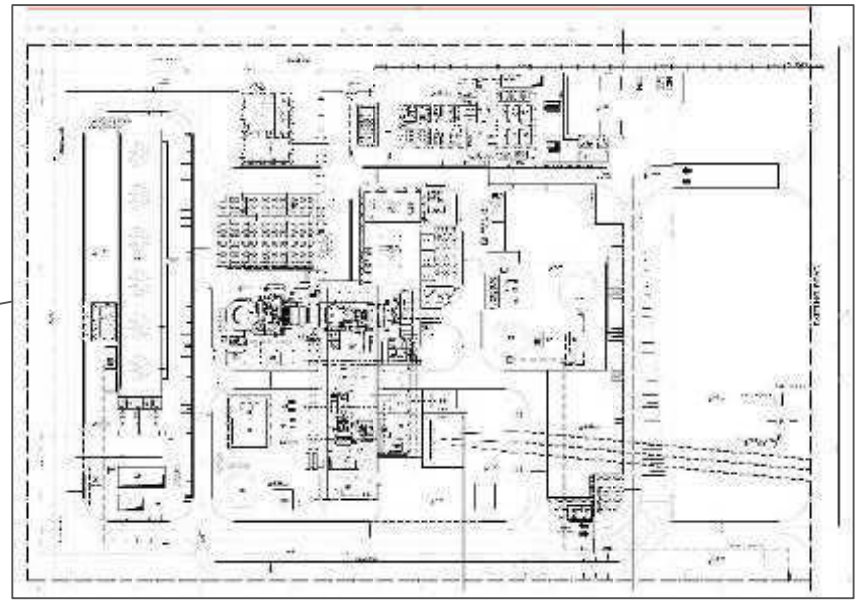
- where the current noise pressure is under the applicable limits, the New CCGT operation will not produce any exceedance of the said limit, either during the daytime or during the night time
- where the current noise pressure is already over the applicable limits, the New CCGT operation will produce a negligible contribution, respecting the IFC standard of not exceeding an increase of 3 dB in the background levels.

As last consideration, it has to be underlined that, although at the CCGT fence no sensible receivers are present, the Sound level contribution of the New CCGT operation will be significantly below the applicable industrial areas noise limits.

8. Annexes

Annex A – noise map at +2m
Annex B – noise map at +10m





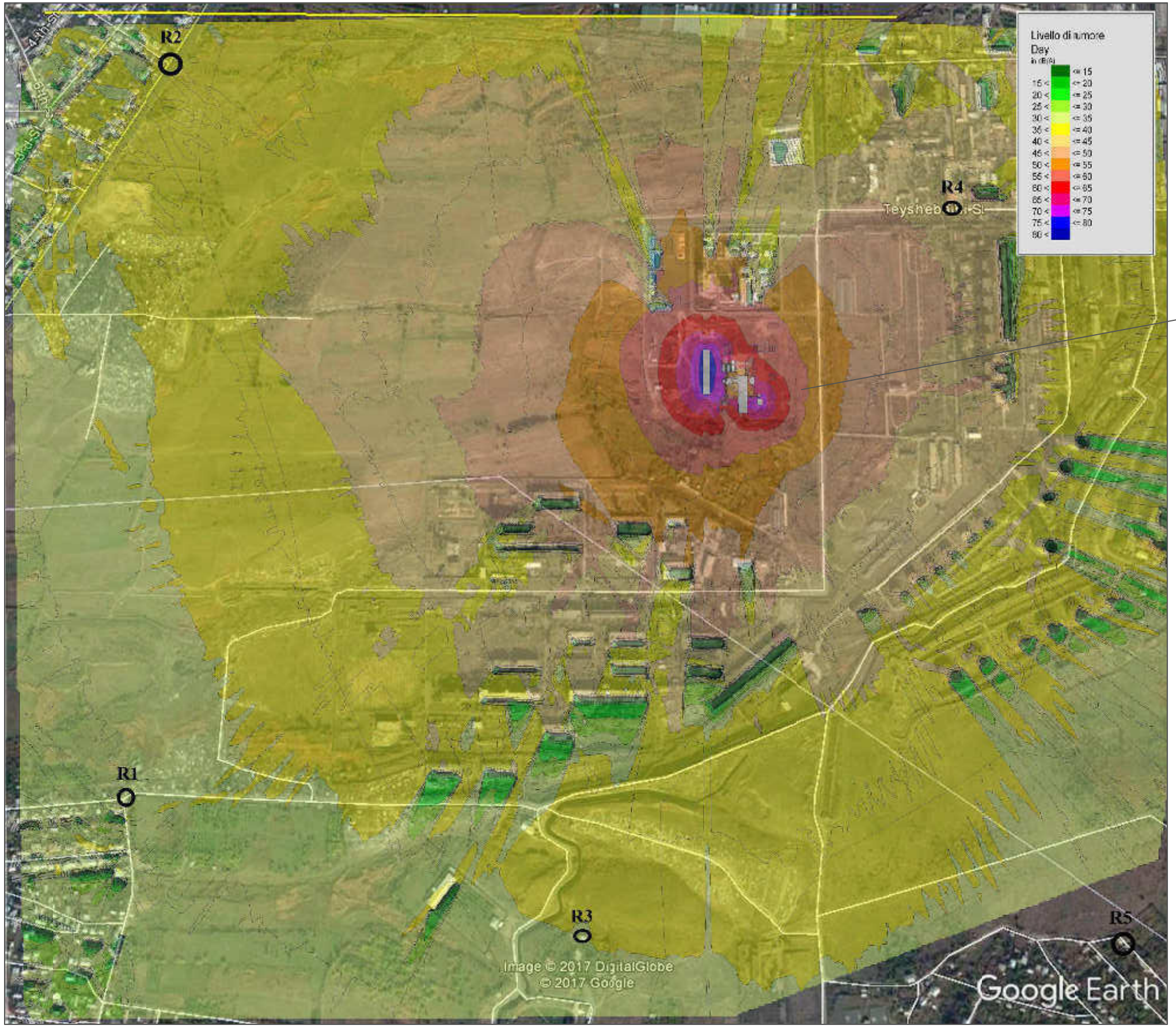
Plant layout

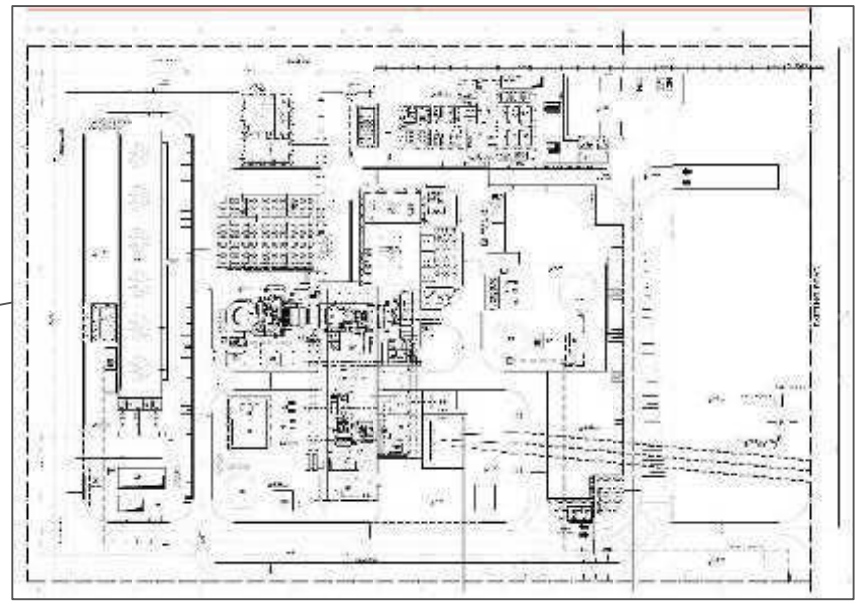
Item	Source	Lw(A) [dB(A)]
HRSG	Lateral Walls	71
	Roof	71
Air intake G.T.	Intake	77
HRSG Diffusor	All surfaces	70
Main Machine Building (G.T. ST)	All surfaces	60
Stack	External surfaces	75
	Mouth	80
Close cycle heat exchanger	All surfaces	75
Cooling Towers	All surfaces	80
Main Transformer	All surfaces	80
Units Transformer	All surfaces	75
Fuel Gas Booster Compressors Building	All surfaces	80
Ausiliary Boiler	All surfaces	60

Most relevant Noise emission items considered in the Plant project

0 100 500 1000 m

	Annex A	
	Noise emissions - 2 m height noise map	





Plant layout

Item	Source	Lw(A) [dB re 1pW(A)]
HRSG	Lateral Walls	71
	Roof	71
Air intake (x")	Intake	77
HRSG Diffuser	All surfaces	70
Main Machine Building (G.L. ST)	All surfaces	60
Stack	External surfaces	75
	Mouth	80
Close cycle heat exchanger	All surfaces	75
Cooling Towers	All surfaces	80
Main Transformer	All surfaces	80
Units Transformer	All surfaces	75
Fuel Gas Booster Compressors Building	All surfaces	80
Auxiliary Boiler	All surfaces	60

Most relevant Noise emission items considered in the Plant project

0 100 500 1000 m

	Annex B	
	Noise emissions - 10 m height noise map	

WASTE WATER TEMPERATURE PROFILE STUDY

(STEADY STATE)

CONTENTS

1 INTRODUCTION

Ministry of Energy (MOE) of Republic of Armenia has planned, inside a wider program of develop of production of Energy in the Country, to improve the total efficiency of the existing power plant by replacing the older and lower efficient power units with the most modern steam gas combined cycle power generation technology.

To partially reduce the gap between the offer and demand of electric Energy foreseen in the Republic of Armenia for the next years, the MOE has signed for the construction of a new 250 MW (nominal) combined cycle type power plant, gas fired, to be built on the clean and empty field adjacent to the existing YCCPP-1, in the vicinity of Yerevan city.

1.1 SITE LOCATION

The new 250MW Yerevan Combined Cycle Power Plant ("YCCPP2") will be located in the vicinity of Yerevan city, in the area adjacent (on the west side lot) to the existing Yerevan CCPP-1, currently managed by the Yerevan TPP CJSC.

1.2 THE PROJECT

The YCCPP2 Project consists of a nominal 250MW power output power plant, combined cycle as per latest state-of-the art, located in the vicinities of the existing power plant sharing some of the utilities and facilities necessary for its operation. The power output will be assured by a single gas turbine driven electric generator train, which flue gas will be used to produce high pressure stem for additional power recovery through a steam turbine driven electric generator. The Project will be designed for more efficient operation and for higher reliability and availability.

2 SCOPE

The aim of the present study is the evaluation of the water effluent temperature profile from YCCPP2 Power Plant battery limit, up to the existing Hrazdan River during both winter and summer condition:

- Waste water temperature discharge from 25°C in winter to 34,2 in summer season ;
- Lowest River Temperature (Maximum DT between waste water and the receptor-river temperature) during winter season;
- Highest Cooling Water outlet temperature during summer season

As a general note, it shall be considered that the dilution factor due to the very huge flow rate and velocity of the river, has not been considered in the present calculation. These factors could be taken into account to justify, themselves, the negligible environmental impact of the YCCPP-2 waste water on the Hrazdan river. In this regard, data from YCCPP-1 report "YEREVAN TPP CJSC COMBINED CYCLE POWER PLANT (CCPP) STANDARDS OF MAXIMUM ALLOWABLE OUFLOW (MOA) OF HARMFUL SUBSTANCES POURED INTO THE SEWERAGE COLLECTOR AND WATER RESOURCES" state the following river characteristics:

- Flow Rate: around 80.000 m3/hour
- Velocity: 2m/sec

2.1 TEMPERATURE PROFILE MODELS (STEADY STATE)

Two dedicated heat transfer model have been adopted depending the specific trunk line discharge section considered.
Basically we have two main trunk line:

1. Trunk line 1: From tie-in point up to Existing Pit;
2. Trunk line (open channel) : From existing pit to Hrazdan river

Calculation has been done for two main season average temperature: Winter season temperature and Summer season temperature.

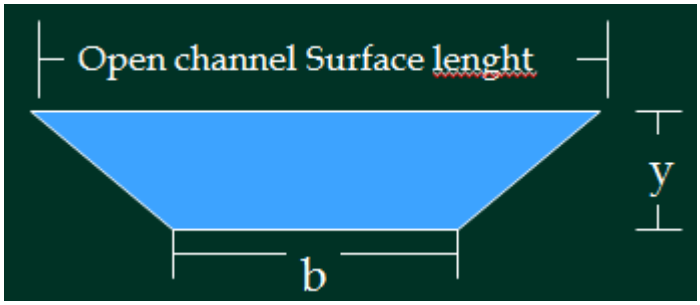
2.2 MAIN DESIGN BASIS AND ASSUMPTIONS FOLLOWS:

Trunk line 1:

- Lenght: 1000 meters
- Material: cement pipe
- Manning Factor : 0.013
- Concrete roughness: 3.05 10-4
- Pipe tickness: 0.04 meter
- ID : 0.297 meters
- Slope 1/100
- Flowrate 100 m3/h

Trunk line 2 (open channel):

- Trapezoidal channel
- Flowrate 100 m3/h
- Assumed water velocity = 1.5 m/sec



- Assumed wind speed : 3 m/sec and 1 m/sec respectively during Winter and Summer season
- Assumed Humidity : 75 % and 45 % respectively during Winter and Summer season
- Assumed T water at Tie-in point : 25 °C and 34 °C respectively during Winter and Summer season
- Assumed lenght of open channel surface (section) : 1 meter
- Calulated open channel Area (assuming 1 meter surface section lenght) : 0.018 m^2
- No credit has been taken for the Radiation heat flux effect due to the sunlight
- No credit has been taken for the sensible heat term;
- No credit has been taken for the heat transfer rate due to the internal channel surface.

2.3 CALCULATION

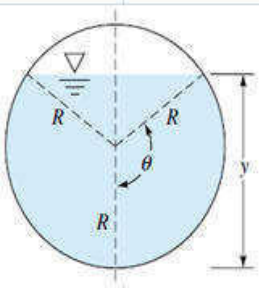
2.3.1 Winter Season temperature Case

Trunk line 1 (buried cement pipe) calculation

Temperature drop along cement trunk line has been calculated assuming that the only heat transfer rate envisaged is belonging to wetted pipe area. Basically the heat dissipation (due to the lower ground temperature assumed as 10 °C) will take place by means the temperature difference between inlet pipe water and outlet pipe bulk material.

To evaluate the liquid depth in the pipe (due to the gravity flow) the manning equation has been adopted:

Manning Equation :	$Q = 1/n \times A \times R_h^{2/3} \times S^{1/2}$			
Consider a liquid depth as D/5 meters as first guess				
Liquid Depth	**y**	0.0594	m	
Manning Factor	**n**	0.013		
Radius	**R**	0.1485	m	
Centre Angle	**2θ**	106.2602047	°	
Liquid Section	**A**	0.020448929	m2	
Wetted Perimeter	**P**	0.275406447	m	
Hydraulic Radius	**Rh = A/P**	0.07425	m	
Hydraulic diameter	**$D_h = 4R_h$**	0.297	m	
Slope in the line	**S**	0.0100		
Froude Number	**Fr = V / √ (g x D)**			
(From McGraw-Hill_20Piping_20Handbook_20_287E_29)				
Liquid Velocity	**V**	1.36	m/s	
Full Pipe Area	**At**	0.07	m2	
Full Pipe Velocity	**Vt**	0.40	m/s	
Froude Number	**Fr =**	0.23501859	≤ 0.3	in order to be selfventing
Conclusion				
Considering a slope of 10 meters every 1000 meters a 297 Internal Diameter Pipe with a liquid depth of 0.0594 m shall be calculated.				



Liquid Exit Temperature Calculation			
INPUT DATA			
Pipeline Lenght	**L**	1000	m
Elevation change	**Y**	10	m
Pipeline Internal Diameter	**ID**	0.297	m
Burial depht to center	**h**	1.15	m
Inlet Temperature	**T1**	25	°C
Ground Temperature	**Tg**	10	°C
Ground Thermal Conductivity	**k**	1.49	kcal/hm°C
Mass Flow	**M**	100000	kg/h
Specific Heat	**Cp**	1	kcal/kg°C
Factor j	**j**	426.5	kgm/kcal

Heat Transfer Factor calculation							
$\alpha = 2h/D$	α	7.74					
$s = 2k\pi/[\ln(x+(x^2-1)^{1/2})]$	s	3.42	kcal/hm°C				
Heat Flow Ratio per unit lenght calculation							
a = s/MCp	a	0.000034	1/m				
Asymptotic Temperature calculation							
Ta = Tg - (J x DP + Y/(j x Cp))/aL	(Joule Thomson Effect not considered; J*DP = 0)						
	Ta	9.31	°C				
Downstream Temperature calculation							
$T2 = (T1 - Ta) \times e^{-aL} + Ta$	T2	24.5	°C				
Therefore calculated duty relevant temperature drop from 25 to 24.5 °C is calculated as follows:							
Delta Q = (25-24.5) x 1 x 100000	Delta Q	50000	Kcal/h				
Assuming that only a part of the pipe surface will be affected by the heat flux, a 60% of the heat flow will be							
considered: 30000 kcal/h							
Hence:							
30000 = DeltaT x 1 x 100000	Delta T	0.3	°C				
As result the exit pipe temperature shall be reasonable assumed as 24.7 °C.							

Trunk line 2 (open channel) calculation

Since the water is flowing through an open channel, we assume that the evaporative heat flux across the air-water interface is the most significant factor in dissipation of stream heat (Parker and Krenkel 1969).

Special consideration must be taken in addressing the simulation of evaporation rates, since the evaporation flux is the energy process in which streams dissipate most heat energy, and therefore, contributes most to decreases in water column temperature.

The vapor pressure gradient between the water surface (es) and the air (ea) directly above the stream drives evaporation (i.e. the vaporization of water molecules) when the gradient is positive (ea - es). Only when the air is saturated does evaporation cease to occur (ea = es). The evaporative flux can be calculated as a summation of the sensible carried with evaporated water vapor and the product of the latent heat of evaporation (LHV), density of water (ρw) and the rate of evaporation (Ē). The energy needed for water to change from a liquid to a gas, the latent heat of vaporization (LHV), is a function of water temperature (McCutcheon 1989).

The **evaporative flux** can be calculated as follows (Eq. 1):

$$\Phi_{evaporation} = \rho_{H_2O} \cdot L_e \cdot \bar{E}$$

(Eq. 1) ……

Where Le is the latent heat of vaporization expressed as (eq.2):

(Eq.2) …… $L_e = 1000 \cdot (2501.4 + (1.83 + T_W))$

While Ē is the evaporation rate. The Mass transfer evaporation rate can be calculated considering the Dingman equation (Digman 2002).

(Eq.3)…….. $\bar{E} = f(\vec{W}) \cdot (e_{s\cdot} - e_{a\cdot})$

Where e_s is calculated as

(Eq.4)…….. $e_{s\cdot} = 6.1275 \cdot e^{\left(\frac{17.27 \cdot T_{wi}^{t}}{(237.3 + T_{wi}^{t})}\right)}$

And e_a is calculated as

(Eq.5)…… …… $e_{a\cdot} = \frac{H}{100\%} \cdot e_{s\cdot}$

(Eq.6)…… $f(\vec{W}) = a + b \cdot \vec{W}$

From the above equation the Evaporation Flux is calculated considering the following step:
Using for Eq 4 and 5 followings coefficient respectively

- e_s = 31.2
- ea = 23.4

Using Eq. 6 f(W) is equal to 1.4 x 10^{-8} considering the followings coefficient

- a = 5 x 10-9
- b = 3 x 10-9

By using Dingman equation the Evaporation mass rate is

- Ē = 1.4 x 10^{-8} (31.2 – 23.4) =1.1x10^{-7}
- L_e = 1000 x (2501.4 (1.83+ 24.7 °C) = 2527930 J/kg

$\varphi_{evaporation}$ = 1000 x 2527930 x 1.1 10^{-7} = 276 W/m^2

In order to estimate the temperature changes along the entire open channel we can reasonably assume that the heat load for each m^2 of the channel is 276 W.

Water will be exposed for this specific heat load during the time (sec) needed to reach river discharge located at 7000 meter far away. Hence the total time required to reach the river is:
7000 [meter]/ 1.5 [m/sec] = 4667 sec

The calculated Duty associated to 4667 sec is:
276 W * 4667 [sec] = 1288963 J = ΔQ

The Mass of water considered for 1 meter of specific water surface is calculated as follows:

Mass water = Volume x ρ_w = 0.018 * 1000 = 18 kg

Therefore the heat load associated to 18 kg of water mass can be expressed also as:
ΔQ = M cp ΔT

And the calculated ΔT is : (1288963 [J]) / (18 [kg]*4186 [J/Kg °C]) = **17.1 °C**

So the final Winter Case waste water temperature into the river is **7.6 °C.**

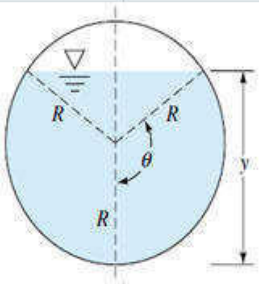
2.3.2 Summer Season temperature Case

Trunk line 1 (buried cement pipe) calculation

Temperature drop along cement trunk line has been calculated assuming that the only heat transfer rate envisaged is belonging to wetted pipe area. Basically the heat dissipation (due to the lower ground temperature assumed as 10 °C) will take place by means the temperature difference between inlet pipe water and outlet pipe bulk material.

To evaluate the liquid depth in the pipe (due to the gravity flow) the manning equation has been adopted:

Manning Equation :	$Q = 1/n \times A \times R_h^{2/3} \times S^{1/2}$			
Consider a liquid depth as D/5 meters as first guess				
Liquid Depth	**y**	0.0594	m	
Manning Factor	**n**	0.013		
Radius	**R**	0.1485	m	
Centre Angle	**2θ**	106.2602047	°	
Liquid Section	**A**	0.020448929	m2	
Wetted Perimeter	**P**	0.275406447	m	
Hydraulic Radius	**Rh = A/P**	0.07425	m	
Hydraulic diameter	**$D_h = 4R_h$**	0.297	m	
Slope in the line	**S**	0.0100		
Froude Number	**Fr = V / √ (g x D)**			
(From McGraw-Hill_20Piping_20Handbook_20_287E_29)				
Liquid Velocity	**V**	1.36	m/s	
Full Pipe Area	**At**	0.07	m2	
Full Pipe Velocity	**Vt**	0.40	m/s	
Froude Number	**Fr =**	0.23501859	≤ 0.3	in order to be selfventing
Conclusion				
Considering a slope of 10 meters every 1000 meters a 297 Internal Diameter Pipe with a liquid depth of 0,0594 m shall be calculated.				



Liquid Exit Temperature Calculation			
INPUT DATA			
Pipeline Lenght	**L**	1000	m
Elevation change	**Y**	10	m
Pipeline Internal Diameter	**ID**	0.297	m
Burial depht to center	**h**	1.15	m
Inlet Temperature	**T1**	34	°C
Ground Temperature	**Tg**	10	°C
Ground Thermal Conductivity	**k**	1.49	kcal/hm°C
Mass Flow	**M**	100000	kg/h
Specific Heat	**Cp**	1	kcal/kg°C
Factor j	**j**	426.5	kgm/kcal

Heat Transfer Factor calculation			
$\alpha = 2h/D$	**α**	7.74	
$s = 2k\pi/[\ln(x+(x^2-1)^{1/2})]$	**s**	3.42	kcal/hm°C
Heat Flow Ratio per unit lenght calculation			
a = s/MCp	**a**	0.000034	1/m
Asymptotic Temperature calculation			
Ta = Tg - (J x DP + Y/(j x Cp))/aL	(Joule Thomson Effect not considered; J*DP = 0)		
	Ta	9.31	°C
Downstream Temperature calculation			
$T2 = (T1 - Ta) \times e^{-aL} + Ta$	**T2**	**33.2**	**°C**
Therefore calculated duty relevant temperature drop from 25 to 24.5 °C is calculated as follows:			
Delta Q = (25-24.5) x 1 x 100000	Delta Q	83042	kcal/h
Assuming that only a part of the pipe surface will be affected by the heat flux, a 60% of the heat flow			
considered:		49825	kcal/h
Hence:			
49825 = DeltaT x 1 x 100000	Delta T	0.5	°C
As result the exit pipe temperature shall be reasonable assumed as **33.5 °C.**			

Trunk line 2 (open channel) calculation

Using for Eq. 4 and 5 followings coefficient respectively:

- e_s = 51.9
- ea = 23.4

Using Eq. 6 f(W) is equal to 3.5 x 10^{-9} considering the followings coefficient:

- a = 2.5 x 10-9
- b = 1.0 x 10-9

By using Dingman equation the Evaporation mass rate is

- Ē = 3.5 x 10-9 (51.9 – 23.4) = 1 x 10-7
- Le = 1000 x (2501.4 (1.83+ 33.5 °C) = 2536730 J/kg

$\varphi_{evaporation}$ = 1000 x 2536730 x 1 x 10^{-7}= 253 W/m^2

In order to estimate the temperature changes along the entire open channel we can reasonably assume that the heat load for each m^2 of the channel is 253 W.

Water will be exposed for this specific heat load during the time (sec) needed to reach river discharge located at 7000 meter far away. Hence the total time required to reach the river is:
7000 [meter]/ 1.5 [m/sec] = 4667 sec

The calculated Duty associated to 4667 sec is:

253 W * 4667 [sec] = 1182675 J = ΔQ

The Mass of water considered for 1 meter of specific water surface is calculated as follows:
Mass water = Volume x ρ_w = 0.018 * 1000 = 18 kg

Therefore the heat load associated to 18 kg of water mass can be expressed also as:
ΔQ = M cp ΔT

And the calculated ΔT is : (1182675 [J]) / (18 [kg]*4186 [J/Kg °C]) = **15.7 °C**

Summer Case waste water temperature into the river is : **17.8 °C.**

Considering a lower evaporation rate due to the solar radiation effect (assumed as 20% of the evaporation flux) the new calculated ΔQ is:

ΔQ = 1182675 [J] x 0.8 = 946140 J

The calculated ΔT is : (946140 [J]) / (18 [kg]*4186 [J/Kg °C]) = **12.6 °C**

Summer lower evaporation Case waste water temperature into the river is : **20.9 °C.**

3 CONCLUSION

The final estimated waste water temperatures at Hrazdan river discharge (as per above mentioned calculation procedure and assumption) is reported in the here below table 1.
The Cooling Water outlet temperature for seasonal cases, is reported in respect to waste water temperature into the river

SEASON	Cooling Tower Discharge Temp [°C]	Water Effluent Discharging in Hrazdan River Temp [°C]	Seasonal Hrazdan River Temp (Average 2015-2016) [°C]	Temperature Change ΔT [°C]	Deviation from Hrazdan River Temp (< 3°C) [°C]
WINTER	25.0	**7.6**	10.3	17.1	**-2.7**
SUMMER	34.0	**17.8**	20.5	15.7	**-2.7**

Table 1 Water Temperatures

The outlet water temperature as per above calculation results to be in compliance with the seasonal average values of Hrazdan river being always below the 3 degree threshold limit. (refer to table 1)

Seasonal average values of Hrazdan river have been calculated according the following assumptions.

For winter season the following months have been considered for average value calculation:

- January
- February
- November
- December

For Summer season the following months have been considered for average value calculation:

- May
- June
- July
- August

For Season average River temperature refer to Table 2:

Month	2015 [°C]	2016 [°C]
1	9.8	9.7
2	10.8	10.8
3	12.1	11.8
4	15.7	14.4
5	19.4	17.8
6	21.2	19.4
7	22.7	20.2
8	23.6	19.8
9	20.7	16.9
10	17.6	13.5
11	13.6	10.1
12	10.2	7.6

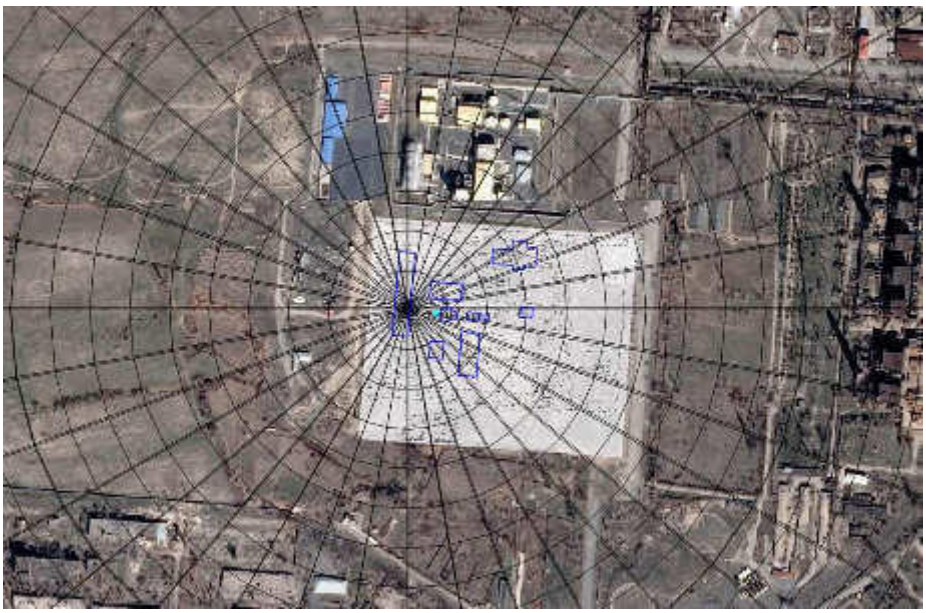
	[°C]	[°C]	**Average** (2015-2016) [°C]
Winter average Temp Month (1-2-11-12)	11.1	9.6	**10.3**
Summer average Temp Month (5-6-7-8)	21.7	19.3	**20.5**

Table 2 Average water Temperature of Hrazdan river

Final Report
March 2018

Yerevan 2 CC Power Plant
Armpower CJSC

Air Dispersion Calculation



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Rev No.	Rev-date	Contents /amendments	Prepared/revised	Checked/released
0	18.08.2017	Draft Report for incorporation into the Draft ESIA	Sousa	Heinold
1	04.10.2017	Draft Final Report for incorporation into the Draft Final ESIA	Sousa	Heinold
2	20.11.2017	Draft Final Report for incorporation into the Draft Final ESIA	Sousa	Back
3	07.12.2017	Draft Final Report for incorporation into the Draft Final ESIA	Sousa	Paulsch
4	14.02.2018	Final Report for incorporation into the Final ESIA	Sousa	Paulsch
5	19.03.2018	Final Report for incorporation into the Final ESIA	Sousa	Paulsch

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List of abbreviations and acronyms

AQS = Air Quality Standard(s)
CC = Combined Cycle
CO = Carbon Monoxide
ECD = European Council Directive(s)
ELV = Emission Limit Values
IFC = International Finance Corporation
MAC = Maximum Allowable Concentration
masl = meters above sea level
NG = Natural Gas
NO_2 = Nitrogen Dioxide
PP = Power Plant
UHC = Unburned hydrocarbon(s)
WB = World Bank
YCCPP = Yerevan Combined Cycle Power Plant

1. Scope of the Report

The Ministry of Energy (MOE) of the Republic of Armenia plans to improve the total output capacity of its electric energy production, complementing the power units of the existing Yerevan Combined Cycle Power Plant (YCCPP-1) with a more modern and efficient power plant. For this reason a new gas fired Combined Cycle Power Plant of 234 MWe (YCCPP-2) is planned to be built at the site next to the existing YCCPP-1.

RENCO SPA will be the EPC Contractor for this Project, which will be operated by ArmPower CJSC, a subsidiary company of RENCO SPA.

In order to obtain financing from the International Financing Corporation (IFC) and the Asian Development Bank (ADB), a bankable Environmental and Social Impact Assessment (ESIA) Report to the YCCPP-2 ("the Project") on the basis of the relevant World Bank Group's guidelines has to be delivered to IFC and ADB for review and approval.

Fichtner is providing Technical Advisory Services to Armpower CJSC ("Project Company" or "Client"), including the elaboration of the bankable ESIA. The present report presents the Air Dispersion Calculation performed for the Project, and is part of the ESIA.

The objective of the study is to assess the contribution of the air emissions of the YCCPP-2 to the air quality in the area, and to indicate whether the national and international air quality standards are expected to be fulfilled or not. The assessment ultimately leads to the determination of the conditions required to fulfill these standards. The criteria pollutants CO and NO_2 are subject of analysis in this context.

The Air Dispersion Calculation is performed using the dispersion modeling software BREEZE AERMOD (version 8.0.0.39 from 2017), based on a U.S. EPA (United States Environmental Protection Agency) Regulatory Model.

2. Project Site

The YCCPP-2 will be located in the city of Yerevan, Armenia, nearby the existing YCCPP-1 in an industrial area (Figure 2-1 and Figure 2-2). The coordinates of the site center are approximately:

- Northing: 40°6'48.06"N;
- Easting: 44°29'49.55"E;
- Zone: 38T (WGS 84).

Noragvit (a residential district of Yerevan) is located approx. 1,350 m to the west, Ayntap (a major village in the Ararat Province) is located approx. 1,500 m to the south west, Kharberd (another major village in the Ararat Province) is located 1,200 m to the south, and the nearest residential areas of the Erebuni District are located approx. 1,200 m north east of the proposed plant site. Right at the vicinity of the site there are some temporary houses, as well as former industrial buildings and a local Fire Service Training Center. There is no one living within the site.

Nearby the Project site, there is one non-operational power plant and many other active industrial plants:

- YCCPP-1
- "Plant of Pure Iron" OJSC
- "Armenian Molybdenum Production" LLC
- "Nairit 1" and "Nairit 2" Chemical Plants
- Others

Information about the air emissions of other active industrial plants in the area could only be obtained for the YCCPP-1, since this power plant is from the same complex as the new YCCPP-2. The other neighboring industrial plants belong to companies unrelated to the developers of the Yerevan power plants 1 and 2, who shared only some limited information with the Client. Such data did not have enough detail to be used in the ADC.

The site is located close to the Erebuni Airport, and the E 117 highway.

Although the present study focus on the impacts of the Yerevan - 2 PP on the air quality, it would be necessary to consider as well the emissions of the existing neighboring plants, road and airport for a complete analysis. Since there is a large number of air emission sources in the area, and it is not possible to obtain data for all of them, a baseline air quality assessment has been undertaken. Please see Section 4.5 for further details.

The future installation of other industrial plants in the area cannot be reasonably foreseen at this stage.

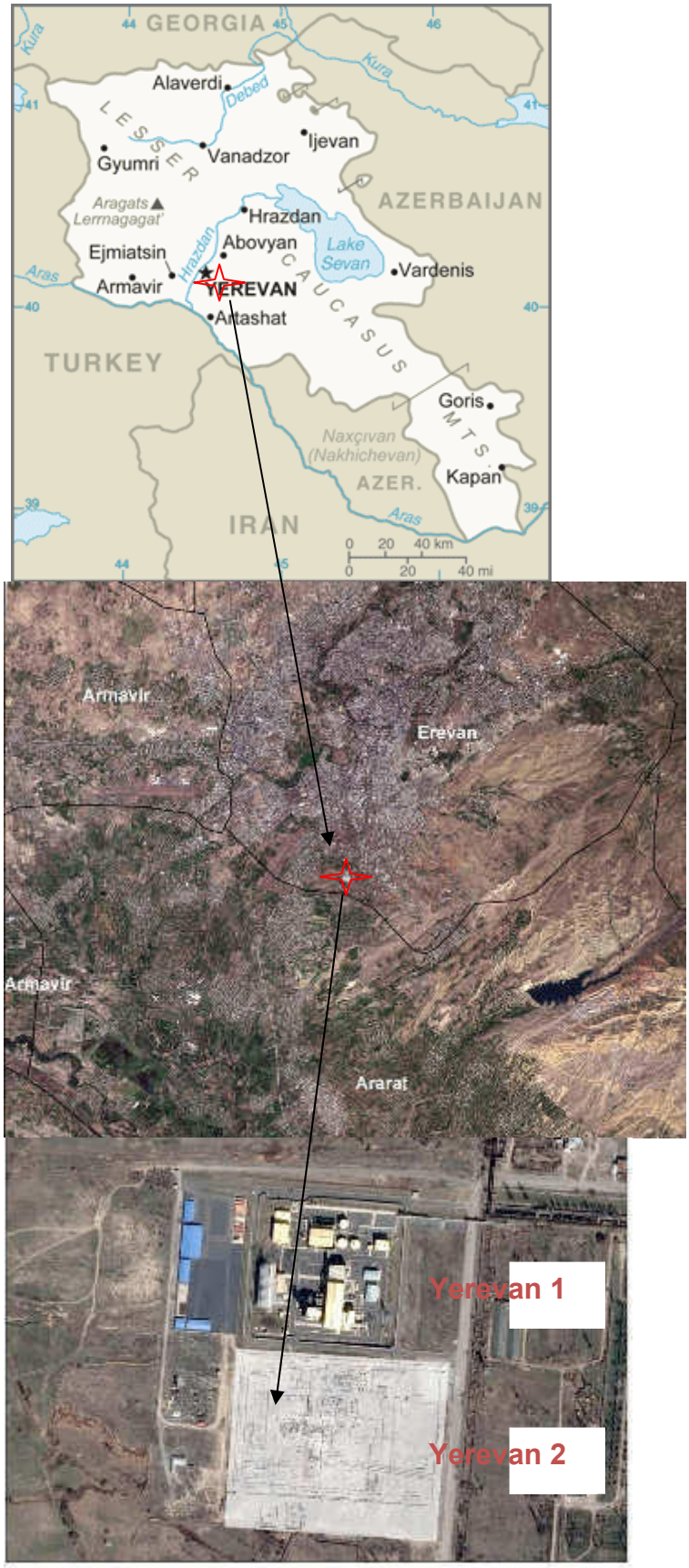

Figure 2-1: Location of the future Yerevan - 2 PP (source of the topographic map: URL 1)

Figure 2-2: Overview of the immediate surroundings of the Yerevan Power Plants 1 and 2

3. Air Emissions and Air Quality Legislation

In order to protect human health, vegetation and/or properties from the negative effects of air pollution, limits are imposed to:

- the concentrations of the pollutants that are emitted from various sources - air emission limits; *and to*
- the concentrations of the pollutants that are present in the atmosphere - air quality standards.

In several countries, these limits (or standards) are defined in the national laws/regulations, but there are also internationally accepted values like the ones from the World Bank Group Guidelines or the European Union Directives.

The air emission limits represent the maximum concentrations that are allowed in the flue gas coming out of the source (a stack, in this case) and are given in mg of pollutant per normal m^3 of dry flue gas (mg/Nm^3). The N stands for "Normal conditions": temperature of 0°C and atmospheric pressure of 101.3 kPa.

The air quality standards (AQS) state the maximum concentrations that are allowed in the ambient air, in this case, in the airshed surrounding the power plant. The standards are presented in µg of pollutant per m^3 of ambient (exterior) air ($\mu g/m^3$). For gaseous pollutants, the results of the air quality monitoring shall be standardized at a temperature of 293 K (20°C) and an atmospheric pressure of 101.3 kPa.

This chapter presents the national and international standards for air emissions and for air quality that are applicable to the project.

3.1 Air Emission Limits

The International Finance Corporation (IFC, World Bank Group) defined emission guidelines (EG) for facilities with a power input larger than 50 MW_{th} using gas turbines (Table 3-1).

Pollutant	EG for combustion turbines; facilities > 50 MW_{th}
	Natural Gas
NO_2	51 mg/Nm^3
Dry gas, excess O_2 content	15%
Temperature flue gas	0°C

Table 3-1: IFC emission guidelines for facilities larger than 50 MW with combustion turbines (IFC, 2008)

There are no national air emission limits for thermal power plants. The specifications for Yerevan 2 demand the compliance with the performance

guarantee values for CO, NO_2 and Unburned Hydrocarbons (UHC) as shown in Table 3-2.

Pollutant	Performance Guarantees
CO	30 mg/Nm^3
NO_2	50 mg/Nm^3
UHC	10 mg/Nm^3
Dry gas, excess O_2 content	15%
Temperature flue gas	0°C
Load	From 70% to 100%

UHC: Unburned Hydrocarbons

Table 3-2: Performance Guarantees for YCCPP-2 - air emissions

The performance guarantee values for NO_2 comply with the IFC emission guidelines. No emission guidelines are defined by IFC for CO. For the project at hand, and based on the specific natural gas composition, the emissions of UHC may include pollutants such as methane (85 to 96% of the gas is composed of methane), ethane, propane, butane, and pentane. IFC does not define emission guidelines for UHC in general nor for any of the listed chemicals in particular.

3.2 Air Quality Standards

The Air Quality Standards are defined according to the different levels of danger that the pollutants pose depending on the exposition period. This way, the standards are defined for different time frames, allowing the protection against the short term acute impacts, the medium term impacts and the long term impacts.

IFC states that emissions from projects shall not result in pollutant concentrations in the ambient air that reach or exceed the relevant ambient air quality guidelines and standards by applying the national legislated standards or, in their absence, the World Health Organization (WHO) Guidelines or other internationally recognized sources like the U.S. EPA (United States Environmental Protection Agency) or the European Council Directives (ECD).

The IFC recommends, in addition, that the emissions from a single project should not contribute with more than 25% of the applicable ambient air quality standards to allow additional, future sustainable development in the same airshed. This implies that even when a ground level concentration (GLC) of a certain pollutant respects the air quality standard, it shall be evaluated whether it is below or above 25% of that standard. This is also assessed in the present study.

Table 3-3 presents the national ambient air quality standards, or MAC - maximum allowable concentrations (established by Governmental Decree

Nr. 160-N of 2 February 2006), and the standards defined by the European Council Directive 2008/50/EC that are applicable to the project.

Pollutant		Averaging period	Air Quality Standards [µg/m³]	
			National MAC	ECD
CO		Short-time	5,000	-
		24 hours	3,000	-
		Max. daily 8 hour mean	-	10,000
NO_2		Short-time	200	-
		1 hour	-	200 *Not to be exceeded more than 18 times per year*
		24 hours	40	-
		1 year	-	40
UHC	Methane	-	-	-
	Ethane	-	-	-
	Propane	-	-	-
	Butane	Short-time	200,000	-
	Pentane	Short-time	100,000	-
		24 hours	25,000	-
PM_{10}		Maximum	300	-
		24 hours	60	50 *Not to be exceeded more than 35 times per year*
		1 year	-	40
SO_2		Maximum	500	-
		1 hour	-	350 *Not to be exceeded more than 24 times per year*
		24 hours	50	125 *Not to be exceeded more than 3 times per year*

Table 3-3: National and ECD Ambient Air Quality Standards

The ECD 2008/50/EC does not set a limit for the type of UHC that are expected from natural gas operation (methane, ethane, propane, butane, and pentane). The limits shown in Table 3-3 for butane and pentane are based on the national legislation, but seem to be overly permissive. In fact, the national air quality monitoring network does not measure hydrocarbons (WHO, 2003), for what there is not a real experience on the application of

the standards for UHC. Given this, these standards are not be used in the present ADC, and **focus is provided on CO and NO_2**.

Although PM_{10} and SO_2 are not expected to be emitted by the YCCPP - 2, these standards are mentioned as they are of importance for the air quality baseline assessment shown in Section 4.5.

It shall be noted that the national MAC for 24 hr NO_2 of 40 µg/m³ corresponds to the ECD limit for annual averages. This shows that this national MAC is very stringent when compared to the international standards.

According to the RA Regulation Nr. 1673-N of 27 December 2012, to determine the specific emission limits for projects such as power plants, an air dispersion calculation shall be undertaken that evaluates the compliance with the short time MACs. The short time MAC for CO is 5,000 µg/m³ and for NO_2 is 200 µg/m³ (for residential areas). Therefore, in what regards compliance with national requirements, focus is only provided in this study to the short-time MACs. To evaluate compliance with international requirements, compliance with all applicable ECD air quality standards is also assessed.

4. Baseline Data

4.1 Affected area and receptors

The air quality standards considered in this study are defined for protection of human health. Given this, the study will focus particularly on the analysis of the air quality effects in areas where human presence exists. An area of 314 km^2 around the power plant is defined as the eventually affected area for air pollution impacts. This includes the neighboring settlements up to 10 km in all directions counting from the stack of the YCCPP-2 (Figure 4-1).

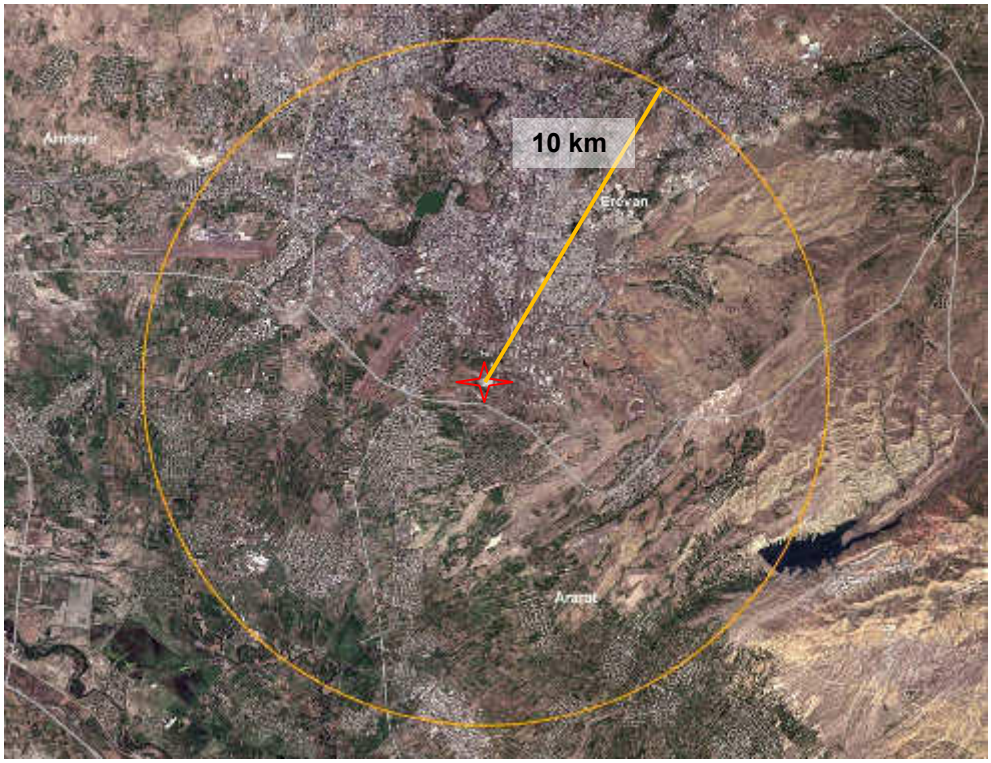

Figure 4-1: Location of the affected area

In the direct proximity of the power plant (up to 1 km), there are some temporary informal houses to the northeast and southeast, deactivated industries and the local Firefighters Training Center to the southwest, a non-operational power plant to the east, and agricultural fields/pastures to the west and northwest (Figure 4-2).

Figure 4-2: Closer view of the affected area

4.2 Meteorological Data

In order to conduct the Air Dispersion Calculation, recent meteorological data from a monitoring station located nearby the project site (Zvartnots Airport) have been analyzed. The data set includes information such as wind speed and direction, cloud cover, temperature, sensible heat flux, surface roughness, etc.

Figure 4-3 presents the wind rose for the years 2014 to 2016. It shows that the prevailing winds blow from northeast (NE). The wind rose also indicates that the more frequent wind speeds are between 1.5 and 3 m/sec, which is equivalent, in the Beaufort scale, to the levels “light air” and “light breeze”.

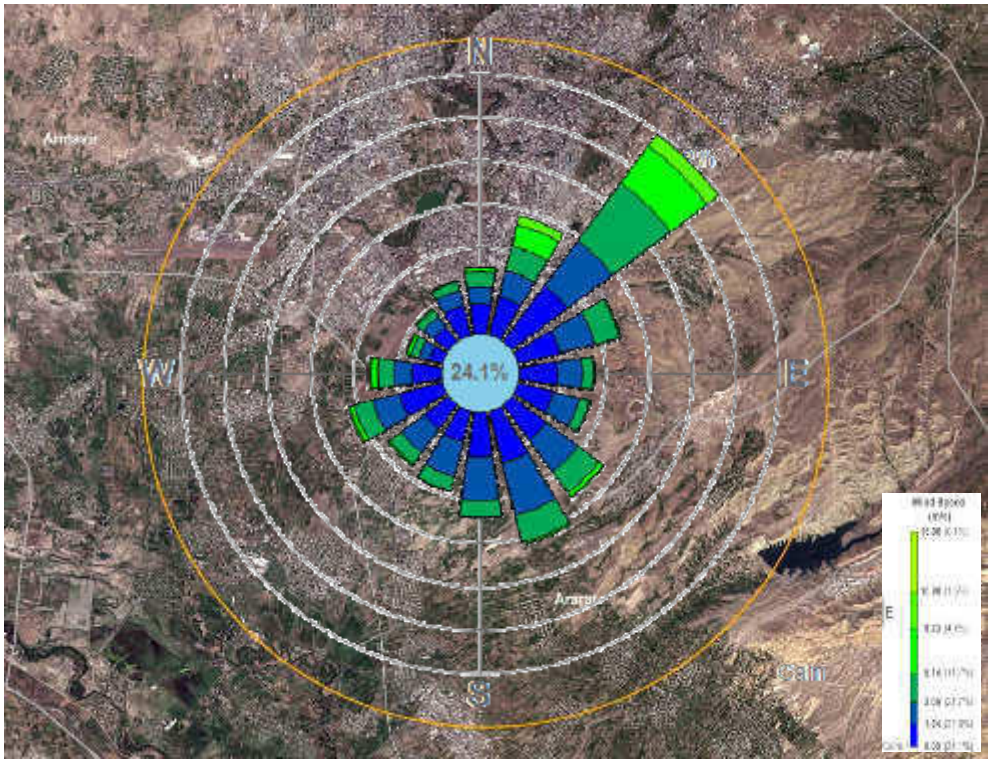

Figure 4-3: Wind rose for the years 2014-2016 (wind blowing from)

4.3 Terrain data

To account for the different heights above sea level of the sensitive receptors and the plants, terrain data were acquired. These allow a 3D representation of the terrain of the assessment area and a more accurate simulation of the pollutants' distribution. Figure 4-4 shows a representation of the area's terrain.

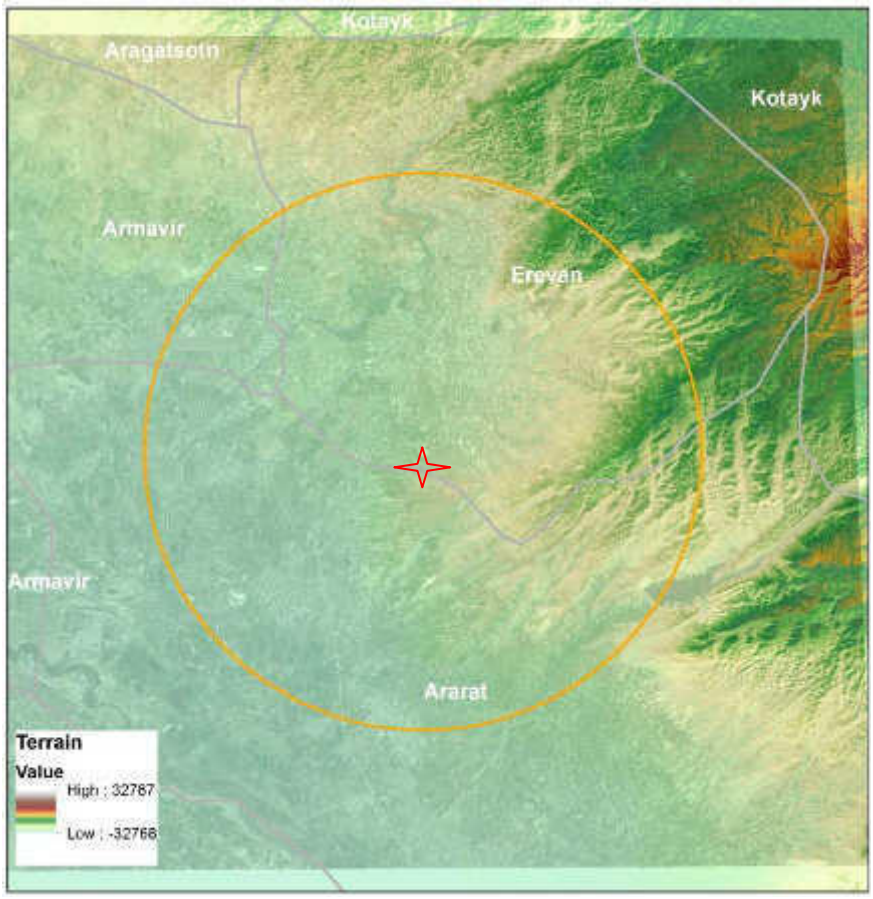

Figure 4-4: Representation of the terrain of the affected area

The project site is located at a height of ca. 930 masl. The terrain and the immediate surroundings are generally flat. Around 3 km to the east of the plant the terrain becomes more elevated where the Gegham mountains begin (Figure 4-5).


YCCPP 1
YCCPP 2
Gegham Mountains
Non-operational PP
Plant of
Pure Iron

Figure 4-5: Landscape/terrain at the site and its surroundings (Fichtner, July 2017)

4.4 Emission Data

To the date of writing this report, emission data of YCCPP-1 and forecast emission data for YCCPP-2 could be obtained (see Table 4-1). Complete data for other neighboring plants could not be obtained, since these belong to companies unrelated to the developers of the Yerevan power plants 1 and 2, who shared only some limited information with the Client. Such data did not have enough detail to be used in the ADC.

Parameter	New YCCPP-2		Existing YCCPP-1	
	Value	Source	Value	Source
Number of stacks	1	Tender specifications/Client	1	Site visit
Location of stacks [m; WGS 84, Zone 38T]	Easting: 457,128		Easting: 457,150	
	Northing: 4,440,461		Northing: 4,440,617	
Height of stacks [m]	35 - 66 (TBD)		45	
Diameter of stacks (inner) [m]	6.23		6.7	
Flue gas exit temperature [K]	370		399	
Flue gas exit velocity [m/s]	20		19	
Actual* flue gas exit flow [m^3/s] per stack	606		670	Calculated based on information collected during the site visit
Concentration CO [mg/Nm³] dry, 15% O2	30		0.86	Client
Concentration NO_2 [mg/Nm³] dry, 15% O2	50		43.4	
Concentration UHC [mg/Nm³] dry, 15% O2	10		-	-
Emission rate CO [g/s] per stack	12.4	Calculated based on information provided by the Client	0.4	Calculated based on information provided by the Client
Emission rate NO_2 [g/s] per stack	20.6		18.0	
Emission rate UHC [g/s] per stack	4.1		NA	-

TBD = To be determined

* Actual means at the actual conditions of temperature, pressure, moisture and O_2 content of the flue gas

Table 4-1: Emission data for YCCPP-2 and YCCPP-1

4.5 Baseline Air Quality Data - Summer and Autumn 2017; Winter 2017/2018

A baseline air quality assessment has been undertaken in July/August 2017 (Summer), October/November 2017 (Autumn), and December 2017/January 2018 (Winter) in the Project Area of Influence, including the specific areas where the highest pollution levels resulting from the operation of the YCCPP - 2 are expected.

The primary objective of this assessment was to determine if the Project's airshed is degraded or non-degraded. A degraded airshed is one where the applicable air quality standards are exceeded (IFC, 2007). With this objective, the ground level concentrations (GLC) of PM_{10}, SO_2 and NO_2 have been monitored in 5 different locations as shown in Figure 4-6. Although PM_{10} and SO_2 are virtually not expected to be emitted by the YCCPP - 2, it is important to determine their concentrations to assess whether the airshed is degraded or not.

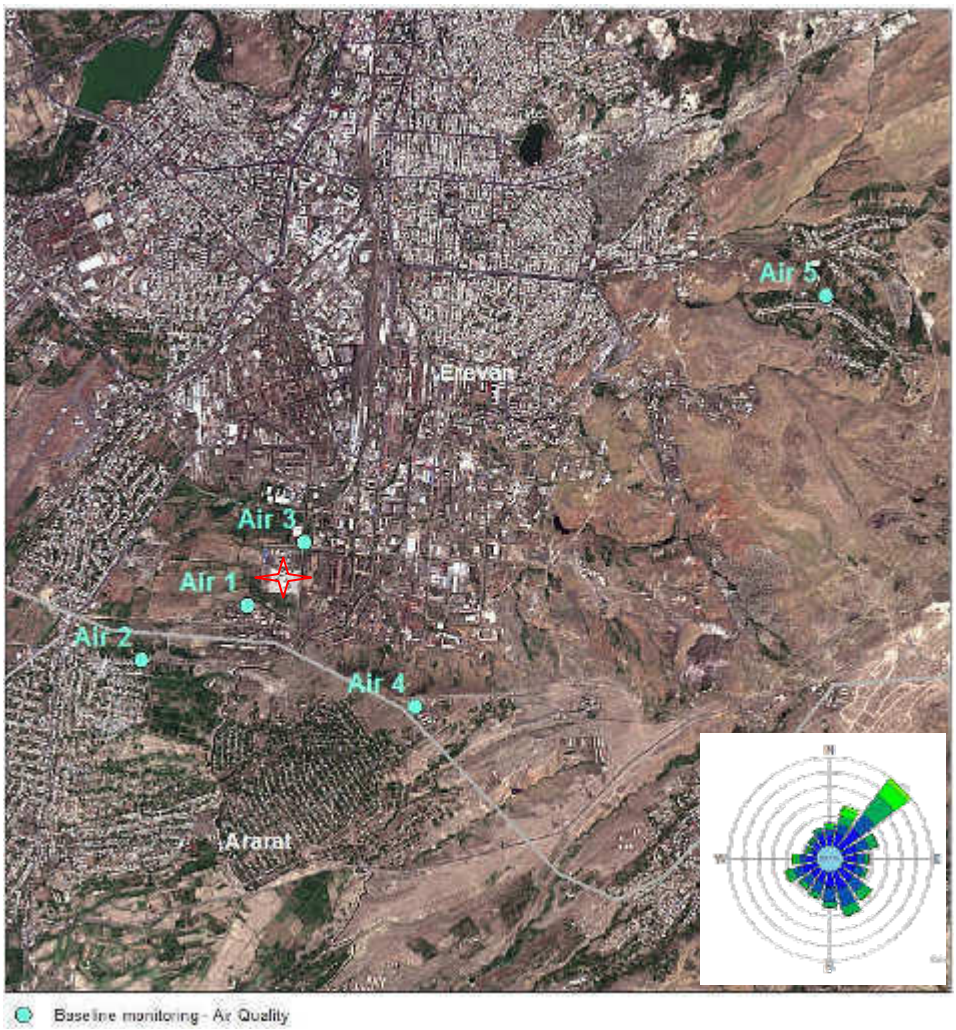

Figure 4-6: Baseline Monitoring Points - Air Quality

The measurement point Air 1 is situated in industrial area near the southeast border of YCCPP - 1, between the local Firefighters Training Center and an abandoned production facility. The measurement point Air 2 is placed approx. 1,700 m to the south-west of YCCPP - 2; it is located near the northeast border of the Ayntap community between the cemetery and private cultivated gardens. Points Air 1 and Air 2 are located downwind the main wind direction. The measurement point Air 3 is placed in an industrial area near the northern border of the YCCPP - 2. The points Air 4 and Air 5 have been defined after one test model run, being located in the areas where the highest GLC of NO_2 resulting from the operation of YCCPP - 2 are expected.

4.5.1 PM_{10}

The complete reports of the measurements of PM_{10} can be found in Annex 1 to this ADC.

The dust concentration was measured by using the dust particle meter DT-96 in accordance with the GOST 17.2.4.05-83 - “Environmental protection. Atmosphere. Gravimetric method for determination of suspended dust particles”.

The equipment collected 5 daily measurements of 5 minutes along 5 days between 27.07.2017 and 05.08.2017 (Summer), along 5 days between 28.10.2017 and 04.11.2017 (Autumn), and along 30 days between 17.12.2017 and 03.02.2018 (Winter). The results are presented in Table 4-2.

The baseline data for PM_{10} has been collected as averages of 5 minutes sampled 5 times per day, meaning that 25 minutes of data have been sampled per day. Electronic equipment to undertake continuous monitoring like the ones used, for example, in the European Union, is not readily available in Armenia. Monitoring with such equipment would allow a direct comparison of the measured values with the air quality standards. Because such equipment is not available, such comparison is hindered. One can however state, as a reasonable approximation, that the averaged values assessed on these campaigns correspond to approximations of 1 hour averages. The corresponding daily (24hr) and annual (1yr) averages are expected to be lower than the presented 1 hour averages.

According to the results shown in Table 4-2, the air quality standards for PM_{10} are presently respected in the area.

Point	PM_{10} [µg/m³] Average 5 mins in 5 days Summer 17	PM_{10} [µg/m³] Average 5 mins in 5 days Autumn 17	PM_{10} [µg/m³] Average 5 mins in 30 days Winter 17/18	Air Quality Standards [µg/m³]			
				National MAC		ECD	
				Max.	24 hr	24 hr	1 yr
Air 1	11.4	17.7	6.3	300	60	50	40
Air 2	18.2	21.0	6.6				
Air 3	18.2	28.6	6.4				
Air 4	N.A.	18.4	6.0				
Air 5	N.A.	23.4	6.1				

N.A. = Not Available

Table 4-2: Baseline air quality measurement results - PM_{10}

4.5.2 SO_2 and NO_2

The complete reports of the measurements of gases (SO_2 and NO_2) can be found in Annex 2 to this ADC.

The baseline concentration of gases in the project area has been measured with diffusion tubes, which is the method used in the national monitoring network. The tubes have been placed in monitoring points Air 1 to Air 5 for 7 days in Summer, 10 days in Autumn and 30 days in Winter. The resulting GLC has been determined in the Laboratory of Environmental Monitoring and Information Center of the Ministry of Nature Protection (Table 4-3 and Table 4-4).

Point	NO_2 [µg/m³] Average 7 days Summer 17	NO_2 [µg/m³] Average 10 days Autumn 17	NO_2 [µg/m³] Average 30 days Winter 17/18	Air Quality Standards [µg/m³]			
				National MAC		ECD	
				Max.	24 hr	1 hr	1 yr
Air 1	16.0	4.3	15.8	200	40	200	40
Air 2	11.9	4.7	16.0				
Air 3	21.3	4.5	20.2				
Air 4	20.1	4.7	16.7				
Air 5	9.2	4.7	19.4				

Table 4-3: Baseline air quality measurement results - NO_2

Point	SO_2 [µg/m^3] Average 7 days Summer 17	SO_2 [µg/m^3] Average 10 days Autumn 17	SO_2 [µg/m^3] Average 30 days Winter 17/18	Air Quality Standards [µg/m³]			
				National MAC		ECD	
				Max.	24 hr	1 hr	24 hr
Air 1	19.4	18.7	25.4	500	50	350	125
Air 2	22.1	26.7	17.6				
Air 3	28.4	19.7	23.2				
Air 4	N.A.	26.2	17.1				
Air 5	N.A.	33.5	26.0				

N.A. = Not Available

Table 4-4: Baseline air quality measurement results - SO_2

The Autumn measurements of NO_2 show a significant difference to those of the other seasons. This may be explained by the rainy weather that was felt during the Autumn measurement campaign. The Winter and the Summer averages are not significantly different, unlike what would be expected (i.e., it is normally expected that the GLC of pollutants in Winter are higher). This may be explained by the abnormally mild weather felt in Yerevan during the Winter sampling period (see Annex 3 for related temperature graphics).

The baseline data for gases has been collected as averages of several days. Electronic equipment to undertake continuous monitoring like the ones used, for example, in the European Union, is not readily available in Armenia. Monitoring with such equipment would allow a direct comparison of the measured values with the air quality standards. Because such equipment is not available, such comparison is hindered. One can however state, as a reasonable approximation, that the averaged values assessed on each monitoring point correspond to approximations of 24 hour averages.

According to the results shown in Tables 4-3 and 4-4, the national and international 24 hr air quality standards for SO_2 and NO_2 are presently respected in the area. The following section depicts a calculation of the 1 hour and annual averages of NO_2 based on a recognized U.S. EPA methodology.

4.5.3 Treatment of the baseline data - NO_2

NO_2 baseline data needs to be used as an input to the model with the objective of assessing the cumulative impacts of the YCCPP-2 in the hourly and annual NO_2 ground level concentrations. As described in the previous section, the concentrations resulting from the monitoring campaign can be approximated to daily (24 hr) averages. Based on EPA, 1992, the following

multiplying factor has been developed to convert the 24 hr averages into 1 hr averages:

Multiplying Factor - to convert 24 hr to 1 hr
2.5

Table 4-5: Multiplying factor to convert 24 hour concentrations to 1 hr concentrations (adapted from EPA, 1992)

The conversion of 1 hour averages into other averaging periods can be done as well. In the present case, there is the need to estimate annual averages. This is done by applying the multiplying factor shown in Table 4-6 below to the 1 hr value.

Averaging period	Multiplying Factor - to convert 1 hr to other averaging periods
Annual	0.08

Table 4-6: Multiplying factor for point sources to convert 1 hour concentrations to annual periods (EPA, 1992)

In order to assess the cumulative impacts of the YCCPP-2 in the worse case scenario possible, the highest GLC detected during the sampling period are used to represent the baseline/existing 24 hr concentrations. The 1 hr and 1 yr concentrations are calculated based on the multiplying factors shown in the previous tables. The results are found below. They show that presently all national and international standards are respected in the area.

Point	NO_2 [µg/m^3]			Air Quality Standards [µg/m^3]			
				National MAC		ECD	
	24 hr (measured highest value) *	1 hr (calculated) **	Annual (calculated) ***	Max.	24 hr	1 hr	1 yr
Air 1	16.0	40.0	3.2	200	40	200	40
Air 2	16.0	40.0	3.2				
Air 3	21.3	53.2	4.3				
Air 4	20.1	50.2	4.0				
Air 5	19.4	48.5	3.9				

* See Table 4-3
** Using the multiplying factor shown in Table 4-5
*** Using the multiplying factor shown in Table 4-6

Table 4-7: Measured and calculated NO_2 baseline concentrations in the project area

4.5.4 Baseline assessment - conclusion and future work

The results show that the airshed surrounding the future YCCPP - 2 can be classified as **non-degraded** regarding the pollutants PM_{10}, SO_2 and NO_2. New monitoring campaigns will be undertaken in Spring 2018 to capture the seasonal variations in the pollutant's GLC, and reinforce or adapt this conclusion.

5. Air Dispersion Calculation

5.1 Air Quality Model

The Air Dispersion Calculation was performed using the dispersion modeling software BREEZE AERMOD, version 8.0.0.39 (from 2017), which predicts pollutant concentrations from continuous point, flare, area, line, volume and open pit sources. This steady-state plume model is a US-EPA Regulatory Model.

The simulations performed with BREEZE AERMOD for each of the pollutants CO and NO_2 result in worst case scenarios, that is, the software outputs the maximum concentrations expected to be found in the area due to the operation of the plants.

The NO_2 results were obtained after application of the following ratios to the simulations of NOx:

- Short term (1 hour) NO_2 results are calculated by applying a rate of 50% to the modeled short term NOx results;
- Long term (annual) NO_2 results are assumed to be 100% of the modeled long term NOx results.

This approach is valid for short range modeling and is recommended by the Air Quality Modelling and Assessment Unit from the United Kingdom's Environment Agency as a worst case approach[1]. Such conversion ratios are only considered appropriate for combustion processes, where no more than 10% of the emitted NOx is in form of NO_2. This is applicable for the project at hand.

One of the objectives of the ADC is determining the height that the stacks of the plant shall have so that the national and international air quality standards (AQS) are fulfilled at the next receptor points in every scenario. Three stack heights are considered: 35 meters (as planned by design), 43 meters (alternative design 1) and 66 meters (alternative design 2).

5.2 Calculation Scenarios

Altogether 3 scenarios are simulated:

- Baseline scenario, or **Scenario A** - considers only the baseline air quality data collected in the area for NO_2; for CO, it considers the contribution of YCCPP-1.
- Project scenario, or **Scenario B** - considers the isolated operation of YCCPP-2;

[1] http://webarchive.nationalarchives.gov.uk/20140328232919/http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for__NOx_and_NO2_.pdf

- Cumulative scenario, or **Scenario C -** considers the baseline air quality data *and* the operation of the YCCPP-2 (determination of cumulative impacts) for NO_2; for CO, it considers the operation of YCCPP - 1 and YCCPP - 2.

Each of the scenarios is simulated for a stack height of 35 meters (design), for a stack height of 43 meters (alternative design 1), and for a stack height of 66 meters (alternative design 2).

5.2.1 Note on Scenarios A and C

In respect for international requirements, it is important to understand the quality of the airshed before the project is implemented (baseline - Scenario A). Only considering the baseline it is possible to understand the cumulative impact of the project (Scenario C). In simple terms, the following applies:

$$Scenario\ C = Scenario\ A + Scenario\ B$$

The baseline (Scenario A) can be determined in two alternative ways:

a) Data regarding all surrounding industries and other emission sources is made available, and given as an input to the model; the model will then simulate the impacts of the existing sources in the air quality in the area; *or*
b) An air quality monitoring campaign is undertaken at site.

For CO:
The contribution of all other surrounding sources for the existing CO GLC (option a) could not be considered, due to a lack of important technical and emission data - only data for YCCPP-1 was made available. For this reason, for this pollutant Scenarios A and C are indicative only. Considering the usually very low ambient concentrations of CO, and the comparably very permissive ambient air quality standards, this approximation is deemed to be acceptable, and an air quality campaign for CO was not undertaken.

For NO_2:
In the same way as for CO, the contribution of all other surrounding sources for the existing NO_2 GLC (option a) could not be considered, due to a lack of important technical and emission data - only data for YCCPP-1 was made available. For this reason, Fichtner undertook a baseline air quality monitoring campaign in Summer 2017, Autumn 2017, and Winter 2017/2018 (option b). The highest GLC sampled in each monitoring point are used to represent Scenario A for this pollutant.

5.3 Buildings and downwash effects

The term „building downwash“ describes the effect that wind flowing over or around buildings has on pollutant plumes released from nearby stacks. Essentially, buildings create a cavity of recirculating winds in the area near the buildings, and these building cavities cause increased vertical dispersion of plumes emitted from stacks on or near the buildings. Building downwash often leads to elevated concentrations downwind of affected stacks (Wanger, A., 2011).

For the present ADC, a 3D model of the main buildings of both power plants YCCPP-1 and YCCPP-2 has been set up and included in the model in order to account for eventual downwash effects. Based on this, AERMOD calculated the Good Engineering Practice stack height - GEP stack height - following the recommendations of the IFC EHS guidelines. The GEP stack height is the one that avoids the creation of downwash effects. For the case of YCCPP-2, the GEP stack height is of 66 meters.

5.4 ADC Results

This Section contains the results of the simulations performed with BREEZE AERMOD for each of the pollutants CO and NO_2 for all the different averaging periods for which the applicable standards are defined.

The results are presented in the form of:

- Tables showing the **maximum simulated ground level concentrations** (GLC) in the assessment area for all scenarios. The respective comparison with the Air Quality Standards is made. The tables show in addition the percentage of the AQS which the maximum GLC represent.

- **Plot maps** of the maximum simulated GLC for selected outputs.

It is **important to note** that the results shown represent maximum GLC. The maximum GLC are expected in different times and locations for each scenario. This implies that there is not a direct correlation between the maximum GLCs simulated for the three scenarios.

As explained in Section 3.2, to assess compliance with national requirements only the short-time MACs are evaluated (the short time MAC for CO is 5,000 µg/m³ and for NO_2 is 200 µg/m³). On the other hand, to assess compliance with international requirements, the fulfillment of all defined applicable AQS is assessed.

5.4.1 CO - Short-time MAC

The national legislation defines a short-time MAC for CO of 5,000 µg/m³. A definition of "short-time" is given in the national legislation as a 2 hours period. In this study the comparison is made with the simulated 1-hour values. The ECD does not define a 1-hour AQS for CO.

The comparison of the model results with the national MAC shows that the MAC is expected to be respected throughout the entire assessment area in all scenarios for all stack heights (Table 5-1). The contribution of YCCPP-2 represents less than 25% of the applicable AQS (i.e., 1.9% for 35 meters stack, 1.8% for 43 meters stack, and 1.1% for 66 meters stack), being in line with IFC's recommendation for a future sustainable development in the area.

Time period	CO maximum modeled GLC [µg/m³]			Air Quality Standards [µg/m³]	
	Stack YCCPP-2: 35 m (original design)	Stack YCCPP-2: 43 m (alternative design)	Stack YCCPP-2: 66 m (GEP stack height)	National MAC	ECD
Indicative SCENARIO A - Only YCCPP-1					
1 hour / Short time	2.0	2.0	2.0	5,000	-
SCENARIO B - Only YCCPP-2					
1 hour / Short time	92.5 ***% of the AQS:*** *1.9%*	88.5 ***% of the AQS:*** *1.8%*	53.9 ***% of the AQS:*** *1.1%*	5,000	-
Indicative SCENARIO C - YCCPP-1 + YCCPP-2					
1 hour / Short time	93.9	89.9	55.2	5,000	-

Standard is not exceeded Standard is exceeded

Table 5-1: Maximum simulated 1 hr CO GLC and comparison with the air quality standards

The concentration plots for the simulation of the Scenario C with a 66 meters stack (Figure 5-1 and Figure 5-2) show that the higher values are found in the areas to the east and southeast of the power plants' area. All the high values are below the AQS.

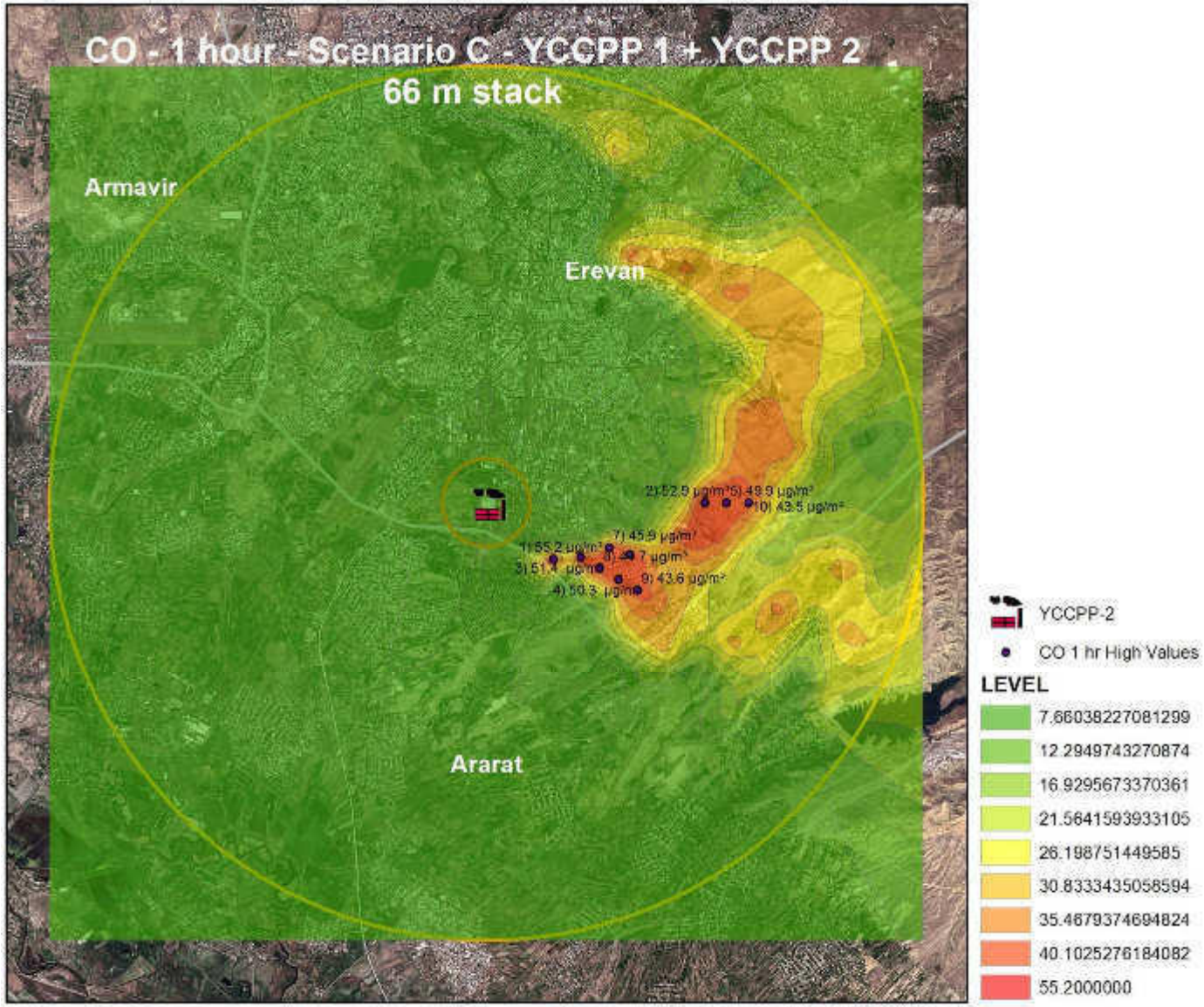

Figure 5-1: Maximum simulated 1 hr CO GLC - indicative cumulative effects - YCCPP-1 + YCCPP-2

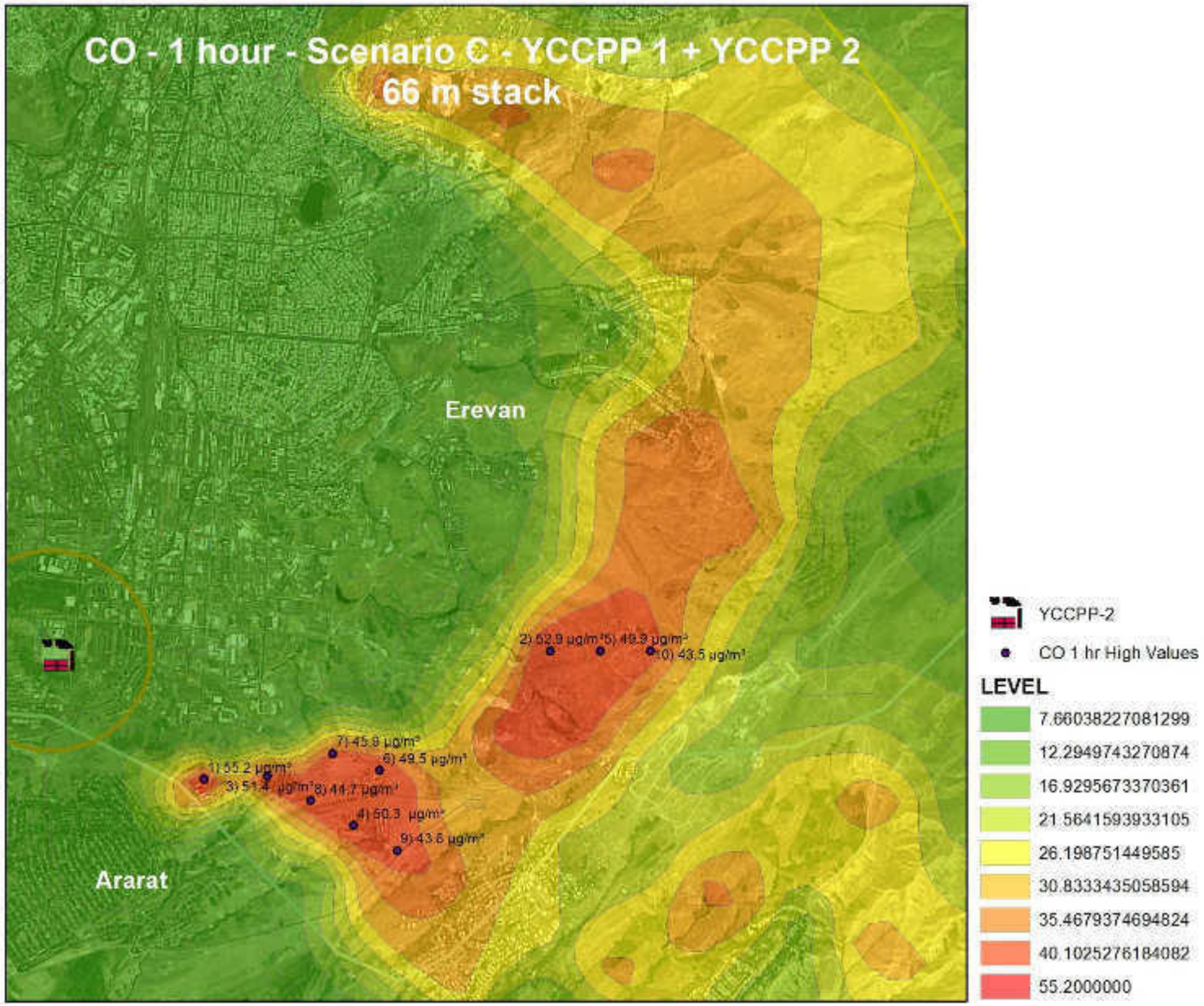

Figure 5-2: Maximum simulated 1 hr CO GLC - indicative cumulative effects - YCCPP-1 + YCCPP-2 - closer view of the higher values

5.4.2 CO - 8 hours International AQS

The ECD defines an 8-hours air quality standard for CO, unlike the Armenian legislation. The model results (Table 5-2) show that no difficulties are expected regarding fulfillment of this standard in any of the scenarios.

The contribution of YCCPP-2 represents less than 25% of the applicable AQS for all stack heights (i.e., 0.6% and 0.3%), being in line with IFC's recommendation for a future sustainable development in the area.

Time period	CO maximum modeled GLC [µg/m³]			Air Quality Standards [µg/m³]	
	Stack YCCPP-2: 35 m (original design)	Stack YCCPP-2: 43 m (alternative design)	Stack YCCPP-2: 66 m (GEP stack height)	National MAC	ECD
Indicative SCENARIO A - Only YCCPP-1					
8 hours	0.98	0.98	0.98	-	10,000
SCENARIO B - Only YCCPP 2					
8 hours	59.5 ***% of the AQS:*** *0.6%*	57.8 ***% of the AQS:*** *0.6%*	30.9 ***% of the AQS:*** *0.3%*	-	10,000
Indicative SCENARIO C - YCCPP-1 + YCCPP 2					
8 hours	60.3	58.6	31.8	-	10,000

Standard is not exceeded Standard is exceeded

Table 5-2: Maximum simulated 8 hr CO GLC and comparison with the air quality standards

The concentration plots for Scenario C (66 meters stack height) (Figure 5-3 and Figure 5-4) show that the absolute cumulative maximum of 31.8 µg/m³ is found in the areas to the east and southeast of the power plants' area. All the high values are below the AQS.

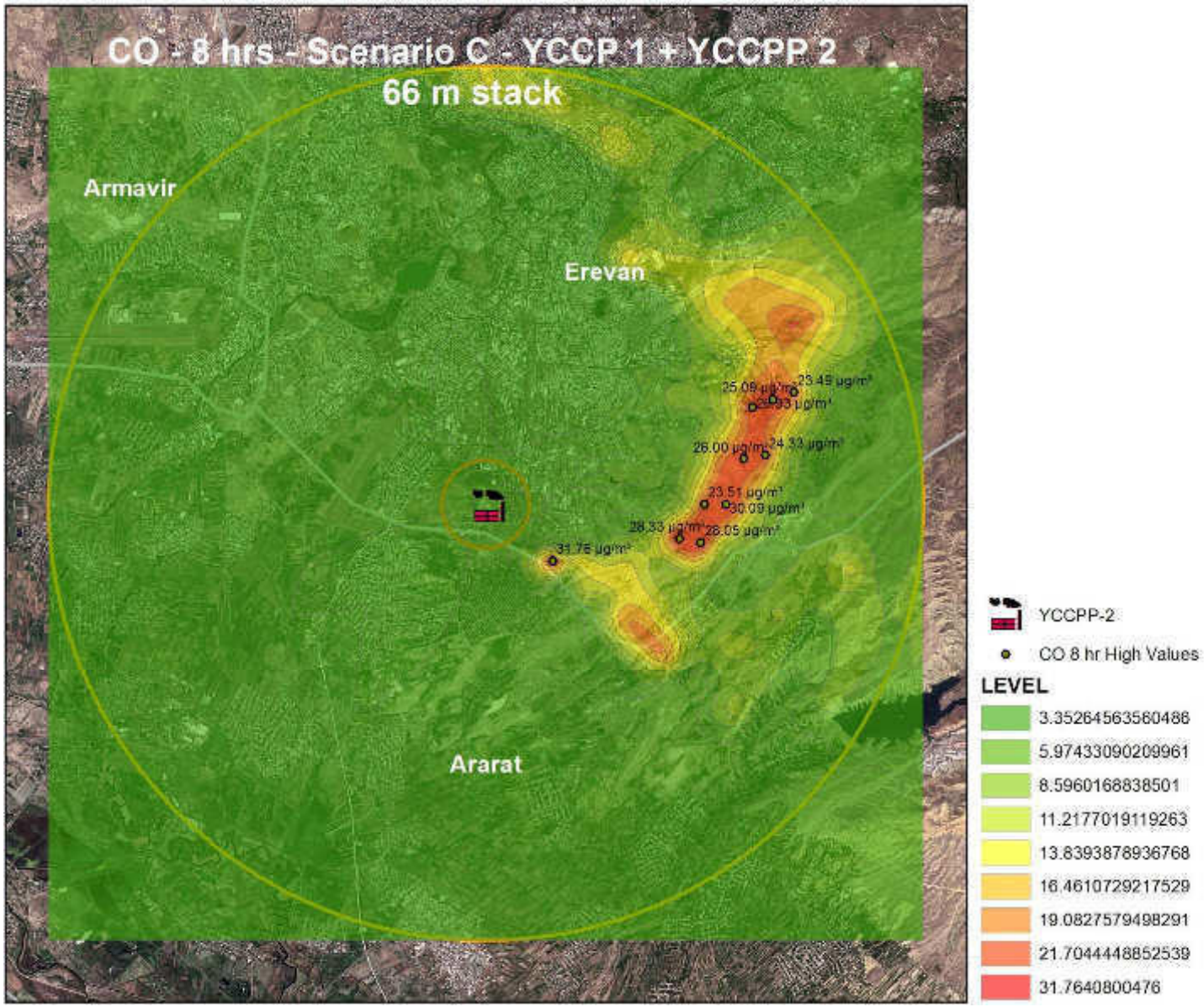

Figure 5-3: Maximum simulated 8 hr CO GLC - indicative cumulative effects - YCCPP-1 + YCCPP 2

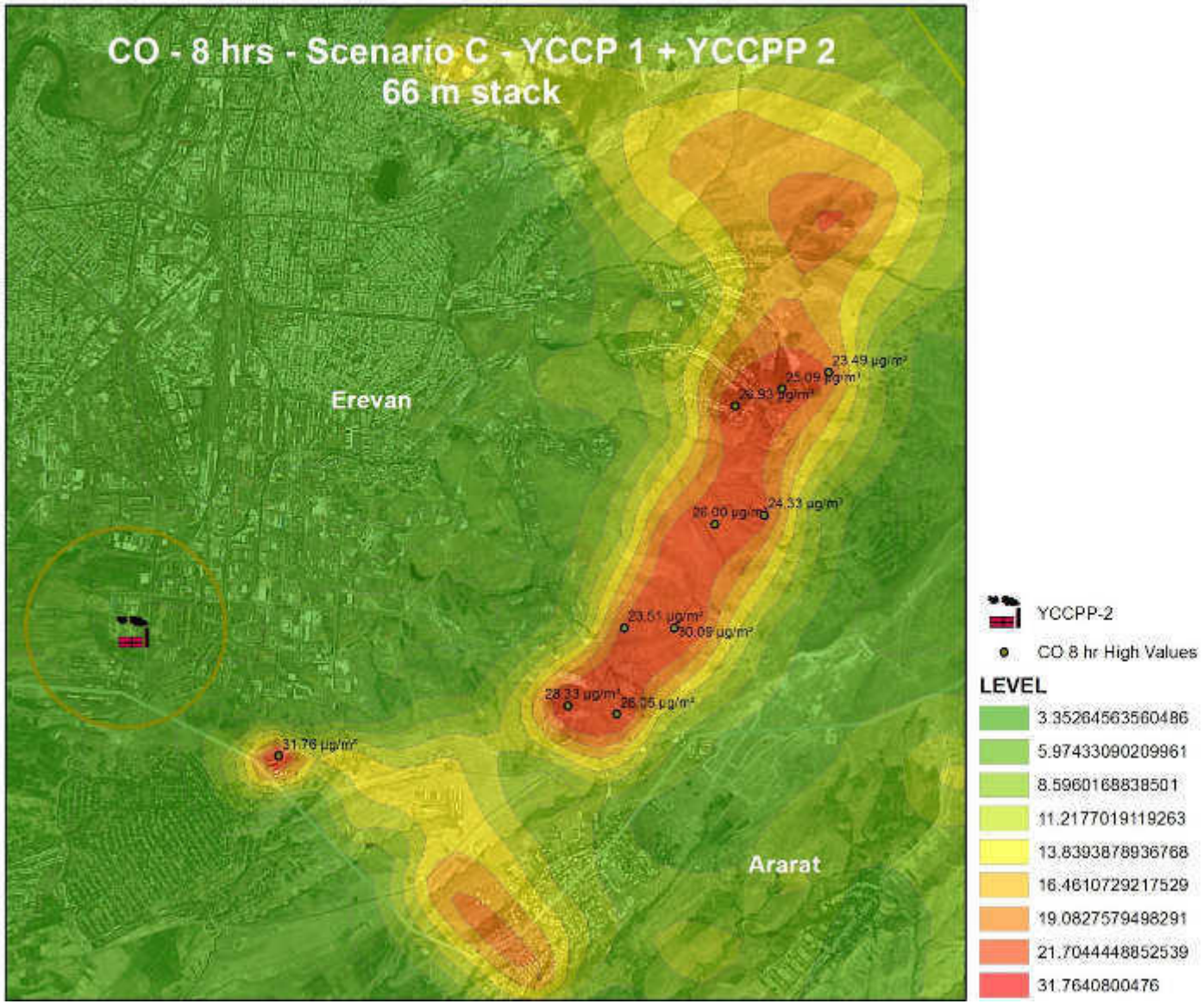

Figure 5-4: Maximum simulated 8 hr CO GLC - indicative cumulative effects - YCCPP-1 + YCCPP-2 - closer view of the higher values

5.4.3 NO_2 - Short-time MAC and 1 hour International AQS

The national legislation defines a short-time MAC for NO_2 of 200 µg/m³. A definition of "short-time" is given in the national legislation as a 2 hours period. In this study the comparison is made with the simulated 1-hour values. The ECD defines a 1 hour standard of 200 µg/m³ for NO_2.

Table 5-4 shows that the maximum modeled 1 hr NO_2 GLCs are expected to be below the national and the international standards throughout the entire assessment area for all scenarios and all stack heights.

The results of Scenario B show that the effect of YCCPP-2 is expected to represent more than 25% of the standards for a 35 meters stack (i.e., 38.5%) and for a 43 meters stack (i.e. 36.7%), but less than 25% of the standards for a 66 meters stack. In other words, if the power plant is built with a GEP stack height, the IFC recommendation for a future sustainable development in the area is respected.

Time period	NO_2 maximum modeled GLC [µg/m³]			Air Quality Standards [µg/m³]	
	Stack YCCPP-2: 35 m (original design)	Stack YCCPP-2: 43 m (alternative design)	Stack YCCPP-2: 66 m (GEP stack height)	National MAC	ECD
SCENARIO A - Baseline data					
1 hour / Short time	40.0 - 53.2	40.0 - 53.2	40.0 - 53.2	200	200 18 times/year
SCENARIO B - Only YCCPP-2					
1 hour / Short time	77 ***% of the AQS:*** *38.5%*	73.5 ***% of the AQS:*** *36.7%*	44.7 ***% of the AQS:*** *22.3%*	200	200 18 times/year
SCENARIO C - Cumulative impacts					
1 hour / Short time	127.0 - 130.2	113.5 - 126.7	84.7 - 97.9	200	200 18 times/year

Standard is not exceeded Standard is exceeded

Table 5-3: Maximum simulated 1 hr NO_2 GLC and comparison with the air quality standards

Figure 5-5 (overview) and Figure 5-6 (close-up) show the maximum concentration plots for Scenario B with a 66 meters stack height. The plots show that the higher values are expected to be found in the industrial and residential areas to the east and to the southeast of the YCCPP-1 and 2. These higher values are, however, below the national MAC and the international AQS.

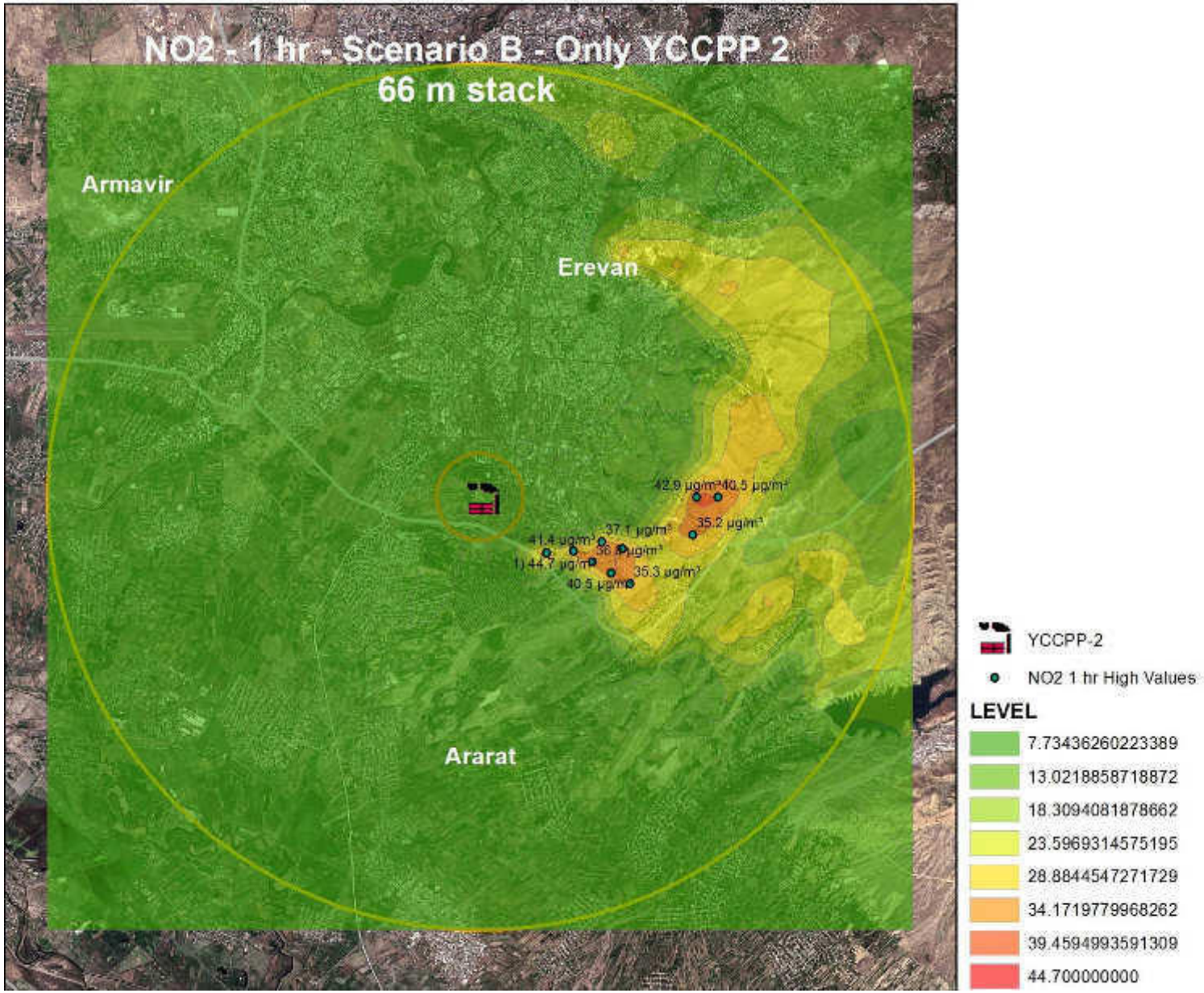

Figure 5-5: Maximum simulated 1 hr NO_2 GLC - Scenario B - YCCPP 2 only

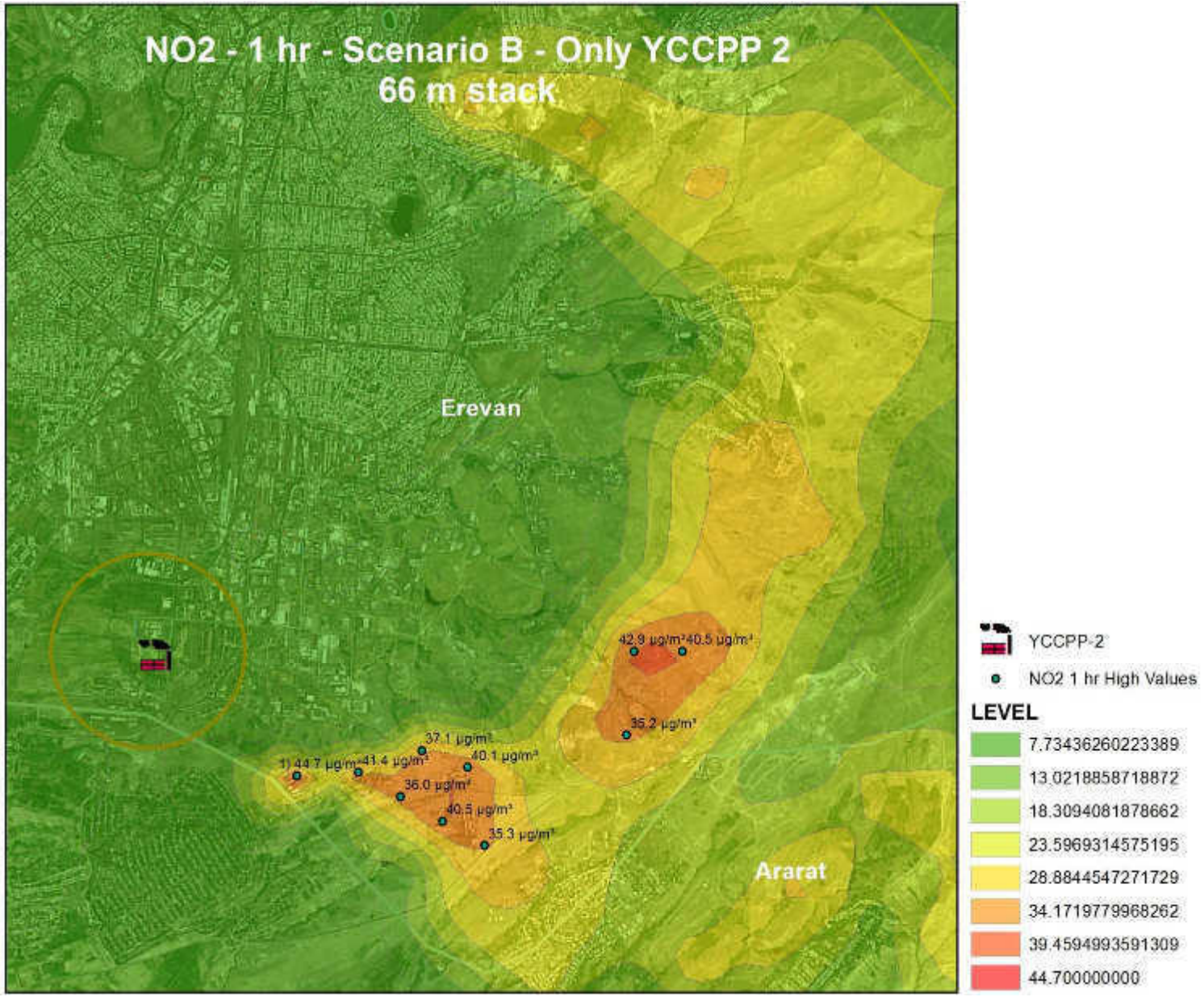

Figure 5-6: Maximum simulated 1 hr NO_2 GLC - Scenario B - YCCPP 2 only- closer view of the higher values

5.4.4 NO_2 - Annual International AQS

The predicted annual NO_2 values in the project area are very low. The comparison with the applicable air quality standard (only ECD) reveals that this is not expected to be exceeded (Table 5-4).

The maximum increment in the NO_2 annual mean represents far less than 25% of the ECD AQS, which respects IFC's dispositions regarding future sustainable development in the area.

Time period	NO_2 maximum modeled GLC [µg/m³]			Air Quality Standards [µg/m³]	
	Stack YCCPP-2: 35 m (original design)	Stack YCCPP-2: 43 m (alternative design)	Stack YCCPP-2: 66 m (GEP stack height)	National MAC	ECD
SCENARIO A - Baseline data					
1 year	3.2 - 4.3	3.2 - 4.3	3.2 - 4.3	-	40
SCENARIO B - Only YCCPP 2					
1 year	1.0 ***% of the AQS:*** *2.5%*	1.0 ***% of the AQS:*** *2.5%*	0.8 ***% of the AQS:*** *2.0%*	-	40
SCENARIO C - Cumulative impacts					
1 year	4.2 - 5.3	4.2 - 5.3	4.0 - 5.1	-	40

Standard is not exceeded Standard is exceeded

Table 5-4: Maximum simulated annual NO_2 GLC and comparison with the air quality standards

Figure 5-7 and Figure 5-8 show the maximum GLC plots for Scenario B (only YCCPP-2) for a 66 meters stack. The plots show that the maximum GLC are expected very close to the power plant. These maximum GLC are below the applicable standard.

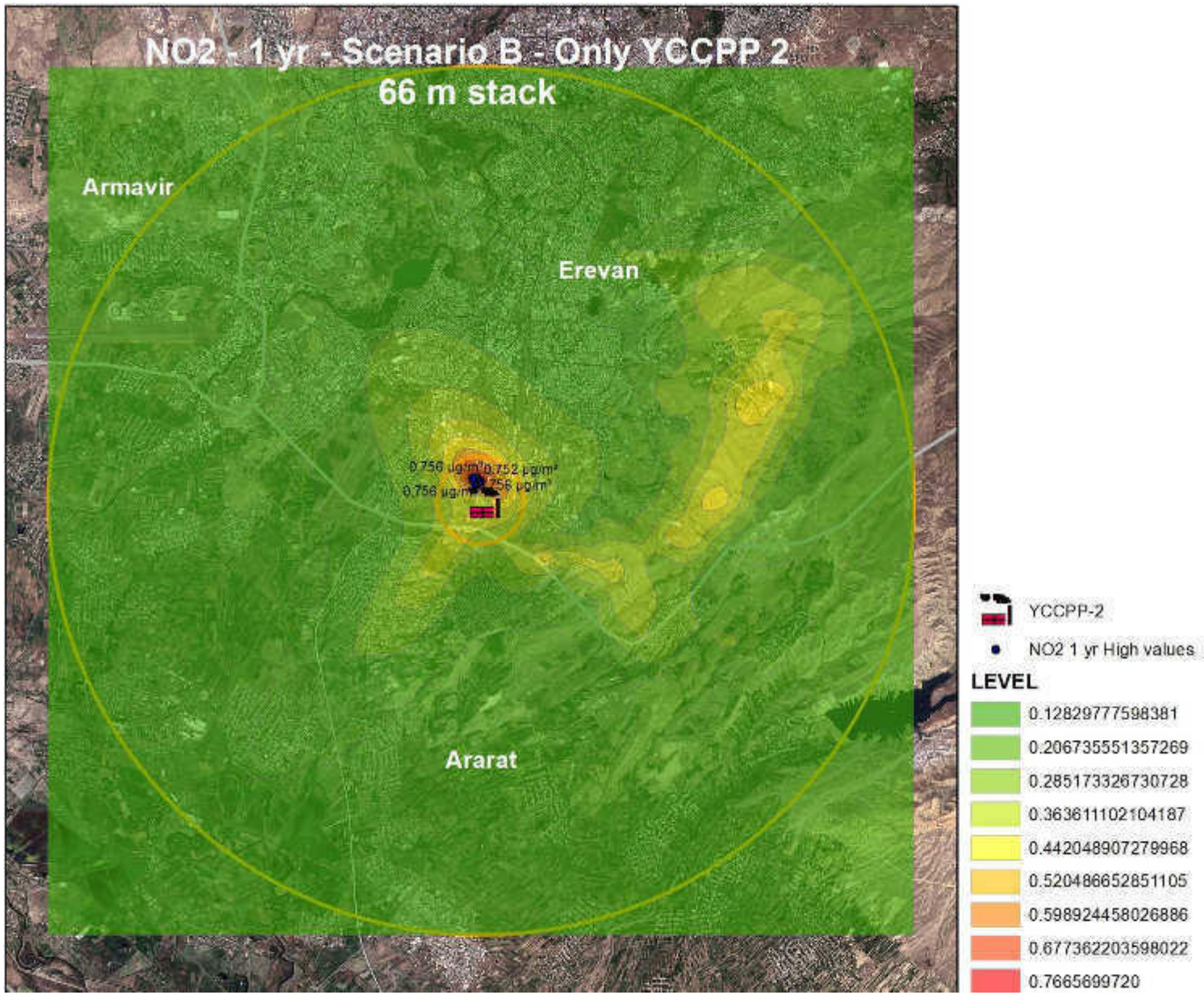

Figure 5-7: Maximum simulated 1 yr NO_2 GLC - Scenario B - YCCPP 2 only

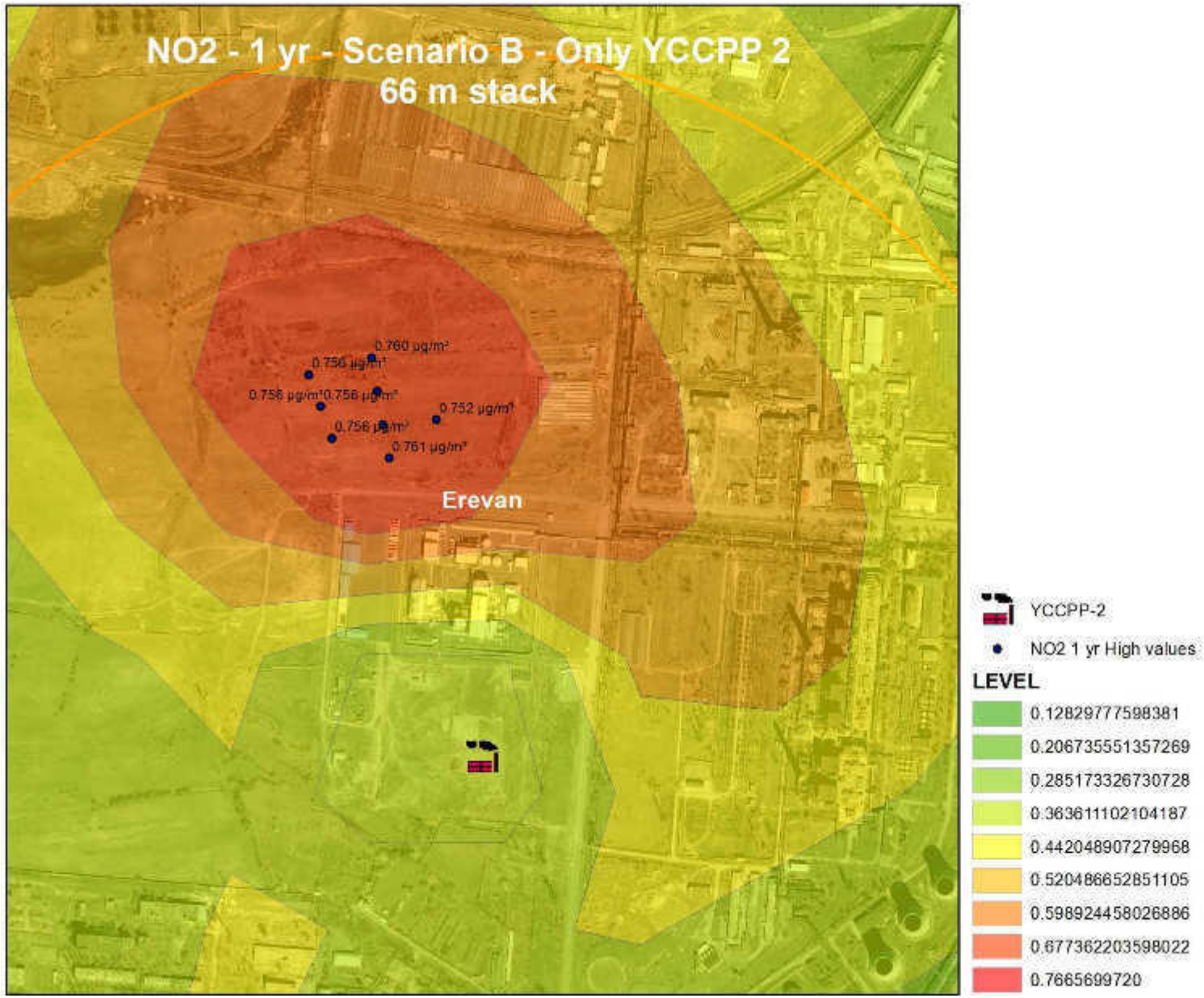

Figure 5-8: Maximum simulated 1 yr NO_2 GLC - Scenario B - YCCPP 2 only - closer view of the higher values

6. Summary of the results

The present ADC allows understanding what is the expected impact of the YCCPP-2 on the airshed of Yerevan.

In respect for international requirements, it is important to understand the quality of the airshed before the project is implemented **(baseline)**. Only considering the baseline it is possible to understand the **cumulative impact** of the project. Baseline data have been collected in Summer 2017, Autumn 2017 and Winter 2017/2018 in the project area with this objective. They show that the airshed in the area is non-degraded.

Altogether **3 scenarios** were simulated:

- Baseline scenario, or **Scenario A**;
- Project scenario, or **Scenario B**;
- Cumulative scenario, or **Scenario C**.

Each of the scenarios was simulated for a stack height of **35 meters** (design), for a stack height of **43 meters** (alternative), and for a stack height of **66 meters** (alternative 2, or Good Engineering Practice (GEP) stack height). To keep up with best international practice, the YCCPP-2 will be built with a 66 m stack height.

The simulation of **CO** shows that all applicable international and national air quality standards are foreseen to be fulfilled in the area in all scenarios for all stack heights.

The maximum simulated GLCs of CO derived from the operation of YCCPP-2 only (Scenario B) represent less than 25% of all applicable air quality standards for all scenarios and for all stack heights investigated.

The maximum modeled **NO_2** GLCs are expected to be below the national and the international AQS throughout the entire assessment area for all scenarios and for all stack heights.

The maximum modeled NO_2 1 hr GLC as a result of the operation of YCCPP-2 only (Scenario B) represent less than 25% of the applicable standards only when considering a stack height of 66 meters. The annual GLC of NO_2 is kept below 25% of the applicable standards for all stack heights.

7. Conclusion

The ADC presents the simulation of the individual impact and the cumulative impact of the YCCPP-2 on the surrounding airshed. The results show that the national and international air quality standards for CO and NO_2 are expected to be fulfilled in all cases.

The fulfillment of IFC's specific requirements for a future sustainable development in the area is only achieved if a stack height of 66 meters is built (GEP stack height). The Client has committed to implement this measure into the design.

8. References

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IFC, 2008: *Environmental, Health, and Safety Guidelines for Thermal Power Plants*, International Finance Corporation, December 2008

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9. Annexes

9.1 Annex 1: PM_{10} Baseline Studies

Project: **Environmental and Social Impact Assessment for a Combined Cycle Power Plant - Yerevan 2**

Project №: **8559P01**

Noise and PM10 Baseline Study

Report

Rev01

Prepared for

Fichtner GmbH & Co. KG

Prepared by

"ATMS Solutions" Ltd.

August, 2017

Contents

1. Introduction

Within the Main Contract between ARMPOWER SJSC (hereinafter - Client) and Fichtner GmbH & Co. KG (hereinafter - Employer) the latter has signed a subcontractor agreement with ATMS Solutions Ltd. (hereinafter - Contractor) to conduct the following tasks:

- Task I. Noise measurements
- Task II. PM10[1] measurements
- Reporting.

Noise and PM10 measurement points have been selected by the Employer and presented in Annex 1. Quantities, durations and times (day-time / night-time) of noise and PM10 measurements were also defined by the Employer and presented below in Table 1.

Table 1. Measurement pre-conditions

Measurement point	Measuring parameters	Time of measurement	Quantity, measurements	Duration	Total quantity, measurements
Noise measurements					**20**
Work-day					**10**
Noise 1	Noise, wind speed	Day-time/	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 2	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 3	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 4	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 5	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Weekend					**10**
Noise 1	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 2	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 3	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 4	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
Noise 5	Noise, wind speed	Day-time	1	1 hour	2
	Noise, wind speed	Night-time	1	1 hour	
PM10 measurements					**75**
Air 1	PM10, temperature, RH[2]	Day-time	5 x 5[3]	5 min[4]	25
Air 2	PM10, temperature, RH	Day-time	5 x 5	5 min	25
Air 3	PM10, temperature, RH	Day-time	5 x 5	5 min	25

[1] Particle matters with 10 μm size
[2] Relative humidity
[3] 5 measurements per day during the 5 days
[4] 5 minutes for each measurement

2. Objective of the Study

The objective of the Study is to conduct instrumental measurements of noise levels and PM10 concentrations at the points around the Yerevan 2 Power Plant, which are expected to be impacted during the construction and operation stages. The measurement points have been selected by the Employer (see Annex 1). The study results should be reported to the Employer.

This Noise and PM10 Baseline Study Report (hereinafter - Study Report) provides an overview of the measurement process and equipment, description of the measurement (sensitive) points, noise and dust (PM10) national sanitary standards, a quantitative analysis, assessment of measurement results and main conclusions. The instrumental measurements were conducted between the 27.07.2017-05.08.2017 at five 5 noise and 3 air sensitive points.

3. Measurement Methodology and Equipment

3.1 Measuring Equipment and Software

3.1.1 Noise Measurement

Instrumental measurements of noise levels are performed using a Sound Level Meter (SLM) "WS1361". The SLM consists of a microphone, electronic circuits and a readout display. The microphone detects the small air pressure variations associated with sound and transforms them into electrical signals. Afterwards, these signals are processed by the electronic circuitry of the instrument. The readout displays the sound level in decibels. The duration of each noise measurement is 1 hour.

The SLM has SLOW and FAST response options. The response rate is the time period over which the instrument averages the sound level before displaying it on the readout. Usually measurements of background noise are taken in the SLOW response mode.

Data on the State verification, as well as technical characteristics of the Sound level meter are listed in Verification certificate that presented in Annex 2. The verification date of the device is 16.05.2017. It is valid until 16.05.2018.

The SLM has the following technical characteristics:

- Measurement range: 30÷130 dB (sub-ranges: 30÷80, 40÷90, 50÷100, 60÷110, 70÷120, 80÷130, 30÷130),
- Frequency Range: 31.5÷8500 Hz,
- Accuracy: ±1.5 dB.

In order to ensure continuous measurements over a certain period of time and further analysis of the results, the SLM WS1361 is connected to a tablet. The special software installed in the tablet allows to record noise levels with one second frequency and provides complete information on the noise level (both in digital imaging and as a graph), including the minimum, maximum and average values of the sound level.

The wind speed during the noise measurements have been determined by the Microclimate parameters measuring device "Meteoscop". Data on the State verification, as well as technical characteristics of "Meteoscop" are listed in Verification certificate (see Annex 2) and summarized below:

- Measurement range of wind speed: 0.1~20 m/sec,
  Accuracy: ±(0.05+0.05V), if wind speed is up to 1m/sec and ±(0.1+0.05V), if wind speed is between 1÷20m/sec,

- Measurement range of temperature: between -10 and +50°C,
  Accuracy: ±0.2,
- Measurement range of relative humidity: between 3 and 97%,
  Accuracy: ±3,
- The verification date of the device is 16.05.2017. It is valid until 16.05.2018.

3.1.2 PM10 Measurement

Dust concentration is measured by using of Dust particle meter DT-96. This device is equipped with 2.5um and 10um size channels to measure PM2.5 and PM10 simultaneously as well as air temperature and relative humidity. The duration of each PM10 measurement is 5 minutes. The obtained data is analyzed and compared with corresponding threshold limit value.

Technical parameters of the device are listed below:

- Concentration measurement: 0~2000 ug/m^3, resolution: 1 ug/m^3,
- Temperature range: 0~50°C, resolution: 1°C, accuracy: ±0.1°C,
- Humidity Range: 0 to 100%RH, accuracy: ±5%RH, 0~20%RH, 80~100%RH; ±3.5%RH, 20~80%RH.

The verification of Dust particle meter is conducted by manufacturer on 08.08.2016 and valid till 08.08.2017 (Annex 2).

4. Normative Framework

4.1 Sanitary Norms for Noise

Noise instrumental measurements, analysis and evaluation of results were carried out in accordance with the following regulations/standards:

- RoA Sanitary Norms №2-III-11.3 "Noise in the workplaces, in residential and public buildings and in residential construction areas" adopted by the order of RoA[5] Minister of Health №138 on 06.03.2002,
- Guidelines for Community Noise, World Health Organization (WHO), 1999.

As criteria for determination of the conformity level of the actual noise in identified measurement points, the normative value of the equivalent (average) sound level is used, according to the RoA Sanitary Norms №2-III-11.3 "Noise in the workplaces, in residential and public buildings and housing in construction areas" as well as WHO's Guidelines for Community Noise (see Table 2).

Table 2. Threshold limit value (TLV) for noise

№	Premises and territories	Time	TLV (equivalent to sound level), dBA
1	Industrial and commercial areas[6]	07:00-22:00 Day-time	70
		22:00-07:00 Night-time	70
2	Territories adjacent to residential buildings, clinics, ambulatories, rest houses, care homes, disabled persons homes, libraries,	06:00-22:00 Day-time	55

[5] Republic of Armenia
[6] Source: WHO's Guidelines for Community Noise

№	Premises and territories	Time	TLV (equivalent to sound level), dBA
	kinder gardens, schools and other educational facilities[7]	22:00-06:00 Night-time	45

4.2 Environmental Norms for Dust

The PM10 measurements were conducted and evaluated in accordance with the following normative documentation acting in the Republic of Armenia:

- GOST 17.2.4.05-83. "Environmental protection. Atmosphere. Gravimetric method for determination of suspended dust particles",
- RoA Government Decree №160-N. "Norms of maximum permissible concentrations (MPC) of atmospheric air pollutants in residential areas".

The maximum permissible concentrations of PM10, including daily average values are defined by the RoA Government Decree №160-N and summarized below in Table 3.

Table 3. Daily average and maximum permissible concentrations (MPC) for PM10

№	Name of substance	MPC (mg/ m^3)	
		Max	Daily average
1	PM10	0.3	0.06

5. Description of Measurement Points

The given Study Report presents results of noise levels and PM10 concentration measurements for the points defined by the Employer (see Annex 1) and described below. Totally, 20 noise instrumental measurements were conducted at 5 points and 75 PM10 measurements were carried out at 3 points.

Noise 1, Air 2

Measurement points Noise 1 and Air 2 are placed approx. 1700m to the south-west from the CCPP Yerevan-2 site. These points are located near the northeast border of Ayntap community between the cemetery and private cultivated garden (see Figures 1, 2).

Noise 2

Measurement point Noise 2 is situated at the distance of approx. 1750m to the west from the CCPP Yerevan-2 site. The point Noise 2 is located on the eastern border of Noragavit settlement in front of the highway, connecting the capital Yerevan with the M2 roadway (see Figure 3).

Noise 3 and Noise 5

Measurement points Noise 3 and Noise 5 are located in Kharberd horticultural settlement. Both points are situated along the northern border of the settlement. Noise 5 is the closest point to the CCPP Yerevan-2 site, at the distance of approx. 1100m, while the distance between the point Noise 3 and Project site is 1500m (see Figures 4, 5).

Noise 4, Air 3

[7] Source: Sanitary Norms № 2-III-11.3 "Noise in the workplaces, in residential and public buildings and in residential construction areas"

Measurement points Noise 4 and Air 3 are placed in industrial area near the northern border of the CCPP Yerevan-2 site (see Figures 6, 7).

Air 1

Measurement point Air 1 is situated in industrial area near the southeast border of current Yerevan-1 thermal power plant, between the fire brigade and abandoned production facility (see Figure 8).

Figure 1. Measurement process at point Noise 1

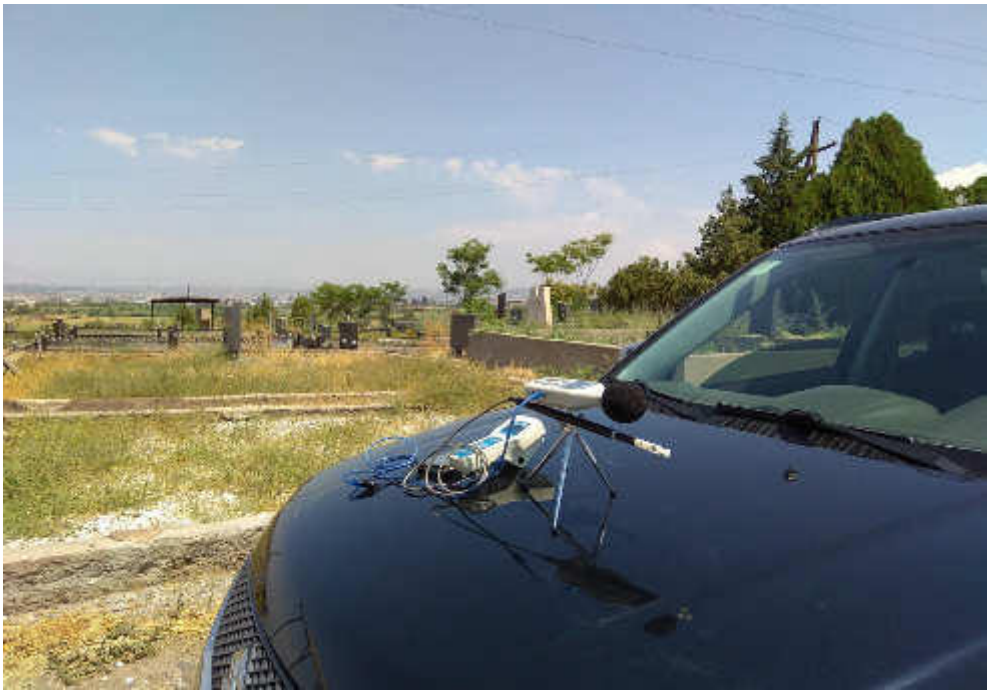

Figure 2. Measurement process at point Air 2

Figure 3. Measurement process at point Noise 2

Figure 4. Measurement process at point Noise 3

Figure 5. Measurement process at point Noise 5

Figure 6. Measurement process at point Noise 4

Figure 7. Measurement process at point Air 3

Figure 8. Measurement process at point Air 2

6. Measurement Results and Evaluation

Noise and PM10 measuring results are summarized in Table 4 (for noise) and Table 5 (for PM10) correspondingly. Diagrams, demonstrating equivalent noise levels at measurement points compared with the TLV are shown in Figures 9-11. Diagrams of PM10 actual concentrations in comparison with the MPCs (maximum and daily average) are presented in Figures 12-14.

Table 4. Results of noise measurement

Point of measurement	Wind speed (m/s)	Time of measurement	Leq(A), dB(A)	TLV (equivalent to sound level), dB(A)	Compliance
Work-day					
Noise 1	<1.7	Day-time	49.8	55	
	<1.8	Night-time	47.1	45	
Noise 2	<1.9	Day-time	72.6	55	
	<2.3	Night-time	62.4	45	
Noise 3	<1.8	Day-time	48.1	55	
	<1.7	Night-time	40.0	45	
Noise 4	<1.6	Day-time	53.6	70	
	<1.9	Night-time	57.3	70	
Noise 5	<1.7	Day-time	36.2	55	
	<2.0	Night-time	39.4	45	
Weekend					
Noise 1	<1.5	Day-time	43.4	55	
	<2.1	Night-time	49.0	45	
Noise 2	<1.8	Day-time	72.8	55	
	<2.5	Night-time	59.2	45	
Noise 3	<1.9	Day-time	43.9	55	
	<2.0	Night-time	33.9	45	
Noise 4	<1.8	Day-time	56.4	70	
	<2.0	Night-time	57.2	70	
Noise 5	<1.5	Day-time	35.6	55	
	<1.8	Night-time	34.2	45	

Table 5. Results of PM10 measurement

Point of measurement	Temperature, °C	Relative humidity, %	PM10, mg/m^3	MPC max, mg/m^3	MPC daily average, mg/m^3	Compliance
30.07.2017						
Air 1	38	20	0.014	0.3	0.06	
	38	21	0.011			
	38	20	0.01			
	39	19	0.01			
	38	19	0.011			
Air 2	39	22	0.02	0.3	0.06	
	39	20	0.041			
	39	20	0.021			
	39	21	0.021			
	38	20	0.019			
Air 3	38	22	0.022	0.3	0.06	
	38	21	0.017			
	39	21	0.013			
	39	20	0.013			
	38	19	0.016			
01.08.2017						
Air 1	37	22	0.013	0.3	0.06	
	37	21	0.01			
	38	21	0.011			
	38	19	0.012			
	38	21	0.014			

Point of measurement	Temperature, °C	Relative humidity, %	PM10, mg/ m^3	MPC max, mg/ m^3	MPC daily average, mg/ m^3	Compliance
	38	20	0.02			
	39	19	0.016			
Air 2	39	19	0.018	0.3	0.06	
	39	20	0.019			
	39	21	0.02			
	37	23	0.027			
	38	21	0.023			
Air 3	38	20	0.011	0.3	0.06	
	39	20	0.016			
	38	21	0.025			
02.08.2017						
	38	20	0.014			
	38	21	0.011			
Air 1	39	21	0.017	0.3	0.06	
	39	20	0.01			
	37	22	0.009			
	39	20	0.02			
	40	18	0.018			
Air 2	39	19	0.017	0.3	0.06	
	40	19	0.017			
	39	21	0.02			
	39	21	0.042			
	39	22	0.037			
Air 3	39	20	0.031	0.3	0.06	
	38	19	0.023			
	38	20	0.027			
03.08.2017						
	37	20	0.013			
	38	21	0.009			
Air 1	38	21	0.01	0.3	0.06	
	39	20	0.011			
	39	19	0.009			
	38	23	0.013			
	39	22	0.01			
Air 2	39	19	0.011	0.3	0.06	
	39	20	0.012			
	39	20	0.014			
	38	19	0.009			
	38	20	0.011			
Air 3	39	20	0.012	0.3	0.06	
	38	19	0.013			
	38	19	0.012			
05.08.2017						
	38	20	0.012			
	39	21	0.01			
Air 1	39	20	0.012	0.3	0.06	
	39	18	0.011			
	38	19	0.011			
	37	22	0.011			
	38	21	0.019			
Air 2	38	22	0.013	0.3	0.06	
	39	19	0.036			
	38	19	0.01			
	37	23	0.009			
	39	22	0.008			
Air 3	39	19	0.014	0.3	0.06	
	39	19	0.012			
	38	20	0.012			

Figure 9. Diagram of noise equivalent levels at measurement points located in/ near the residential areas compared with the TLV in day-time

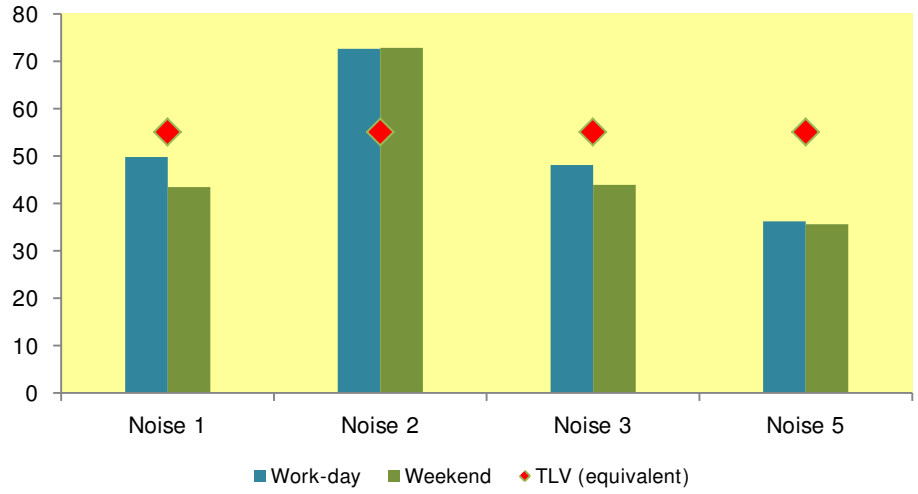

Figure 10. Diagram of noise equivalent levels at measurement points located in/ near the residential areas compared with the TLV in night-time

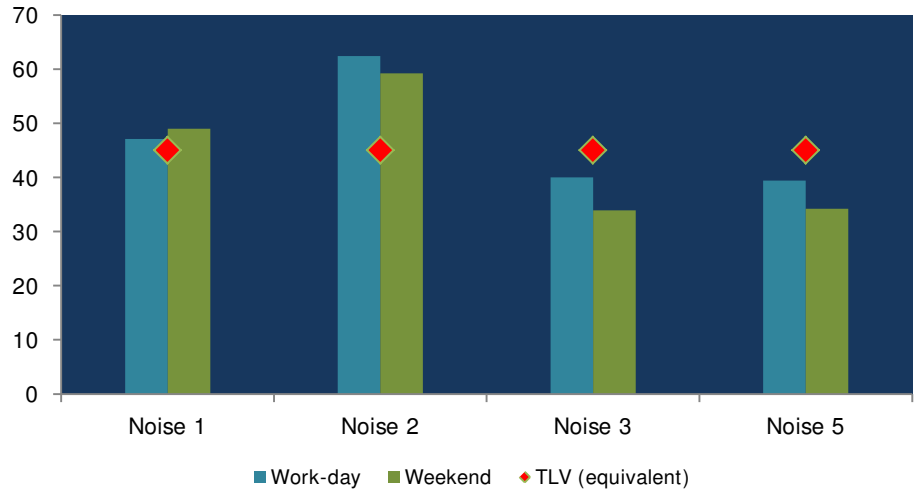

Figure 11. Diagram of noise equivalent level at measurement point Noise 4 (located in industrial area) compared with the TLV

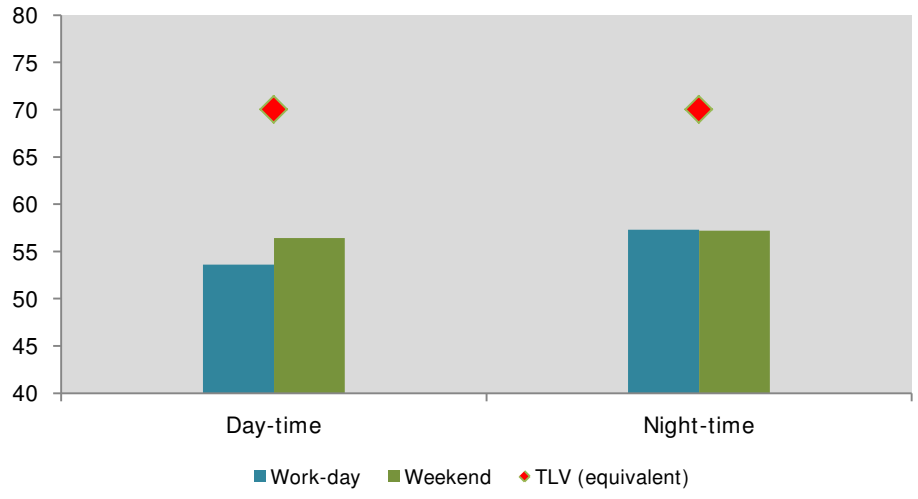

Figure 12. Diagrams of PM10 actual concentrations at point Air 1 compared with the MPC (max and daily average)

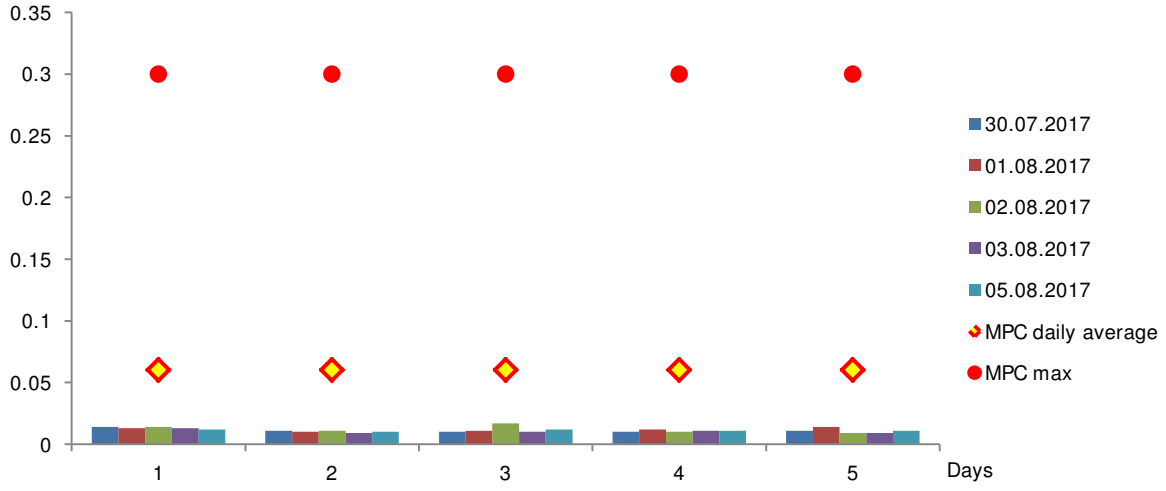

Figure 13. Diagrams of PM10 actual concentrations at point Air 2 compared with the MPC (max and daily average)

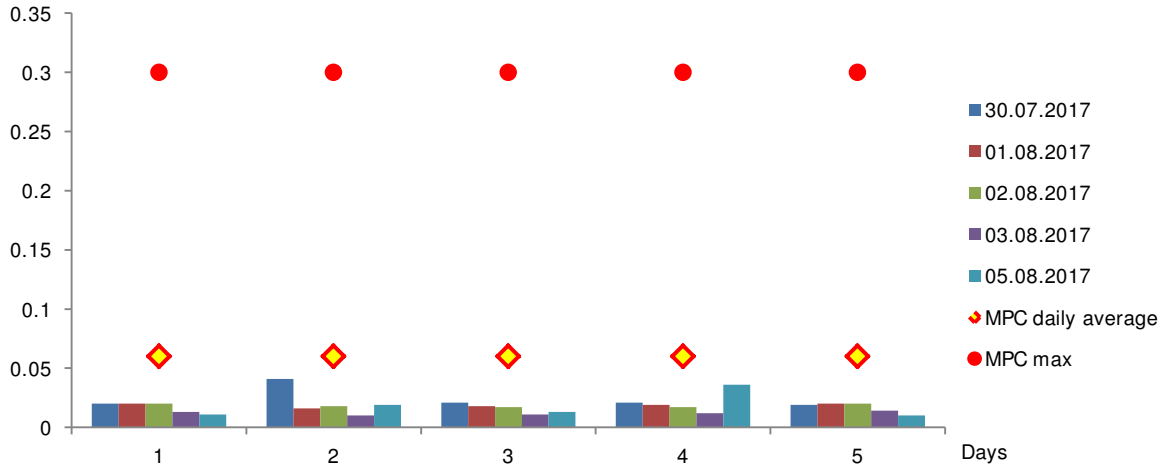

Figure 14. Diagrams of PM10 actual concentrations at point Air 3 compared with the MPC (max and daily average)