Client: **Bechtel**
Project: Alba Potline (6) and Power Plant (PS 5) Expansion

Addendum to Environmental and Social Impact Assessment Report

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Abbreviations and Units

Abbreviations	
Alba	Aluminium Bahrain
CTG	Combustion Turbine Generator
DLN	Dry Low NO_x
EIA	Environmental Impact Assessment
EPC	Engineering Procurement and Construction
ESIA	Environmental and Social Impact Assessment
EWA	Electricity and Water Authority
FHM	First Hot Metal
GDP	Gross Domestic Product
GLCs	Ground Level Concentrations
GT	Gas Turbine
H_2S	Hydrogen Sulphide
HF	Hydrogen Fluoride (Gaseous Fluoride)
HGP	Hot Gas Path
LHM	Last Hot Metal
MI	Major Inspection
NFPA	National Fire Protection Association
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
OHS	Occupational Health and Safety
PM_{10}	Particulate Matter with a diameter smaller than 10 µg
SCE	Supreme Council for Environment
SO_2	Sulphur Dioxide
STP	Sewage Treatment Plant
TME	Tebodin Middle East Ltd.
US	United States
VDC	Vertical Direct Chill
VOC	Volatile Organic Carbons

Units	
%	Per cent
dB(A)	A-weighted Decibel
km^2	Square Kilometre
kWh/kg	Kilowatt-hour per kilogram
m^3	Cubic Metre
MW	Mega-Watt
tpy	Tonnes per Year
MMSCF/D	Million Standard Cubic Feet per Day
SCF/Ton	Standard Cubic Foot Per Ton
kg/tAl	Kilogram per tonne Aluminium
mg/Nm^3	Milligram per Normal Cubic Metre

1 Executive Summary

Aluminium Bahrain (Alba) commenced its operations in 1971 and has operated with increasing success and growing production over 30 years. Alba is planning a further expansion from its current level of production of approximately 884,000 tonnes per annum of Primary Aluminium to a nominal production capacity of 1,446,321 tonnes of aluminium per annum via an additional Potline and Power Station (the Line 6 (L6) & Power Station 5 (PS5) Project).

Tebodin was commissioned to undertake an Environmental and Social Impact Assessment (ESIA) of the Proposed Line 6 Expansion Plan in accordance with Ministerial Order number 1 of 1998, to determine whether this project should be allowed to proceed from an Environmental and Social perspective. An ESIA report was submitted to the authorities in June 2014.

However after submittal of the ESIA report, design changes were made for the power station configuration. Tebodin prepared this addendum to inform SCE on these changes and to assess the change in impacts on the environment.

The initial design of PS5, for which the ESIA was prepared, comprised two (2) F class units. In the current design change, an extra F class unit is added to the power station. Furthermore, the existing PS-2 will be shut-down and 150MW additional power will no longer be sourced from the Electricity and Water Authority (EWA) grid.

Based on this ESIA addendum it can be concluded that majority of the environmental impacts by adding the third F class power generation unit are identical compared with previous ESIA study. Some impacts have been slightly reduced (air quality during operational phase, no use of groundwater), and some impacts have slightly increased (traffic during construction phase, construction waste, noise during operational phase).

Based on a detailed study of both Alba's existing and planned operations, as well as an impact analysis and comparison with national and international standards and policies, Tebodin's findings and recommendations are set out in this report and can be summarized as follows:

1. The envisaged expansion meets all current environmental legislative requirements in Bahrain and will utilise what can be regarded as Best Available Technologies.

2. Tebodin is accordingly of the opinion that, subject to the qualifications set out in clause 4 below, the plan for the Line 6 (L6) & Power Station 5 (PS5) Project is acceptable with respect to the environmental standards and that unacceptable environmental impacts are not expected related to this expansion. We accordingly recommend that the Project receive Environmental Approval from the concerned authorities.

3. Having analysed both the positive and negative impacts of the project, Tebodin is of the opinion that adverse environmental impacts that we believe could arise from the project can be mitigated satisfactorily, subject to the implementation of the recommended mitigation measures listed below explained in more detail in this report:

    a. Stricter operating practices would be implemented in line with those considered for Potline 6 to reduce the SO_2 and HF emissions for Potline 4 and Potline 5.

    b. Alba proceeds to retire Power Stations 1 and 2;

c. Alba's environmental monitoring protocol should be expanded to include the monitoring recommendations brought forward in the ESIA report;

d. The environmental management control in Alba's ISO 14001 certified management system be extended to the Potline 6 expansion;

e. Efforts to reduce waste and wastewater taking into account the recommendations described in this ESIA, e.g. regarding Spent Pot Lining wastes and sulphur waste reduction should be continued;

f. Alba should actively consider the other minor suggestions and recommendations in this report and implement them to the extent that they are relevant, feasible and practicable.

g. Alba, together with land developers will investigate a revised location of its waste water outfall to sea ensuring proper mixing, taking into account Bahrain's Master Plan 2030.

It is noted that Alba is ISO 14001 certified, and is continuously improving its environmental performance. A concrete example is that environmental improvement is one of the 5 Key parameters chosen as part of Alba's 5 year Strategic Plan, and involves commitment to reduce unrecycled waste by 25% in the following 5 years, notwithstanding the growth in production and activity from the expansions.

It is also evident that the proposed expansion project will have a number of positive impacts. For example, it is clear that there will be positive socio-economic impacts. A number of positive environmental impacts are also likely; key amongst is the eventual retirement of the old Power Stations 1 and 2 and its replacement by a new more energy efficient power station with low NOX emissions.

Tebodin also believes, given Alba's continuing commitment to their environmental performance, that the environmental impacts associated with the expansion can be effectively managed and minimised.

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2 Introduction

This addendum has been prepared to inform the Supreme Council for Environment (SCE) on the design changes related to Aluminium Bahrain (Alba)'s Potline (L6) and Power Plant (PS 5) expansion project.

Alba, located in the Kingdom of Bahrain, commenced its operations in 1971 with an annual capacity of 120,000 tonnes per year (tpy). Over the years additional production facilities were added. The current Alba smelter consists of five (5) Potlines supplied with electrical power by four (4) on-site power stations. Alba's total production was 912,700 tpy in 2013. Alba's total annual production would be a nominal 924,654 tpy at the crept, future increased production, for Potline 1 through 5. The smelter would consume a nominal average power demand of approximately 1,575 Mega-Watt (MW) including Potlines, smelter and inter-bus power losses.

Alba is presently considering expanding its smelter operations to include an additional Potline 6 (L6), a Power Station 5 (PS 5), and supporting facilities.

Alba awarded the feasibility study to Bechtel Corporation. Bechtel, with Alba's approval, retained the services of Tebodin Middle East (TME) to conduct an Environmental and Social Impact Assessment (ESIA) study as requested by the General Directorate of Environment & Wildlife Protection.

This study was submitted to SCE in June 2014 [1][1]. However after submittal of the ESIA report, design changes were made for the power station configuration. TME prepared this addendum to inform SCE on these changes and to assess the change in impacts on the environment.

2.1 Addendum Scope

As indicated in the ESIA, the existing Alba aluminium smelter is spread across an approximate area of 3.5 square kilometre (km^2) with an existing five (5) Potlines, three (3) Cast Houses, three (3) Paste Plants, a dedicated Carbon Plant, ten (10) Fume Treatment Plants, port facilities, and four (4) power stations. At the port, Alba's facilities include a 550,000 tpy coke calcining plant and a water desalination plant.

The initial design of PS 5, for which the ESIA was prepared, comprised two (2) F class units. In the current design change, an extra F class unit is added to the power station, hereafter referred to as PS-5C. Furthermore, the existing PS-2 will be shut-down and additional power[2] will no longer be sourced from the Electricity and Water Authority (EWA) grid.

This will result in the following additions (more details provided in **Chapter 3**):

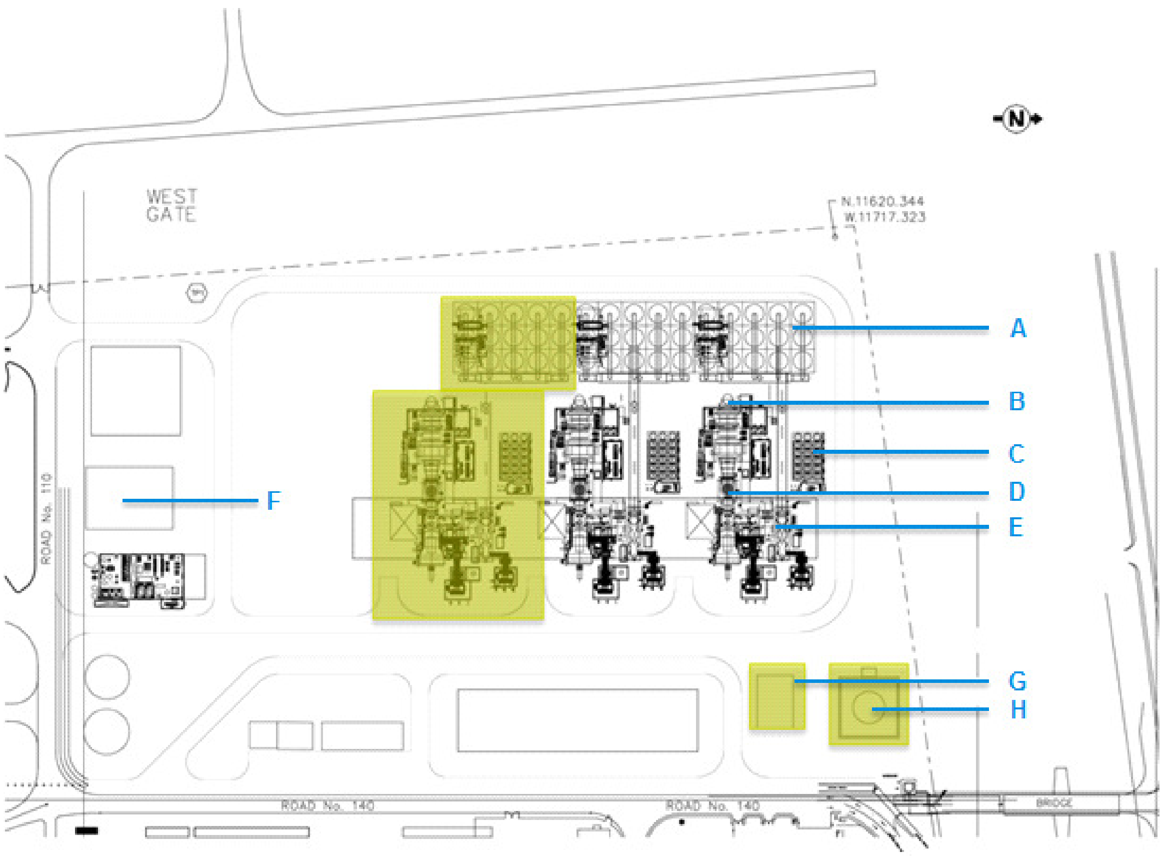
- Additional F class unit for Power Station 5;
- Increased capacity of water storage tanks; and

[1] Numbering corresponds with references listed at the end of this report.

[2] Up to 150 Mega Watt (MW)

- Addition of an extra oily water separator.

The above listed design changes are illustrated in **Figure 1**.



	Design Changes
A – Air Cooled Condenser B - Heat Recovery Steam Generator C - Fin Fan Coolers D - Gas Turbine	E – Steam Turbine F – Fuel Gas Compressors G – Blackstart (**new**) H – Fuel Oil Storage (**new**)

Figure 1: Design Changes in Power Station 5

The scope of this addendum is to assess the additional environmental impacts[3] related to this “new” design. This means that the previous environmental impacts combined with “new” potential impacts are assessed for each environmental aspect.

Considering the design changes, the effect on ambient air quality as well as the impact on ambient noise has been assessed quantitatively using, respectively, CALLPUFF and Sound PLAN software. Changes for other companies have been assessed qualitatively.

Also, future developments based on Bahrain’s Economic Vision 2030, which was launched in October 2008, have been taken into account in this addendum (where feasible).

2.2 Previous Environmental Studies

In 2003, an Environmental Impact Assessment (EIA) was prepared by TME for the proposed expansion of Potline 5 and Potline 6. However, Potline 6 was never constructed. Alba received approval for the EIA in 2003 from the competent regulatory authorities.

Recently, an Environmental Scoping Report (ESR) was prepared by Tebodin and submitted to SCE on 16th January 2014 for the proposed expansion. The ESR described the proposed project, available environmental baseline data, proposed environmental baseline surveys, anticipated environmental impacts and methodology for executing the ESIA for the project.

Subsequent to the approval of the Environmental Scoping Report[4] TME prepared the ESIA which was submitted to SCE on the 9th of June 2014 [1]. Also, on August 28th a stakeholders meeting was held to present the first result of the submitted ESIA.

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[3] Positive as well as potential negative impacts.

[4] The ESR was approved by SCE with comments on March 5, 2014. Comments on the ESR were subsequently discussed with the authorities on March 18, 2014.

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3 Project Description - Project Changes

3.1 Construction Phase

By adding a third F class unit at PS5, the construction scope of work for PS5 has increased by 50% and the duration of the construction of PS5 will be extended by 2 months to build the 3rd power unit. The overall construction activities for the entire project (L6 and PS5) will start two (2) months later than indicated in previous ESIA study. The overall construction schedule for the entire project will be extended with three (3) months (June 2018 to September 2018) compared to previous ESIA study [1].

There will be no change in the peak and average amount of construction workers. However, the peak for the construction stage for PS5 will start as previously planned and lasts 2 months longer than it was in the previous ESIA study [1]. The construction activities for L6 and other facilities remain unchanged.

No other changes are envisioned as construction activities are similar and the required manpower remains unchanged and is anticipated to be:

- On average 2,600 staff for smelter and 750 staff for Power Station 5; and
- Maximum number of working people would be 5,200 staff for smelter and 1,500 staff for Power Station 5.

3.2 Operation Phase

As indicated, subsequent to submission of the ESIA, design changes were made for the power station configuration. This includes the addition of Power Station 5C, which will be made up of an extra Combustion Turbine Generator (CTG) F class unit (a total of three (3) instead of two (2) units) to meet the incremental power requirements of Line 6. The ESIA report dated June 2014 [1] considered import of 150 MW from the national grid as well as operation of Power Station (PS) 2. The new design will have no import of additional power and PS 2 will not be in use.

An overview of the design changes is provided in **Table 1** below.

Table 1: Design Changes

#	Aspect	Original	Design Change
1	Utilities – Process Water System	Two (2) 12,500 m^3 capacity water storage tanks	Two (2) 15,000 m^3 capacity water storage tanks
2	Utilities - Common Services / Infrastructure	Sewage Treatment Plant 3 (STP3) for Potline 6 requirements of 150 m^3 per day (sized for 750 people) in the vicinity of the Line 5 STP.	Power Station 5 will forward its sewage wastes to the same treatment plant (STP3).
3	Utilities - Common Services / Infrastructure	There would be two (2) oily water separators (one at the vehicle maintenance and one at the rectifiers) to ensure capture of oily waters so as not to contaminate the surface water drainage.	Another oily water separator will be provided for Power Station 5.

#	Aspect	Original	Design Change
4	Power Plant	Two (2) combined cycle units, each nominally 450 MW in a 1x1x1 configuration. NOx emissions would be 100 mg/Nm^3.	Three (3) combined cycle units, each nominally 450 MW in a 1x1x1 configuration. For each unit, the major process equipment and support systems are the same as in the original design. NOx emissions are considered as 51 mg/Nm^3.
5	Power Import	Up to 150 MW of power would be sourced from the Electricity and Water Authority (EWA) grid for normal operations.	No import from the grid.
6	Back-up System	None, as power from EWA grid can be used.	A black start unit, either of aeroderivative gas turbine or reciprocating engine design, capable of firing either natural gas or distillate for emergency start-up of PS5, including a distillate day tank with containment walls and delivery pumps.
7	Existing Power Stations	Operation of existing PS 2.	PS 2 will not be in use. Groundwater consumption by PS 2 will be stopped.

3.2.1 Black Start

During normal operation, the electric power used within the plant is provided from the power station. However, if all of the power stations main generators are shut down, external power is required to re-start PS5. As the new design will not use power from the Electricity and Water Authority (EWA) grid, a *black start* is used as a power back-up system.

To provide a black start, diesel generators with a capacity of 18 to 22 MW will be used. These generators require the installation of a diesel storage tank (see **Figure 1**) with a storage capacity of 140 cubic metres (m^3), sufficient for one day operation.

In case of external power requirement, the black start operated for approximately one (1) hour wherein it will be used to start-up the first Gas Turbine (GT). When this turbine becomes self-sustaining the power from that GT will be used to drive the Load Commuted Inverter (LCI) to start the second and third unit.

The black start will be tested quarterly for a half- to one hour which is expected to require 6,128 gallons or 23.2 m^3 of diesel fuel per year.

3.2.2 Power Station Shut-down

Power station 2 (PS2) will be shut down and will be made available for emergency backup conditions, in case any of the other power stations are not available. Therefore PS 2 will not be demolished. The ESIA report submitted in June 2014 [1] still considered PS 2 operational for a period per year. PS2 is an old power station with a relatively low efficiency and with higher emissions to air. Replacing PS2 will therefore improve the energy efficiency (ratio of natural gas used to produce an amount of electricity) and reduce emissions to air.

3.2.3 Maintenance

Alba schedules regular maintenance for its combustion and steam turbines. For the existing power stations PS3 and PS4, the annual scheduled combustion inspection outages are for approximately six (6) days per combustion turbine. Each combustion turbine is also scheduled every four (4) years for either a Hot Gas Path (HGP) or Major Inspection (MI), each of which requires approximately thirty-six (36) days to complete. For PS5 and the “F” class machines the combustion inspection takes place over a seven (7) day (one (1) week) period during which the combustor section is disassembled to inspect the fuel nozzles, liners, transition pieces, spark assemblies, flame detectors and flow sleeves.

Approximately every four (4) years, a major overhaul is scheduled for PS5, for a period of approximately forty-nine (49) days (seven (7) weeks). The scheduling of these inspections and outages are based on the technology providers’ recommendations with regard to hours of operation, number of starts and trips, runbacks, etc. Steam turbines are maintained on a similar basis within the technology provider’ recommendations.

3.2.4 Sewage treatment plant (STP)

As stated in the ESIA report dated June 2014 [1], a new sewage treatment plant will be added as part of the proposed expansion (section 6.3.2.4 of ESIA report). SCE has requested for more details regarding the proposed STP.

The new Sewage Treatment Plant (STP-3) with a design capacity of **150** m^3 per day (sized for 750 people) will be erected in the vicinity of L5 STP for the treatment of waste water generated from L6, PS 5, and the proposed supporting facilities associated with the expansion project. Sources of waste water received at STP-3 for treatment includes; new cafeteria and change rooms facility as well as the administration building, domestic sewage, etc. Consistent with STP-1 and STP-2, the proposed STP-3 would be based on an extended aeration activated sludge process and will generate Treated Sewage Effluent (TSE) which will be used for irrigation throughout the plant. The treated water therefore will have to comply with the Bahrain irrigation water standards. The discharged effluent will be similar in quality to that being produced currently, and on that basis is not expected to result in impacts of any significance. Arrangements have been made through a contractor who will dispose the associated sludge to Asker landfill.

Some more background information is provided in this ESIA addendum describing the anticipated environmental impacts of STPs; however, since the process technology is not known at this stage, performing a quantitative and detailed impact assessment of the STP is not possible.

The organization responsible for the design, construction and operation of the STP facility will be decided on through a tendering procedure. The selected technology provider must adhere to extensive specifications developed to ensure compliance with engineering performance criteria, environmental regulations and other criteria. For example, basic specifications for influent, effluent, and a number of other projects characteristics are defined for Tenders.

Multiple treatment processes are available, such as:

- Extended Aeration (EA);
- Sequential Batch Reactor (SBR);
- Membrane Bio Reactor (MBR);
- Moving Bed Biofilm Reactor (MBBR).

In principle, these alternatives are all variations of activated sludge treatment; however, they may offer different benefits with respect to aspects such as space utilisation, residence time, purification security/risks, along with practical and financial considerations. Actual performance is, however, more related to individual plant design (i.e. capacity, buffering, etc.), management, and performance limits/controls of the treatment facilities. For example, combinations of different treatment processes can be incorporated to achieve the desired performance for a specific wastewater situation.

The STP design specifications should include the minimisation of odour, noise and other nuisance impacts; assurance of ability to consistently achieve the required effluent standards for irrigation; and assurance of ability to achieve the required sludge quality for disposal in a landfill.

The main concern related to atmospheric emission and air quality during the operation of an STP is odour and H_2S emissions.

3.3 Overall Project Schedule

All construction activities (starting with site preparation) will start 2 months later (postponed from August to October) and the overall construction schedule (L6 and PS5) will extend three (3) months further than indicated in previous ESIA report (postponed from June to September). Construction activities for L6 and other facilities remain unchanged.

The original project schedule would result in the First Hot Metal (FHM) on December 1st 2017 and the Last Hot Metal (LHM) on June 1st 2018. FHM is now expected on the 1st of March 2018, whereas LHM is scheduled for 1st September 2018. Table 2 below provides the original project schedule and the revised project schedule, considering the third power generation unit at PS5.

Table 2: Key Project Milestones

Key Milestones	ESIA Report June 2014 [1]	ESIA Addendum for third unit at PS5
Notice To Proceed of EPCM	01 December 2014	01 December 2014
Commence Site Preparation and Rock Excavation	01 August 2015	01 October 2015
PS5 EPC Contractor Mobilization to Site	01 October 2015	01 October 2015
L6 First Concrete	01 May 2016	01 August 2016
L6 First Hot Metal	01 December 2017	01 March 2018
PS5 Unit 1 Complete	01 January 2018	01 March2018
PS5 Unit 2 Complete	01 April 2018	01 June 2018
PS5 Unit 3 Complete	n.a.	01 August 2018
L6 Last Hot Metal	01 June 2018	01 September 2018

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4 Environmental Impacts

4.1 Introduction and Overview

The ESIA, the environmental aspects of the Alba operation have been described, together with a description of the state of the environment that is currently affected by operations of the existing Alba plant, and that may be affected by the proposed development. Impacts on the environment are a function of these two components, namely the environmental aspects of the operation (existing and proposed) and the state or vulnerability of the existing environment that may be affected by those aspects.

In this addendum, possible impacts of the proposed design changes on the environment are assessed in the same order as previously done for the ESIA. By doing so, the addendum can be used in reference to the environmental impacts identified previously.

The impacts of the design change are assessed based on assessment matrices with low, medium or high ratings, based on the severity and the duration (for planned / normal aspects) or likelihood (for unplanned aspects) of their occurrence.

4.2 Air Quality

4.2.1 Construction Phase

The construction phase activities resulting in air emissions - such as clearing of land and related excavation, operation of heavy machinery, vehicle movements, *et cetera* – are the same for the activities required for the design change.

Therefore, the construction phase activities related to the design change are not expected to result in different impacts to air quality as the activities are of the same nature.

All construction activities (starting with Site Prep) will start 2 months later and the overall construction schedule (L6 and PS5) will extend (3) months further than indicated in previous ESIA report. The peak and average of construction workers remain unchanged; however, the peak construction activities for PS5 will start as previously planned and lasts for two (2) months longer than in the previous study of June 2014 [1].

The slight change in duration of the construction period and the shift of 2 month longer peak construction period for PS5 will lead to higher emissions to air due to the two (2) month higher construction intensity and vehicle movements. The change in construction intensity for the third power generation unit is not expected to have a significant effect taken into consideration that the same mitigation and control measures, as advised in the ESIA, are incorporated by the Engineering Procurement and Construction (EPC) Contractor.

4.2.2 Operation Phase - Sewage Treatment Plant

The installation of the third power unit will not have any impact on the proposed sewage treatment plant (STP3). SCE requested to provide additional information regarding possible environmental impacts of the proposed STP3. Below table provides an overview of relevant sections of an STP for generation of emissions to air.

Table 3: Overview of Threats to Air Quality and Protective Measures in Operational Phase

Installation Component	Threats to Air Quality	Odour potential	Protective Measures As Planned During Design Phase
Influent reception pit	Odour Hydrogen Sulphide (H_2S)	High	Installation will be enclosed and ventilated. The air will be treated in a deodoriser.
Preliminary treatment	Odour H_2S	High	Installation will be enclosed and ventilated. The air will be treated in a deodoriser.
Primary treatment	Odour H_2S	High/moderate	Installation will be enclosed and ventilated. The air will be treated in a deodoriser.
Secondary treatment	Odour	Low/moderate	-
Sludge storage and treatment	Odour	High	Installation will be enclosed and ventilated. The air will be treated in a deodoriser.

Mitigation Follow-up
After finalization of the design or planning of the STP3 it is recommended for the supplier to present an air quality control data package to provide evidence that it is in line with the conditions used in the environmental analysis. The package will illustrate the following:

- Facility start-up procedures designed to avoid odour problems;
- Design features (e.g. master plan drawings) related to coverage of installations for reducing odour impacts;
- Technical details (e.g. deodorizers emissions levels), implemented management procedures (e.g. management plans).

4.2.3 Operation phase - Emissions after expansion with third power unit at PS5

As a part of Environmental and Social Impact Assessment (ESIA) Report, an Air Quality Assessment study was performed using CALPUFF to estimate and predict the impact to air quality upon expansion of the Power Station 5 (PS5) and simultaneous discontinuation of Power Station 1 and 2 (PS1 and PS2). As a part of the assessment emissions from steady operation of the power stations (3, 4 & 5) upon expansion along with its associated stack and potline emissions were analysed. The emission variation would include variation of Sulphur Dioxide (SO_2) and Nitrogen Oxides (NO_x) emissions from the units assuming there would be no change in the stack and potline emissions. There will be no emissions of HF (Hydrogen Fluoride) and PM_{10} (Particulate Matter with a diameter smaller than 10 µg) from the natural gas fired power stations. The study is an update of existing air quality assessment to include the above inclusions and will focus on the effects of proposed project emissions against Bahrain Air Quality Standards. Therefore, Ground Level Concentrations (GLCs) of these components, hereafter referred to as criteria pollutants, were predicted using a CALPUFF air dispersion model and the results discussed in the forthcoming sections.

The assessment considered the following scenario:

- Scenario A- Option A: The Scenario includes an addition of new Power Station (Power Station 5, (PS5)), which consist of three (3) gas turbines. The addition of the turbine within PS5 would replace existing Power Station (PS2), which would be on a stand-by mode. The emissions from the addition of PS5 is combined with the emissions from Scenario-3 (future mitigated operation), which consists of Pot Line -1 through 6, with Sulphur Dioxide (SO_2) emissions from all reduction lines at 24.7 kilogram per tonne Aluminium (kg/tAl) (maximum emissions recorded between 2007-2012) and total fluoride emissions from the high amperage potlines L4 and L5 set at 0.6 kg/tAl, as per L6. Moreover, lower Nitrogen Oxides (NO_x) emitting scenario from 100 milligram per Normal Cubic Metre (mg/Nm^3) to 51 mg/Nm^3 is considered.

The black-start facility as described in **section 3.2.1** will be tested quarterly for a half- to one hour, which is expected to require approximately 23 m^3 of diesel fuel per year. The combustion emissions from this periodic testing will add to SO_2, NO_x and PM_{10} levels in ambient air. However, due to the limited fuel consumption and limited operation (maximum 4 hours per year), impacts to ambient air quality from this activity are considered not significant.

The ambient air quality in Alba's surroundings is being influenced by a variety of activities, such as:

- Emissions from the Al Riffa power plant, 3 kilometres north of Alba contributing to the NO_x and SO_2 concentrations in ambient air, especially in the Riffa residential area.

- Emissions from BAPCO facilities (flares, vents, fugitive emissions, combustion emissions, etc.) contributing to concentrations of NO_x, SO_2, PM_{10}, VOC etc. in ambient air;

- Emissions from industries surrounding Alba (east and south) contributing to the NO_x, SO_2, PM_{10}, VOC etc. concentrations in ambient air;

- Vehicle emissions on roads in Alba's surroundings contributing to the NO_x, SO_2, PM_{10}, VOC etc. concentrations in ambient air.

No information was available on anticipated changes in the activities from above sources possibly leading to additional emissions or reduced emissions, and therefore anticipated impacts to ambient air quality in Alba's surroundings. It can be anticipated that in case the Al Riffa Power Plant will be decommissioned, levels of NO_x and SO_2 levels in ambient air in the surroundings, such as Riffa residential area will be significantly reduced.

Since no details are available, these developments, if any, cannot be considered in this assessment.

4.2.3.1 Emission Inventory Option A - Emissions of Criteria Pollutants (SO_2, NO_x, HF and PM_{10})

The emissions from this scenario were determined based on addition of 3 power trains for PS5 and discontinuance of PS2. PS2 shall be as a stand-by and be used during emergency conditions. Therefore the scenario considered is crept existing operations with discontinuation of PS2 and addition of L6 and Power Stations 5 operating at nameplate production capacity. SO_2 emissions from all reduction lines are set at 24.7 kg/tAl (maximum emissions recorded between 2007-2012) and total fluoride emissions from the high amperage potlines L4 and L5 are set at 0.6 kg/tAl, as per L6. Moreover, lower NO_x emissions from PS 5 are considered compared to the previous performed air quality assessments [1].

Emissions for the Plant wide emission factors were established based on figures obtained from current operations as well as from the current operating permit. **Table 4** lists the emission factors adopted for the PS5 expansion.

Table 4: Applied Emission Factors for Power Stations

Contaminants	Units	Emission rates	Bahraini Standard
Sulphur dioxide (SO_2)			
Power station	ppm H_2S in natural gas	600	600
Nitrogen oxides (NO_X)			
Power stations (PS 3 and 4)	mg/Nm³	100	100
Power stations (PS 5)	mg/Nm³	51	100

The emission of criteria pollutants for the project expansion was estimated for operation of Potline 1 through 6 and PS 3 to 5 for the following scenario:

The SO_2 emissions from the reduction area are limited to a yearly average value of 24.7 kg/t_{Al} (which represents the highest recorded monthly value from 2007 to 2012, and is below the current Bahrain emission standard for the reduction area of 32.0 kg/t_{Al}). The emissions from other units remain the same. The main SO_2 emissions are caused by the sulphur in the petroleum coke during the production of anodes. The highest recorded SO_2 levels from 2007-2012 are used, since it is anticipated that sulphur levels in petroleum coke may increase in the coming years.

Power Station 2 will not be in operation and would function as stand-alone and would be used only during emergency operations. Therefore, no emissions from PS 2 are included. NO_x emissions from PS 2 were at 165 mg/Nm^3 and therefore above the Bahrain emission standard of 100 mg/Nm3. The three Combustion Turbine Generators in PS5 will be equipped with Dry Low-NO_x (DLN) combustors and will achieve NO_x emissions of 51 mg/Nm^3 @ 15% O_2, which is below the Bahrain NO_x emission standard of 100 mg/Nm^3.

Summarized changes compared to previous performed air dispersion assessment:

- Third combined cycle unit as part of PS 5 is added as emission source;
- Emissions from PS 2 have been removed;
- NO_X emissions from PS 5 for all three combined cycle units have been reduced to 51 mg/Nm^3 (compared to 100 mg/Nm^3 in previous assessment).

Table 5 provides an overview of the analysis of pollutant emissions (in tonnes per day) associated with the various project facilities. These values were used as the basis for the air modelling assessment.

Table 5: Major Emissions to Air – Criteria Pollutants

#	Aspect	Pollutant Emissions (t/day)			
		SO_2	HF	PM_{10}	NO_X
A	**Future Operations – Normal Operations (Scenario 3)**				
A1	Stack Emissions[1]	103.1	0.26	1.72	0.48
A2	Potline Emissions[2]	1.98	1.67	5.69	0
A3	Power Station Emissions[3]	14.35	-	-	37.67
	Total Emissions	**119.43**	**1.93**	**7.41**	**38.15**
B	**Future Operations – Normal Operations (Inclusion of 3-PS5 and Discontinuing PS1 & PS2)- Scenario A- Option A**				
B1	Stack Emissions[1]	103.10	0.26	1.72	0.48
B2	Potline Emissions[2]	1.98	1.67	5.69	0.00
B3	Power Station Emissions[3]	16.87	-	-	34.97
	Total Emissions	**121.95**	**1.93**	**7.41**	**35.45**
1. Stack Emissions: include emissions from stack located at Reduction Area, Carbon Area and Casthouses.					
2. Potline Emissions: include emission from roof vents of the potlines.					
3. Power Station Emissions: Emissions were calculated based on operation of all stack emission points at the power station (power stations operate intermittently on a monthly basis).					

Although total emissions of SO_2 has slightly increased, it is to be noted that the 150 MW previously required is not required anymore, thus eliminating the SO_2 and NO_x emissions from EWA for aluminium production.

Since there are no changes in the Particulate and Fluoride emissions from the Reduction and Carbon areas of the Option A in comparison with scenarios 3, no further assessments for HF and PM_{10} were performed. It is also assumed that the contribution of HF and PM_{10} on the local air quality would remain the same as in Scenario 3.

In order to determine ambient concentrations of the criteria pollutants, emissions to air were determined for future operations under Option A scenario. These emissions were used to predict Ground Level Concentrations (GLCs).

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4.2.3.2 Predicted Ambient Air Pollutant Concentrations

In order to assess the contribution of Alba on the regional and local ambient concentration, CALPUFF air dispersion model was used to predict the Proposed Option A operations. Where ambient air quality data was available at selected receptor locations, Alba's contribution for current operations was established and subsequently extrapolated for the situation after expansion. Results of the air dispersion modelling are presented in **Table 6**. Along with Isopleth contours of the scenarios at standard average time (hourly, daily, yearly average values).

The effect on ambient air quality was assessed for the following criteria pollutants:

- change in NO_2 concentrations; and
- change in SO_2 concentrations;

Concentration predictions were obtained using one (1) full year of the meteorological simulation. The resulting overall maxima for the different averaging periods (annual mean, 24-hours and 1-hour depending on available air quality standards) are highlighted in subsequent sections.

As shown in **Table 6**, maximum predicted concentrations of NO_2 were found to be within all applicable limits for all scenarios. In addition, maximum predicted ground level concentrations of SO_2 were within applicable limits for the annual mean averaging period.

Table 7 states the correlated total maximum predicted concentrations; i.e. it includes the actual background data plus the model predicted data for Alba's contribution alone, where the baseline existing case model data has been adjusted to correlate with the actual data, henceforth stated as "correlated".

For SO_2; exceedances (see definition below) were predicted for both 24-hour average concentration (Bahraini limit 125 µg SO_2 /m^3) and one-hour average concentration (Bahraini limit 350 µg SO_2 /m^3) for the future Option A Scenario, which are 176 µg SO_2 /m^3 and 429 µg SO_2/m^3 respectively. The exceedances were also reported for Scenario 3, which were 162 µg SO_2/m^3 and 430 µg SO_2/m^3 for 24-hour average concentration and one-hour average concentration respectively.

It needs to be emphasised that all these exceedances are located within close proximity of the Alba facilities and not at residential areas. **Table 6** below summarises the maximum values of predicted concentrations for the criteria pollutants for the Scenarios 3 and Option A, for hourly, daily and yearly values as applicable per regulations.

Exceedances are defined as concentration higher than the value set in the Bahrain Ambient Air Quality Standard (BAAQS) recorded over for consecutive 3 time averaged concentration (hourly, daily and annual).

- Exceedance of hourly value: if a single receptor records three consecutive occurrences over the hourly BAAQS.
- Exceedance of daily value: if a single receptor records 3 exceedances of the hourly BAAQ for 3 consecutive days then it is recorded as exceedance of the daily value.

- Exceedance of annual value: if 3 consecutive daily occurrences were recorded for a single receptor then that particular receptor is assumed to have an exceedance of the annual value.

The extent of the exceedances of SO_2 is discussed in more detail in Section 4.2.3.4.

Table 7 summarises the number of exceedances for the criteria pollutants for the three Scenarios for hourly, daily and yearly values as applicable per regulations.

Table 6: Air Quality Assessment Summary Results – Maximum Predicted Concentrations

Pollutant	Bahrain Air Quality Standard (µg/m³)		Predicted Maximum Concentration (µg/m³) Alba alone	
			Scenario 3	Scenario A
			Future Mitigated Operations	Option A
Sulphur Dioxide (SO_2)	Annual mean	50	26	28
	24 hours	125	162	176
	1 hour	350	430	429
Nitrogen Dioxide (NO_2)	Annual mean	40	4	3
	24 hours	150	22	20
	1 hour	200	119	110

Table 7: Air Quality Assessment Summary Results – Number of Exceedances

Pollutant	Bahrain Air Quality Standard (µg/m³)		Number of Exceedances Alba alone	
			Scenario 3	Scenario A
			Future-1	Option A
Sulphur Dioxide (SO_2)	Annual mean	50	0	0
	24 hours	125	2	2
	1 hour	350	4	4
Nitrogen Dioxide (NO_2)	Annual mean	40	0	0
	24 hours	150	0	0
	1 hour	200	0	0

4.2.3.3 Concentrations at Sensitive Receptors

In addition to overall maximum concentrations, concentrations were determined at sixteen sensitive receptors (five air monitoring stations and eleven residential areas). An overview of the respective locations is presented in **Figure 2**.

Maximum concentrations observed at the respective sensitive receptors are presented in **Table 8**. Where available, background concentrations of the four criteria pollutants are indicated. The available background air quality data are available for the five locations indicated in grey in **Figure 2** below:

	Air Monitoring Station		Residential Area

Figure 2: Sensitive Receptors

In **Table 8** below, the values indicated in rows for the Scenario 3 and Option A (Scenario A) indicate the predicted contribution of Alba alone (non-correlated) at those locations, excluding the existing monitored background concentrations. The applicable Bahraini Ambient Air Quality Standards are provided in the table header.

Table 8: Maximum Ground Level Concentrations at Sensitive Receptors[5]

#	Sensitive Receptor	Study Case	Maximum Actual and Predicted (Alba alone) Scenarios Concentrations (µg/m^3)					
			SO_2			NO_2		
			Annual mean	24 h	1 h	Annual mean	24 h	1 h
		Bahrain standard	50	125	350	40	150	200
1	Ras Hayyan	Background	5.6	29.2	71.1	1.2	6.1	14.9
		Scenario-3 Future-1	6	37.3	90.7	2.7	12.3	23.6
		Scenario A - Option A	**6**	**37.3**	**90.8**	**2.3**	**10.3**	**23.7**
2	Hidd	Background	5.7	29.7	72.4	NA	NA	NA
		Scenario-3 Future-1	2.4	14.9	36.3	0.1	1.1	10.9
		Scenario A - Option A	**2.3**	**14.6**	**35.5**	**0.1**	**1.2**	**9.6**
3	Maameer	Background	5.9	30.7	74.7	17.2	89.6	218.2
		Scenario-3 Future-1	4.3	26.7	65	0.3	3.5	18.1
		Scenario A - Option A	**4.3**	**26.6**	**64.8**	**0.3**	**3.4**	**17.5**
4	Napeeh Saleh	Background	6	31.2	76	2.8	14.5	35.3
		Scenario-3 Future-1	4.9	30.7	74.7	0.7	6.8	24.2
		Scenario A - Option A	**4.8**	**29.9**	**72.9**	**0.6**	**7.8**	**20.1**
5	Hamad Town	Background	8.2	42.8	104.1	6.8	35.6	86.8
		Scenario-3 Future-1	4.8	29.8	72.6	1	6.2	22.7
		Scenario A - Option A	**4.6**	**29**	**70.5**	**0.9**	**5.7**	**22**
6	Villa 1	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	9.5	59.4	144.7	3.1	17.6	37.4
		Scenario A - Option A	**9.4**	**59**	**143.7**	**2.3**	**13.9**	**36.7**
7	Villa 2	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	10.1	62.9	153.1	2.1	13.1	43.5
		Scenario A - Option A	**10**	**62.5**	**152.2**	**1.9**	**12**	**47**

[5] Numbering refers to **Figure 2**, whereby „grey“ indicates an air monitoring station and „blue“ refers to a residential area.

#	Sensitive Receptor	Study Case	Maximum Actual and Predicted (Alba alone) Scenarios Concentrations (µg/m^3)					
			SO_2			NO_2		
			Annual mean	24 h	1 h	Annual mean	24 h	1 h
		Bahrain standard	50	125	350	40	150	200
8	Villa 3	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	12.9	80.6	196.3	2.2	17.4	76.3
		Scenario A - Option A	**13**	**81.5**	**198.4**	**2**	**17.8**	**78.1**
9	East Riffa	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	11	68.8	167.5	1.4	14	50.6
		Scenario A - Option A	**10.8**	**67.8**	**165.2**	**1.2**	**11.7**	**43.6**
10	Sanabis	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	5	31.1	75.8	0.5	4.5	22.4
		Scenario A - Option A	**4.9**	**30.7**	**74.8**	**0.4**	**4.4**	**19.2**
11	El Eker	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	5.7	35.8	87	0.4	4.8	26.3
		Scenario A - Option A	**5.6**	**34.9**	**84.9**	**0.4**	**4.9**	**23.4**
12	Sitra	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	4.2	26.4	64.3	0.3	3.4	17.1
		Scenario A - Option A	**4.1**	**25.8**	**62.7**	**14.5**	**3**	**14.5**
13	Nuwaidrat	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	6.2	39.1	95.2	0.6	7.5	29.5
		Scenario A - Option A	**6.2**	**38.5**	**93.7**	**0.5**	**6.8**	**27.8**
14	Sanad	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	5.8	36.5	89	0.8	8	25.8
		Scenario A - Option A	**5.8**	**36.6**	**89.1**	**0.6**	**7.3**	**25.1**
15	Ma'ameer Residential	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	4.8	29.9	72.7	0.3	3.9	19
		Scenario A - Option A	**4.9**	**30.6**	**74.5**	**0.3**	**3.8**	**18.4**
16	Labour Camp	Background	NA	NA	NA	NA	NA	NA
		Scenario-3 Future-1	12.4	77.7	189.2	0.6	6.2	41.9
		Scenario A - Option A	**12.3**	**76.9**	**187.1**	**0.6**	**7.6**	**54.9**

The results from the air dispersion modelling as summarised in **Table 8** above show no exceedances of applicable Bahrain Ambient Air Quality Standards at the Sensitive Receptors. This is valid for both Alba's contribution (Scenarios 3 and Option A in **Table 8**) and for the monitored background concentration (with the exception of the

NO_2 1-hour monitored background concentration at Maameer which is located about 5.5 km from Alba). Note: any other background values for sensitive receptors 6 to 16 are not accounted for as these are not available.

In order to compare the total correlated predicated concentrations with applicable Bahraini Ambient Air Quality Standards, the available background concentrations were taken into account (in other words, the actual existing and predicted concentrations were correlated). These results are provided in **Table 9** below for the Air Monitoring Stations.

Table 9: Predicted Total Correlated Concentrations at Sensitive Receptors

#	Sensitive Receptors [1]	Study Cases	Total Correlated Predicted Concentrations (µg/m^3)					
			SO_2			NO_2		
			Annual mean	24 h	1 h	Annual mean	24 h	1 h
			50	125	350	40	150	200
1	Ras Hayyan	Background	5.6	29.2	71.1	1.2	6.1	14.9
		Scenario-3 Future-1	8.1	44.9	109.3	2.1	9.7	18.9
		Scenario A- Option A	8.1	44.9	109.4	1.7	7.7	19.0
2	Hidd	Background	5.7	29.7	72.4	Not available		
		Scenario-3 Future-1	6.5	35.2	85.6			
		Scenario A- Option A	6.5	35.2	85.6			
3	Maameer	Background	5.9	30.7	74.7	17.2	89.6	218.2
		Scenario-3 Future-1	7.7	41.8	101.8	17.3	90.4	221.7
		Scenario A- Option A	7.7	41.7	101.6	17.3	90.3	221.1
4	Napeeh Saleh	Background	6.0	31.2	76.0	2.8	14.5	35.3
		Scenario-3 Future-1	7.9	43.0	104.8	3.0	16.2	41.3
		Scenario A- Option A	7.8	42.2	103.0	2.9	17.2	37.2
5	Hamad Town	Background	8.2	42.8	104.1	6.8	35.6	86.8
		Scenario-3 Future-1	9.8	52.6	128.1	7.1	37.1	93.1
		Scenario A- Option A	9.6	51.7	126.0	7.0	36.6	92.4

A summary analysis of the data from the above table (**Table 9**) is stated below for the Total Correlated Predicted Concentrations.

Isopleth contours of the scenarios and standard average time (hourly, daily, yearly average values) are presented in **Appendix** 2.

4.2.3.4 SO_2 Concentrations

Sulphur dioxide emissions are mainly related to the reduction area of Alba's facilities. As presented in **Table 5**, Scenario A - Option A, emissions indicate, approximately 121 tonnes of SO_2 are emitted per day out of which power plant emissions account for 14% (16.87 t/day) of the total emissions. Option A Scenario emits approximately 2.5 t/day more SO_2 than the Future Mitigated Operation Scenario -3.

4.2.3.4.1 1-Hour Average Concentrations

The maximum predicted 1-hour average SO_2 concentration based on contribution of Alba to the regional background for Option A, is at Ras Hayyan (located downwind of the project site) at 91 µg SO_2 /m^3. The background concentration at this monitoring station is 71 µg SO_2 /m^3. The correlated emissions at Ras Hayyan based on Option A operating conditions is 109.4 µg SO_2 /m^3, which is similar to Scenario 3 (109.3 µg SO_2 /m^3) and which is well below the Bahraini AAQS (350 µg SO_2 /m^3).

As shown in **Table 6** presenting the maximum concentrations by Alba alone, future maximum 1-hour average concentrations caused by Alba alone is 430 µg SO_2/m^3 (Scenario 3), while Option A scenario predicts 429 µg SO_2/m^3. The maximum ground level concentration for Option A (Scenario A) conditions, is projected to increase by approximately 43% compared to the existing operations.

4.2.3.4.2 24-Hour Average Concentrations

The maximum predicted 24-hour average SO_2 concentration based on contribution of Alba to the regional background for Scenario A - Option A, is 176 µg SO_2 /m^3, which is 41% higher than the Bahraini AAQS for 125 µg SO_2 /m^3. The maximum recorded contribution was recorded at Ras Hayyan. The maximum predicted concentration contribution of Alba alone at Ras Hayyan is 37.3 µg SO_2 /m^3. The background concentration at Ras Hayyan monitoring station is 29.2 µg SO_2 /m^3 and the corresponding correlated emissions based on Option A operating conditions is 44.9 µg SO_2 /m^3, which is similar to Scenario 3 (44.9 µg SO_2 /m^3) and is well below the Bahraini AAQS (125 µg SO_2 /m^3).

The 24-hour average maximum concentration is predicted to be within 1 km distance from the boundary line, which is consistent with the hourly predicted concentration. SO2 concentrations are predicted to increase by 43 % for Option A compared to the baseline conditions.

4.2.3.4.3 Annual Mean Concentrations

As shown in **Table 6**, annual predicated SO_2 concentrations were found to be below the stipulated Bahraini AAQS (50 µg SO_2 /m^3). The highest predicted annual SO_2 concentration for Option A is 28 µg/m^3 while 26 µg SO_2 /m^3 for Scenario-3.

4.2.3.5 NO_2 Concentrations

It is predicted that Nitrogen Dioxide (NO_2) emissions will be in compliance with the applicable Bahrain Ambient Air Quality Standards. However, monitored background concentrations indicate that hourly values for NO_2 are being exceeded at Maameer (218 µg/m^3 vs standard of 200 µg/m^3). The modelling study predicted an over prediction of the NO2 concentration at the receptors and the correlated predicted values as given in **Table 9** have been corrected to the baseline concentration.

As stated in **Table 6**, Alba's existing contribution to the maximum recorded hourly air quality of 218 µg/m^3 at Maameer is only 7% (14.55 µg/m^3). This means that other sources (industrial facilities, traffic) are causing the majority of the NO_2 emissions in the Maameer area.

4.2.3.5.1 1-Hour Average Concentrations

The maximum predicted 1-hour NO_2 concentration from Alba's Option A operations is 110 µg/m3 along the facility fence line, which is less than the 1-hour Average Bahraini AAQS of 200 µg/m$^{3.}$ The maximum predicted concentration would be 4% less than the maximum predicted concentration during Scenario 3.

The total correlated hourly NO_2 concentrations at Maameer will increase by 8 % for Option A (17.5 µg NO_2 /m^3). Overall, the total correlated maximum hourly NO_2 values will increase by 4 % for Option A, which is comparable to Scenario 3.

4.2.3.5.2 24-Hour Average Concentrations

The maximum 24-hour NO2 concentration from Alba's Option A operations is predicted to be 20 µg/m^3 along the facility fence line, which is less than Bahraini 24-hour Average AAQS of 150 µg/m^3. The maximum contribution of Alba future Option A operations is at Ras Hayyan Monitoring Station, where a maximum correlated contribution is 7.7 µg/m^3.

4.2.3.5.3 Annual Mean Concentrations

As shown in **Table 6**, annual predicated NO_2 concentrations were found to be below the stipulated Bahraini AAQS (40 µg /m^3). The maximum predicted annual NO_2 concentration by Alba alone for the baseline conditions is 3 µg /m^3, 3 µg /m^3, 4 µg /m^3 for Option A, Scenario 2 and Scenario-3 respectively.

4.2.3.6 Impact on nearby industrial facilities

The study conducted indicated that there would be no impact on the local air quality for HF and PM10 due to the operations of the Power Station 5 (PS5). The total predicted SO_2 concentrations will be above the ambient air quality standards near the vicinity of Alba, which is concurrent with the Scenario-3 studied as a part of the ESIA. Since these areas are used by industrial facilities where people will be present only during working hours, Ambient Air Quality Standards are not directly applicable. Bahraini AAQS are applicable for locations such as hospitals, schools, and residential areas of continuous exposure. Evaluation and impact of the air pollutants on the health has been described in the Section of the health aspect of the study has been reported in **Section 6.2.4**.

4.2.3.7 Compliance with the 2030 National Land Use Strategy

In conjunction with the Bahrain's National Land Use Strategy, the pollutants which are expected to exceed the Bahrain AAQS were plotted on the 2030 Land Use Strategy Map (isopleth contour are presented in **Appendix 2**). Based on the Option A study, 1 hour and 24 hour average SO_2 concentrations were plotted. In addition, yearly average data for HF was plotted on the 2030 map as well. As predicted in the **Section 4.2.3.4.1** and **4.2.3.4.2**, the exceedances were located within the proposed 2030 industrial area, which is located southwest of Alba. It has been identified that all exceedances are located within the area earmarked as industrial area. No impact to the residential or environmentally sensitive receptors would result from the emissions from Alba upon operation of Option A.

This however, does not consider the cumulative impacts to air quality caused by the following activities as indicated on the 2030 Land Use Strategy Map:

- Expansion of heavy industry north and east of Alba
- Quarry south of Alba
- Proposed Bahrain – Qatar Causeway

Currently no details on these activities are available, nor to which extent these activities will be developed. However, it can be assumed that the increased industrial activities and increased traffic travelling to and from the industrial areas and on the Bahrain – Qatar causeway will have a detrimental impact on air quality for parameters such as SO_x, NO_x, PM_{10} in Alba's surroundings.

4.3 Water

4.3.1 Construction Phase

The construction activities, related to the new design, resulting in the generation of waste water are unchanged from the previous assessed situation. Dewatering is anticipated for the same location (Vertical Direct Chill (VDC) pit) and likewise it is assumed that waste water during construction phase will be collected in holding tanks and periodically disposed-off by approved waste collectors. Also, the waste water will not be connected to Alba's existing waste water systems and will be disposed-off in a manner complaint with the applicable Bahraini regulations and standards.

It is to be noted that details with regards to quantities are currently not available. Therefore no quantitative assessment with relation to the construction of the current and previous design was carried out.

4.3.2 Operation Phase

Similar to the previous design, the additional make-up water demand for PS 5 will be supplied from the calciner plant or from the water storage tanks during the calciner shutdown.

Originally, an additional water consumption of approximately fifteen (15) m^3 per hour was anticipated for PS 5 for the boiler feed water as well as for cooling purposes of the two (2) F class units. As PS 2 will be shut-down in the changed design, it is envisioned that the water consumption remains, or is less than, fifteen (15) m^3 per hour.

Therefore, no change in impacts on water usage is expected, except for the type of water being utilized (water from calciner versus groundwater).

4.4 Soil and Groundwater

4.4.1 Construction Phase

As the nature of construction activities will remain unchanged, no additional impacts are expected for the impact on physical changes of soil. Also, the impact from excavation on groundwater will remain the same, as the location will remain unchanged – as indicated in the ESIA, given the depth of the groundwater (between 15 and 18m) at the proposed facility, and the extent of the excavations, it is unlikely that there will be any direct impact on groundwater as a result of excavations.

Moreover, impacts related to chemical changes of soil are of similar nature. Considering implementation of management measures (advised in the ESIA) to reduce the threat of accidental spillage during the construction phase, no additional impact is envisioned.

4.4.2 Operation Phase

Similar, no changes to the physical properties of soil are expected during operations. However, during operations, storage of chemicals and wastes has the potential to impact the quality of the soil.

In the new design, potential spills from the diesel storage tank required for the black start have the potential for soil contamination. Therefore, soil protection measures – a bund or wall sized for 100 per cent (%) of tank capacity plus water quantity to create foam - have been incorporated in the design.

Presently, groundwater is used as process water for PS2. However, as PS 2 will no longer be operated the impact from groundwater abstraction will reduce as a result of the new design.

Taken the above in consideration, no additional impacts on soil and groundwater are expected.

4.5 Ecology

Similar to the previous design, the expansion will occur within Alba's industrial site which has little ecological value. The proposed location of the off-site construction lay-down areas west of the existing Alba facility will remain at the same location. As shown earlier, neither of the areas is of a high ecological value.

Again, the construction phase activities will have an impact on existing ecological features. However, it is assumed that after proper site restoration, the site can be restored to conditions similar to current conditions.

Therefore, impacts during the construction phase are again considered to be marginal, as long as the sites are restored as much as possible to their original condition.

4.6 Energy Use

4.6.1 Construction Phase

The source and peak requirement of fuel and electrical power will remain the same and is as follows:

- Construction power will, in general, be provided from the existing plant distribution system;
- The peak construction load including temporary site lighting is estimated at 5 MW; and
- The peak construction load for PS5 is approximately 2-3 MW.

As shown before, this figure is insignificant compared to the total installed capacity and will thus have a marginal impact on electrical energy use.

The extra fuel quantities (diesel and gasoline), required for onsite machinery during the additional three months construction period, will not have a significant impact on total energy use.

4.6.2 Operation Phase

Table 10 compares the daily total and specific electricity consumption for the production of aluminium of the Alba plant for the original and changed design.

Table 10: Total and specific annual electricity consumption

#		Units	Baseline (2013)	Expansion (incl. PS 5)		Percentage Increase
				Original	Design Change	
1	Total electricity production required for aluminium production	TJ	50,584	73,164	78,241	6.94 %
	of which is attributed to auxiliaries	TJ	3,270	5,077	5,077	0%
2	Production of aluminium	tpy	924,654	1,438,851	1,438,851	0%
3	Total specific electricity use (including all auxiliaries)	kWh/kg	15.2	15.1	15.1	0%
4	Specific electricity use for electrolysis including potline auxiliaries	kWh/kg	14.9	14.8	14.8	0%
5	Specific electricity use for electrolysis excluding auxiliaries	kWh/kg	14.2	14.1	14.1	0%

As shown from **Table 10**, the only increase is related to the total electricity production required for aluminium production (#1). However, this change is not related to the design changes but is included to cover auxiliaries which were previously omitted.

Replacing the older power generation unit (PS2), with modern turbines (PS5) would increase the overall efficiency which would in turn decrease the overall consumption and its effects on the environment per kg of aluminium produced.

Energy efficiency (expressed in kilowatt-hour per kilogram (kWh/kg)), on the other hand, is dependent on technology used in various potlines (L1-L6); and will not change for the new design. Also, shutting down PS2 has no impact on energy efficiency. However, the use of modern turbines will have a positive impact on efficiency of electricity generation from same gas.

In summary, PS5 consisting of a combined cycle electric generating facility will have a positive impact on the overall plant efficiency. As indicated earlier, the three (3) CTGs will be frame “F” units with dry low NO_x (DLN) combustion systems to control exhaust gas NO_x emissions. Frame F units have been selected because of their reputation for efficiency and reliability. A shown in **Table 11** below, the new units have a positive impact and less gas is required per tonne of aluminium produced (reduction of approximately 9.5%).

Table 11: Gas Consumption

Process	TPY Aluminium	Gas Consumption MMSCF/D^{A}	SCF/Ton^{B} of Aluminium
Lines 1 - 5	924,655	375	148,028
Line 6	514,196	153	108,606
Combined	**1,438,851**	**528**	**133,940**
^{A} MMSCF/D = Million Standard Cubic Feet per Day; ^{B} SCF/Ton = Standard Cubic Foot Per Ton			

4.7 Waste Management

4.7.1 Construction Phase

Construction activities related to the new design will result in the same type of wastes, such as surplus excavated material, scrap steel and wood, general rubbish, potential contaminants during demolition work *et cetera*.

However, the construction of the additional CTG unit and associated requirements will result in a 50% increase for construction waste of PS5, resulting in the following solid construction wastes:

- **Approximately 3,500 tonnes recycled solid wastes** - cardboard, plastic, glass & metals, ~ 2,000 tonnes for smelter and ~ 1,500 tonnes for PS5;
- **Approximately 8,000 tonnes un-recycled solid wastes** - construction waste to landfill ~ 5,000 tonnes for smelter plus ~ 3,000 for the PS5 area.

Although the amount of construction waste will increase with 500 tonnes to 3,500 tonnes for recycled solid waste and with 1,000 tons to 3,000 tons for un-recycled waste considering the construction activities for the third power station unit, the properties of these wastes allow them to be safely managed and recycled to a large extent. Implementing good waste management practises as advised in the ESIA will significantly reduce additional impacts on the environment. The impact of the third power station unit is considered of low significance.

As discussed in the ESIA, the types and quantities will have to be confirmed by the construction contractor.

4.7.2 Operation Phase

For both designs, the proposed expansion will result in an increase in waste quantities but the properties of these waste streams will be very similar to those generated currently. As indicated in the ESIA, the majority of waste produced at Alba is related to the production process. Waste quantities related to the expansion can be summarised as follows:

- The increase in quantity will be proportional to the increase in production capacity (i.e. 57% increase compared with the existing 2013 situation)[6];
- A total of 28,228 tonnes of non-recyclable solid waste (including 8,039 tonnes of hazardous waste) is expected to be generated each year, which corresponds to an increase of 49%;
- 389 Tonnes of un-recyclable liquid will be generated and comprises oil / water waste to Asker Landfill;
- 26,677 tpy of recycled solids (an increase of 58%) and 58,528 tpy of recycled liquids (an increase of 38%) will be generated; and
- An additional 5,016 tpy of scrap metals are expected to be sold each year.

Wastes quantities specifically related to the operation of power stations are listed in **Table 12**. Taken the shut-down of PS2 into consideration, further increase in waste generation from the design change is not expected. Demolition of PS2 is not applicable and therefore not considered in waste being generated.

Table 12: Wastes from Power Stations (tpy)

S. No.	Waste Item	Waste Type	L1 - 5 Baseline (2013)	L1 - 5 Crept	L6	Crept L1 - 6
RL1	Waste Oil to BAPCO	Recycled Liquid	811	822	464	1285
RL4	Oil / Water to BAPCO		9,582	9,708	5,477	15,184
RL 5	Hydrocarbon Condensates	Recycled Liquid	9,710	9,837	5,550	15,387
Sold 10	Filter Elements	Scrap Materials (Sold)	45	46	26	72

In summary, the design changes are not expected to result in an increase in waste generation.

[6] Based on production capacity of 2013 and future production capacity of L6 + Crept L1 – 5

Subsequent to the submittal of the ESIA, Alba received confirmation from their contractors with relation to the increased wastes streams. Thereby, Qatar Factory Oil Refinery[1] confirmed to be able to handle the increased oil waste. Crown Industries W.L.L., on the other hand, assured to be able to handle any quantity of additional waste (scrap metal) generated with efficiency. Also, the recycling capabilities for the increase in paper and carton waste is confirmed.

Table 13: Dross

	Cast House 2	Cast House 3
Current Contractor	TAHA	BRP
Process Used	▪ Hot process at Alba; ▪ Cold process at TAHA by mechanical separation and using as material for other products.	▪ After collection, BRP sells the dross overseas (Germany)
Annual Figures	Approximately 5,100 MT/Year	Approximately 4,900 MT/Year

Waste generated by Sewage Treatment Plant (STP)

Below text provided more background information waste being generated by the new STP, which quantitatively was already included in the ESIA report dated June 2014 [1]. The volume of sludge being produced at an STP is depending on the selected treatment technology (MBR, MBBR etc.) and consideration of any sludge treatment on site, such as thickening, dewatering and anaerobic digestion or incineration. A further reduction of the sludge weight is possible by evaporating the remaining water in the sludge (drying). It is assumed that if drying will be applied prior to disposal to the landfill, this will not be done on site due to space constraints. Detailed assessments on waste quantities cannot be performed at this stage since currently no details are available on selected STP technology and sludge treatment technology (if any). The ESIA report as submitted in June 2014 [1] considered that quantities of generated sludge will be in line with the existing STPs at Alba and quantity was added to existing sludge waste figures.

Quality of sludge from an STP applying an aerobic treatment process is mostly determined by the quality of the receiving waste water and presence of any contaminants that cannot be treated (digested) by the microbes. The aerobic treatment process will be removing the components that can be digested by the microbes. Majority of any other components, such as oil, heavy metals will end up in the surplus sludge that will be disposed of as waste to a landfill. Considering the sources of waste water received at STP-3 for treatment new cafeteria and change rooms facility as well as the administration building, domestic sewage, etc., it is not anticipated that the sludge will contain levels of contaminants (heavy metals etc.) that will not allow for disposal to landfill.

[1] Qatar Factory is able to recycle oil waste streams, with the purpose for recycling in the kingdom of Bahrain.

4.8 Traffic

4.8.1 Construction Phase

All construction activities will start two (2) months later and the overall construction schedule (L6 and PS5) will extend (3) months further than indicated in previous ESIA report. The peak and average of construction workers remain unchanged; however, the peak construction activities for PS5 will start as previously planned and lasts for two (2) months longer than in the previous study of June 2014 [1].

There will be no change in routing and logistics of construction traffic. Due to the fact that the peak construction phase for PS5 will be extended with 2 months, the traffic intensity will increase from 90 vehicles per day, six days per week to 180 vehicles per day, six days per week during these two additional months of peak PS5 construction.

The total traffic (860 and 575 vehicles per day during peak and non-peak construction respectively) is not expected to change. However, due to the extended overall construction period (plus one month) and extended peak construction period (plus two months) the cumulative amount of traffic will increase slightly.

4.8.2 Operation Phase

Due to the nature of the design change, the operation of the additional Power Station unit is not expected to result in any additional traffic.

4.9 Visual

As indicated in the ESIA, the prevailing industrial visual character of Alba and its immediate surrounds will not be dramatically changed by the proposed expansion. Taken the proposed design changes into consideration, no additional impacts are expected during construction or operation as:

- The nature of construction activities remains the same;
- The location of the laydown area will be unchanged; and
- The additional CTG unit (PS5C) will be of the same dimensions as two (2) units proposed earlier.

4.10 Noise

4.10.1 Construction Phase

The additional power station will not change any construction activities or use of construction equipment compared to the ESIA study submitted in June 2014 [1]. The potential noise sources during the construction phase will be the same i.e. from construction equipment, DG units, compactors, excavators, construction vehicles, etc. The source noise levels of construction equipment will be maintained in such a way as to comply with applicable regulatory requirements. Same noise levels will be generated as considered in the ESIA report (June 2014); however, the overall construction phase will be extended with one (1) month, and peak construction activity for PS5 will be extended with two months.

Noise levels during the construction phase, including the construction of a third power station unit are considered not to have a significant impact on residential receptors.

4.10.2 Operation Phase

A noise modelling study was performed for the expansion with L6 and PS-5 comprising only two F class units. An updated noise model was prepared considering an additional F class unit south of the proposed two F class units.

Accordingly, a quantitative assessment through noise modelling was conducted as part of ESIA addendum study to determine the additional contributions to the ambient noise levels from the proposed expansion project.

4.10.2.1 Noise Modelling

The noise modelling for evaluation of noise contributions was conducted using SoundPLAN developed by Braunstein & Berndt GmbH, Germany. The model is based on sound pressure wave divergence. SoundPLAN is a Microsoft Windows based software tool, which can accept multiple stationary noise sources.

4.10.2.2 Noise Emission Inventory

The various noise generating sources identified and utilised for modelling are as presented in **Appendix 3**.

4.10.2.3 Noise Modelling Results – Operation phase

Figure 3 and **Figure 4** below provide the overview of Noise Contributions from Alba (baseline noise levels inclusive of L-6 operations) to the surroundings. The noise contributions include traffic movements to and from the site and on site. The different colours indicate the noise levels in dB (A).

In addition, baseline noise levels along with predicted noise levels at Alba's fence line are provided in **Table 14**.

Table 14: Alba operating noise levels at Alba fence lines

Direction	Baseline Noise Levels (dB(A))	Predicted Noise Levels at Fence Line (dB(A))	Predicted Noise Levels at Fence Line (dB(A))	Increase in Noise Levels (dB(A)) by addition of third F class unit	Remarks
		ESIA	ESIA Addendum		
North	61.0	62.0	65.0	3	Substantial increase; however, noise levels well below World Bank Allowable Noise limits.
East	71.0	71.0	71.0	-	Existing noise levels are slightly non-compliant. This is caused by noise from traffic on King Hamad Highway. Further, noise levels at all areas except at south-east corner (close to PL-6 current office area) are within 70 dB(A)
South	61.0	61.7	63.0	1.3	Complies with World Bank Allowable Noise limits
West	66.5	67.0	67.5	0.5	Complies with World Bank Allowable Noise limits

From the modelling study and **Figure 3** and **Figure 4** below it can be concluded that noise levels close to Alba's fence lines are within the regulatory requirement of 70 dB (A) (limits prescribed for Industries by IFC). Impacts to any sensitive receptors (residential areas) are considered negligible due to the distance between Alba and these receptors.

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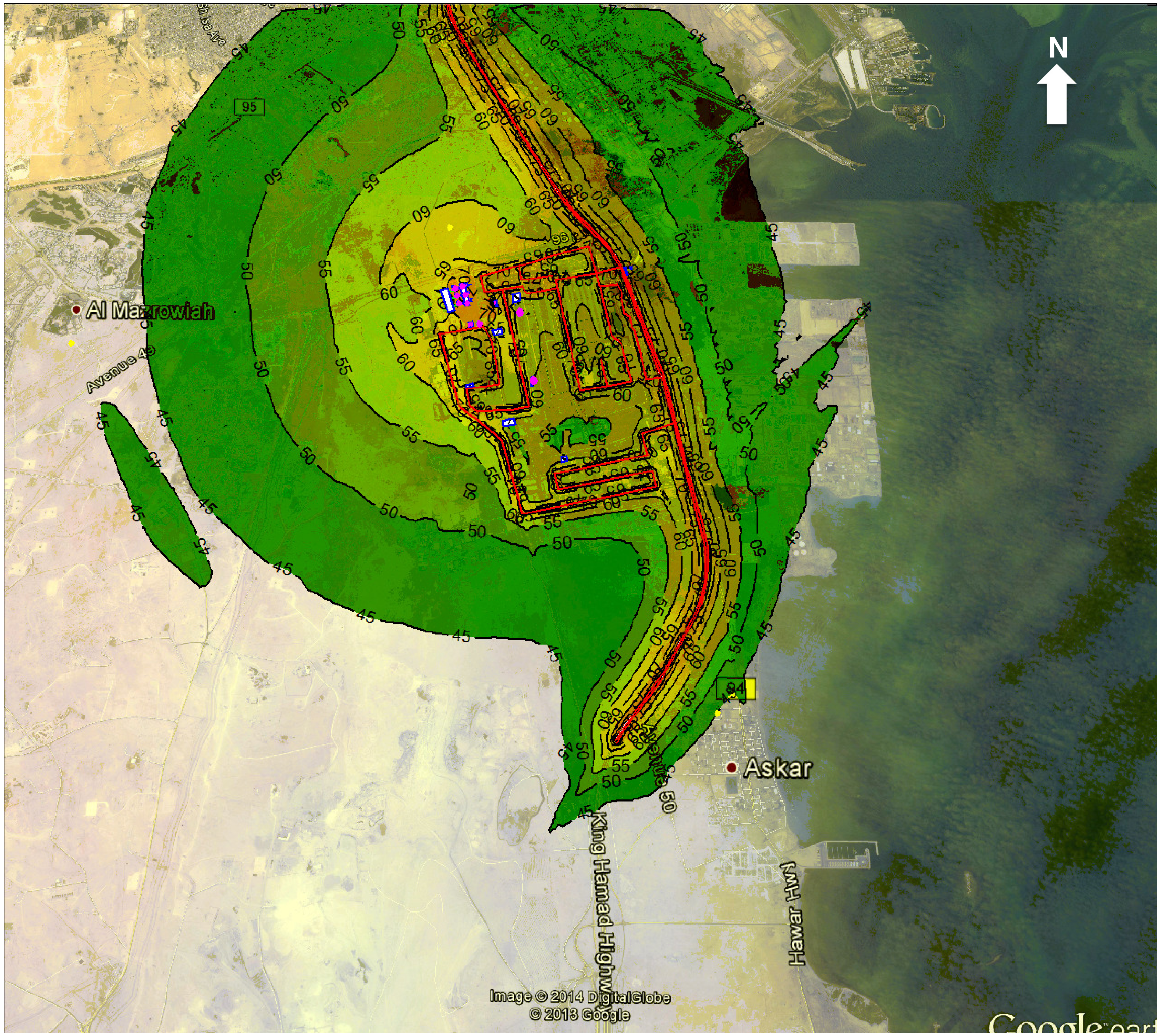

LEGEND

Signs and symbols
- Point source
- Line source
- Area source
- Main building
- Roof area
- Ground absorption
- Elevation line
- Industrial building
- Point receiver
- Residential, Multiple Dwelling

Noise level
Ldn
in dB(A)

<=	45
45 -	50
50 -	55
55 -	60
60 -	65
65 -	70
70 -	75
75 -	80
80 -	85
85 -	90
90 -	95
>	95

Scale 1:3666
0 1000 2000 4000 6000 8000 feet

PRODUCED FOR: alba

CLIENT: BECHTEL
END CLIENT: ALBA
PROJECT: ESIA ADDENDUM FOR ALBA PS-5
PROJECT NO.: 10921.00

SOFTWARE: SoundPLAN 7.3
Calculation in 1.5m above ground

DESCRIPTION:
Noise Contour Map – Option A (3 F Class units PS-5)

PREPARED BY: BILFINGER TEBODIN

Date	Drawn	Checked	Approved
21-09-2014	ASR	MVV	MVV

Figure 3: Overview of Noise Contributions from Alba operations to the surroundings

LEGEND

Signs and symbols	
Point source	
Line source	
Area source	
Main building	
Roof area	
Ground absorption	
Elevation line	
Industrial building	
Point receiver	
Residential, Multiple Dwelling	

Noise level Ldn in dB(A)
<= 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
85 - 90
90 - 95
> 95

Scale 1:2000
0 500 1000 2000 3000 4000 feet

PRODUCED FOR:

CLIENT: BECHTEL
END CLIENT: ALBA
PROJECT: ESIA ADDENDUM FOR ALBA PS-5
PROJECT NO.: 10921.00

SOFTWARE: SoundPLAN 7.3
Calculation in 1.5m above ground

DESCRIPTION:
Noise Contour Map – Option A (3 F Class units PS-5)

PREPARED BY:

Date	Drawn	Checked	Approved
21-09-2014	ASR	MVV	MVV

Figure 4: Predicted Noise Levels close to Alba's Fence line

4.11 Occupational Health and Safety

In line with the ESIA, activities during construction and operations of the proposed expansion present a range of possible occupational health and safety (OHS) risks.

Again, for the most part occupational health and safety issues are best addressed by ensuring that there are appropriate management controls in place, which are continually reviewed and improved. An additional control measure is the use of foam protection[7] as fire fighting measure for the new black start (diesel generators) and diesel storage tank.

Further, no changes with relation to OHS risk are envisioned for the new design.

4.12 Cultural Heritage

Given that the adjusted design will not result in a change in location, and as there are no archaeological or culturally significant sites in the area proposed for the expansion, the possible impacts of the construction activities on cultural heritage remain negligible.

4.13 Social and Economic Environment

The ESIA assessed potentially social-economic effects of the proposed expansion in relation to investment benefits and job creation aspects. Thereby high positive impacts were associated with job creation and contribution to Gross Domestic Product (GDP), whereas the trade balance during construction was found to be moderately adverse, as a result of capital outflows for the purchase of materials and equipment.

As indicated earlier (**Section 3.1**), the employment of craft labour during the construction phase will remain the same, with the only change of a three month longer construction period. Therefore, the design change will slightly improve the job opportunities assessed earlier – due to the extended construction period of three months. The additional permanent employment opportunities at Alba (547 permanent jobs) will remain unchanged.

Considering the above, the effect of the design change on the socio-economic environment is negligible.

[7] Based on United States (US) National Fire Protection Association (NFPA) – 11.

4.14 Summary of Impact Changes

Table 15 below provides an overview of the changes in environmental impacts by installing the third power generation unit at PS5, compared to the assessed environmental impacts in the ESIA from June 2014 [1].

Table 15: Summary of Impacts related to additional Power Station

#	Environmental Aspect	Impact from additional Power Station		Comments
		Construction Phase	Operation Phase	
1	Air Quality	No significant increase	No change or slight improvement	Import of 150MW electricity from the grid is no longer required, therefore reducing emissions at EWA power station. NOx emissions from PS5 reduced from 100 to 51 mg/Nm3. Overall impacts on ambient air quality during operation will not change or will be reduced compared to previous assessment.
2	Water	No change	No change or reduced water consumption	Due to closure of PS2 same or reduced water consumption provided by Calciner. Usage of groundwater for PS2 is stopped.
3	Soil and Ground Water	No change	Positive impact	Usage of groundwater for PS2 will be stopped.
4	Ecology	No change	No change	
5	Energy Use	No significant increase	No change in energy efficiency. Reduction in gas consumption per kg aluminium	9.5% reduction in gas consumption per kg aluminium produced. Import of 150MW is no longer required.
6	Waste Management	Slight increase	No change	Increase with 1,500 ton construction waste (13% increase compared to ESIA figures)
7	Traffic	Slight increase in cumulative traffic movements	No change	The overall construction period will be extended with one month. The peak construction period for PS5 will be extended with 2 months, therefore increasing the amount of vehicles during that period. Cumulatively there will be a slight increase for the total construction phase of the project compared with assessment in previous ESIA study.
8	Visual	No change	No change	

#	Environmental Aspect	Impact from additional Power Station		Comments
		Construction Phase	Operation Phase	
9	Noise	Slight increase	Marginal increase	Noise levels will slightly increase since overall construction phase will increase with one month and peak construction activities for PS5 will be extended with 2 months. Noise levels at fenceline during operation will increase; however, levels are within World Bank standards. No impacts on sensitive receptors
10	Occupational Health and Safety	No change	No change	
11	Social and Economic Environment	Negligible to slight positive	Negligible	The extended overall construction period and peak construction period for PS5 will lead to a slight increase in job opportunities during the construction phase

4.15 Summary of Impact Findings

In order to provide a summary of the possible impacts of the entire proposed Alba expansion (L6, PS5 etc.), impacts are categorised by aspects as shown in Table 16. The categories are the extent, duration, intensity and probability of occurrence. Impact significance is presented as either positive (a benefit) or negative (a cost to the environment).

Table 16: Impact Rating Categories

S. No.	Aspect	Definition / Graded in terms of	
1	Extent (E)	On-site	Only within the confines of the construction or operational areas of the site.
		Local	Within approximately 10 km radius of the plant
		Regional	Beyond local but not affecting the country as a whole.
		National	Affecting the whole country.
		Global	The impact has global significance.
2	Duration (D)	Short term	0 to 5 years

S. No.	Aspect	Definition / Graded in terms of	
		Medium term	5 to 15 years
		Long term	>15 years (with the impact ceasing after the operational lifetime of the development)
		Permanent	The impact once manifested will be permanent.
3	Intensity (I)	Magnitude or size of the impacts and is graded as high, medium, low or negligible.	
4	Probability of occurrence (P)	This is the probability of a significant impact being manifest and is graded as improbable, possible, probable and definite.	
5	Significance (S)	Negligible	The impact is unlikely to be manifested.
		Low	The impact will occur but will not result in substantial, detrimental effects.
		Moderate	The impact will occur and may present a risk of substantial, detrimental effect.
		High	The impact will occur and will result in substantial, detrimental effect.

In line with the above categories, the summary of impacts from the proposed L6 and PS5 expansion project, considering three units, is presented in Table 17.

Table 17: Summary of the potential impacts

Nature of the impact	E	D	I	P	S	Comments
Air Quality						
Construction dust emissions	Local	Short-term	Low	Probable	Low	The size and arid nature of the construction area means that dust will be generated.
Greenhouse gas emissions	Global	Long-term	High	Definite	High	Greenhouse gas emissions from Alba are already significant, and these will be further increased following the proposed expansion. That said, there are no limits specified currently on greenhouse gas

Nature of the impact	E	D	I	P	S	Comments
						emissions and as these emissions do not contravene any direct legal requirement.
Human health impacts from ambient SO_2 concentrations	Regional	Long-term	Moderate	Improbable	Low	Even though SO_2 emissions will increase, impacts on ambient air quality and subsequent human health impacts are considered low.
Human health impacts from ambient NO_2 concentrations	Regional	Long-term	Moderate	Improbable	Low	Even though NO_2 emissions will increase, impacts on ambient air quality and subsequent human health impacts are considered low.
Human health impacts from ambient HF concentrations	Regional	Long-term	Low	Improbable	Low	Predicted ambient fluoride concentrations are well below the standards at which human health effects may be manifest.
Human health impacts of PM_{10} conc.	Local	Long-term	Low	Improbable	Low	The contribution of the proposed expansion to ambient PM_{10} concentrations is small.
Ecological impacts from ambient HF concentrations	Regional	Long-term	Moderate	Possible	Low	HF concentrations are elevated in near vicinity of Alba. However, since no plantations or crops are in close proximity of Alba, impacts are considered low.
Water						
Additional water demand	Regional	Long-term	High	Definite	Low	The additional water use requirements of the proposed expansion will be met through the available reverse osmosis capacity at the Calciner Plant. Groundwater consumption for PS2 will be stopped.
Additional wastewater effluent	Local	Long-term	Negligible	Probable	Low	Majority of waste water will be internally recycled, used for irrigation or discharged to Alba's lake. A negligible increase of waste water effluent will be discharged via the existing outfall to sea (< 0.1% increase). Since the current outfall does not enable proper mixing it is recommended to investigate an outfall location providing proper mixing and therefore minimizing impacts.

Nature of the impact	E	D	I	P	S	Comments
						Domestic waste water and waste water from the truck washing facilities will be treated by the proposed STP-3 and further utilized for irrigation purposes or sent to Alba's lake.
Soil and Groundwater						
Soil contamination	Local	Short-term	Low	Possible	Low	The soil contamination is limited and a function of the existing operation. The contaminated soil will be removed and disposed during the construction phase.
Groundwater	Local	Long-term	Low	Definite	Low beneficial	Groundwater consumption for PS2 will be stopped.
Ecology						
Ecological impacts / habitat loss from construction phase	Local	Short term	Medium	Probable	Low	Due to low ecological significance of the lay-down areas, impacts are considered to be low.
Ecological impacts / habitat loss from operation phase	Local	Long term	Negligible	Probable	Low	Ecological impacts during operational phase are low, since activities will occur at existing industrial facility, within industrial area.
Energy Use						
Consumption of fossil fuels for operations and vehicles	National	Long term	High	Definite	High	Increased consumption of fossil fuels (mostly natural gas) will have a high impact on availability of natural gas in Bahrain. Energy efficiency is however considered in selection of production and power generation technologies. Gas consumption per kg of aluminium produced will be reduced by 9.5%. No import of electricity from EWA grid will be required.
Waste Management						
Construction wastes	Regional	Short-term	Medium	Definite	Low to Moderate	Although the quantities of waste generated during construction will be

Nature of the impact	E	D	I	P	S	Comments
						significant the properties of these wastes allow them to be safely managed.
Spent pot linings	Local	Long-term	Moderate	Possible	Low to moderate	Although the current SPL disposal practice is deemed acceptable, the hazardous nature of SPL dictates improved disposal practise in the medium to long term.
Traffic						
Construction traffic	Local	Short-term	Moderate	Definite	Moderate	The additional vehicles required for the construction phase will exacerbate congestion.
Elevations in traffic density on King Hamad Highway and surrounding internal roads during operation	Local	Long-term	Moderate	Probable	Low to Moderate	A significant increase in traffic density will occur on King Hamad highway from the heavy traffic commuting back and forth from the south east and new south west gates of Alba's smelter
Visual						
Visual impacts to surroundings	Local	Long-term	Low	Improbable	Low	The prevailing industrial visual character of Alba and its immediate surroundings will not be dramatically changed by the proposed expansion.
Noise						
Increase in noise levels due to increased traffic movements and additional noise sources	Local	Long-term	Low	Improbable	Low	The impact assessment indicated an increase of 3 dB(A) north of the site. However, the levels will be complying with World Bank Standards and have no impacts on sensitive receptors (residential areas).
Occupational Health and Safety						
Occupational health and safety – construction phase	On-site	Short-term	Moderate	Probable	Moderate	Occupational health and safety risks always prevail on a large construction site and are complicated by the presence of multiple contractors. No extraordinary health and safety risks are presented by

Nature of the impact	E	D	I	P	S	Comments
						the construction requirements.
Occupational health and safety – operations phase	On-site	Long-term	Mode rate	Possible	Low to moderate	Occupational health and safety risks always prevail in industrial complexes. The finding presented here is based on the expanded expansion not presenting any extraordinary risks of adverse health effects or injury.
Cultural Heritage						
Impacts to cultural and archaeological features	Local	Long-term	Low	Improbab le	Negligible	No cultural heritage sites and/or artefacts occur in close enough proximity to the plant to be directly impacted upon by either the construction or operational activities.
Social Economic						
Job creation	Nationa l	Long-term	High	Definite	High, positive impact	The socio-economic impacts associated with the expansion project is manifested as a positive impact on the Kingdom of Bahrain as a whole
Contribution to GDP	Nationa l	Long-term	High	Definite	High, positive impact	The expanded operation will increase the contribution to GDP by some US$ 300 million per annum.
Trade balance – construction	Nationa l	Short-term	Mode rate	Definite	Moderate	During the construction phase there will be net worsening of the trade balance as a result of capital outflows for the purchase of materials and equipment for the expansion.
Trade balance – operations	Nationa l	Long-term	High	Definite	High, positive impact	Following the commissioning of the expanded plant, there will be a net improvement in the trade balance. This will be a direct function of the surplus between import costs and the revenue generated through the exported product.

5 Alternatives

The technology considered for the third power generation unit will be identical to the earlier two power generation units. Adding a third power generation unit at PS5 will have no impacts on the alternatives assessment included in previous ESIA study [1].

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6 Conclusions

Alba is presently considering expanding its smelter operations to include an additional Potline 6 (L6), a Power Station 5 (PS 5), and supporting facilities. An Environmental and Social Impact Assessment (ESIA) study as requested by the General Directorate of Environment & Wildlife Protection was submitted to SCE in June 2014. However after submittal of the ESIA report, design changes were made for the power station configuration. TME prepared this addendum to inform SCE on these changes and to assess the change in impacts on the environment.

The initial design of PS 5, for which the ESIA was prepared, comprised two (2) F class units. In the current design change, an extra F class unit is added to the power station, hereafter referred to as PS-5C. Furthermore, the existing PS-2 will be shut-down and 150MW additional power will no longer be sourced from the Electricity and Water Authority (EWA) grid.

Based on this ESIA addendum it can be concluded that majority of the environmental impacts by adding the third F class power generation unit are identical compared with previous ESIA study. Some impacts have been slightly reduced (air quality during operational phase, no use of groundwater), and some impacts have slightly increased (traffic during construction phase, construction waste, noise during operational phase).

Of the impacts assessed only two pose a significant risk of impact to the environmental. The first of these is the greenhouse gas emissions that will be generated by the proposed expansion. It is well recognised that aluminium smelters are significant producers of greenhouse gas emissions as is the case for Alba for both the current operations as well as those that will be generated by the proposed expansion.

The second significant impact is that associated with the relatively high SO_2 and HF emissions. The results of the analysis show that the total correlated predicted SO_2 and HF concentrations in the ambient air at indicated sensitive receptors comply with the applicable standards for both the present and future cases. However, there are exceedances of SO_2 and HF levels in the area from Alba's fence line to several kilometres south to south-west. Based on the modelling analysis for the maximum allowable Bahraini emissions criteria, the contribution of criteria pollutants were found to be temporal in nature, since long term average are well below the Bahraini AAQS, except for HF. Therefore, a scenario with additional mitigation measures was evaluated to reduce the impact of HF. This scenario also incorporated lower SO_2 source emission ratios, in line with current Alba operations. This scenario is retained as the scenario applied for the proposed expansion project.

The Best Available Technology considered in the design of proposed Potline 6 and Power Station 5 limit the emissions from the expansion to the extent possible. Furthermore, commitments are made to limit the source emissions for existing Potline 4 and Potline 5 via mitigation through stricter operating practices in line with those considered for Potline 6.

The amount of effluents to sea is expected to remain similar to those of the current operations with the exception of a minimal quantity generated by the Power Station. Recommendations with regards to the marine outfall are provided.

Positive impacts include the increased economic growth that will be brought about by the spending on the project as well as the increased revenues that will be generated by the expanded operation. In addition, the construction phase will see some 4,000 temporary jobs with some 500 permanent jobs being created at the expanded plant. The expanded operation will also keep Alba globally competitive in terms of its unit costs of production, and also capitalise on the continued growth in demand for primary aluminium.

The ESIA has been concluded by presenting mitigation together with recommendations that should be implemented on the proposed expansion. Implementation of the mitigation and recommendations will ensure that the expanded plant does not result in an impact on the environment, and that it will meet the principles of development that is environmentally, socially and economically sustainable.

References

1. Tebodin Middle East Ltd. Alba Potline (6) and Power Plant (PS 5) Expansion - Environmental and Social Impact Assessment Report. Doc. No. 3311002, Rev. C, 9th June 2014

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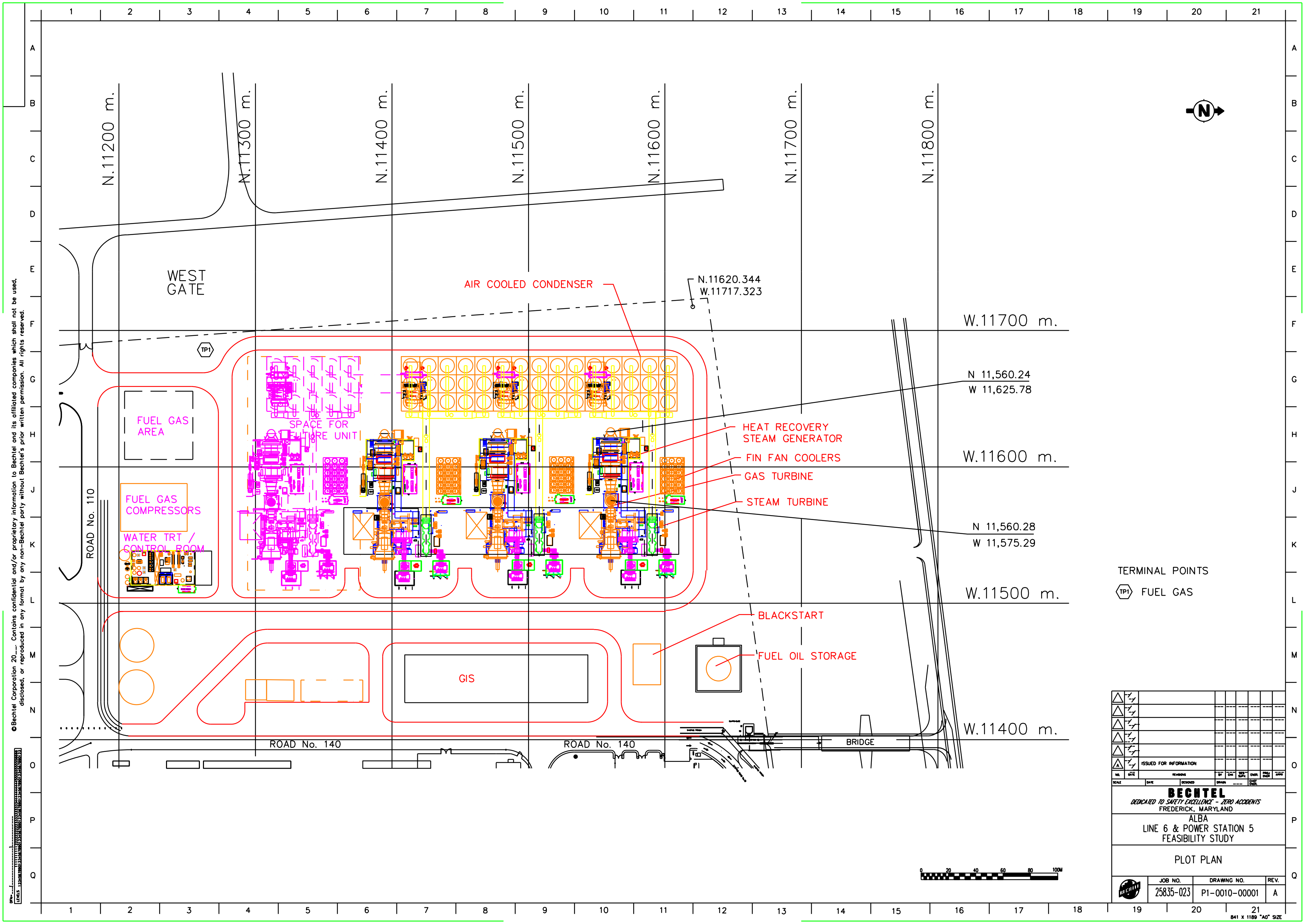
List of Appendices

Appendix 1: Site Layout



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N.11700 m.
N.11800 m.
W.11700 m.
W.11600 m.
W.11500 m.
W.11400 m.
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W.11717.323
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W 11,625.78
HEAT RECOVERY STEAM GENERATOR
FIN FAN COOLERS
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STEAM TURBINE
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W 11,575.29
FUEL GAS AREA
SPACE FOR FUTURE UNIT
FUEL GAS COMPRESSORS
WATER TRT / CONTROL ROOM
ROAD No. 110
BLACKSTART
FUEL OIL STORAGE
GIS
ROAD No. 140
ROAD No. 140
BRIDGE
TP1
TERMINAL POINTS
TP1 FUEL GAS
N
ISSUED FOR INFORMATION
BECHTEL
DEDICATED TO SAFETY EXCELLENCE - ZERO ACCIDENTS
FREDERICK, MARYLAND
ALBA
LINE 6 & POWER STATION 5
FEASIBILITY STUDY
PLOT PLAN
JOB NO.
25835-023
DRAWING NO.
P1-0010-00001
REV.
A
841 X 1189 "AO" SIZE

Client: **Bechtel**
Project: Alba Potline (6) and Power Plant (PS 5) Expansion

Appendix 2 – Air Dispersion Isopleths

Tebodin

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Hamdan Street
Tourist Club Area
P.O. Box 2652
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Rev.	Date	Description	Author	Checked by

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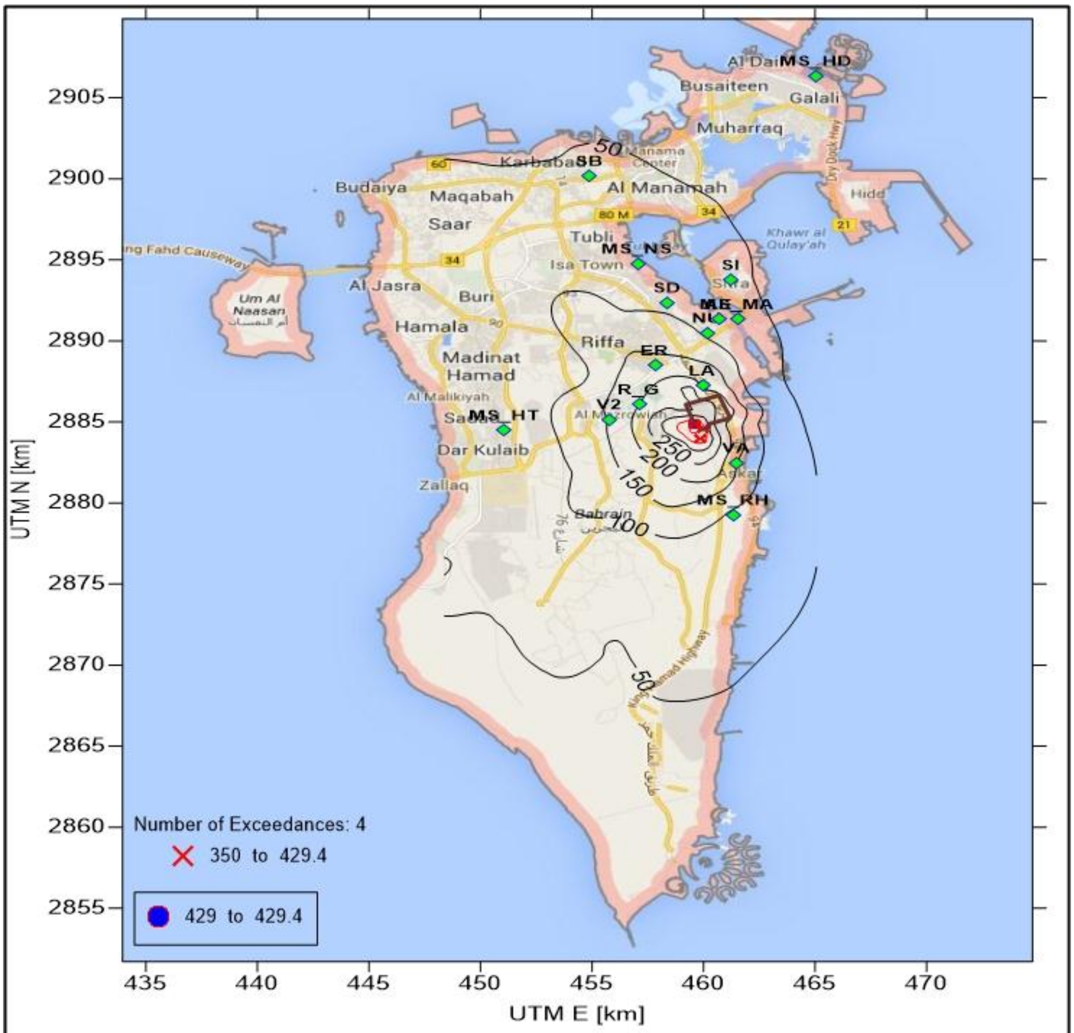
1 Iso-contours Air Modelling

Isopleth contours of the sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) scenarios and standard average time (hourly, daily, yearly average values) are presented in **Figure A 1** to **Figure A 6**. In addition, isopleth contours indicating compliance with the 2030 National Land Use Strategy are presented in **Figure A 7** to **Figure A 9**.



LEGEND:

Ambient Air Quality Standards

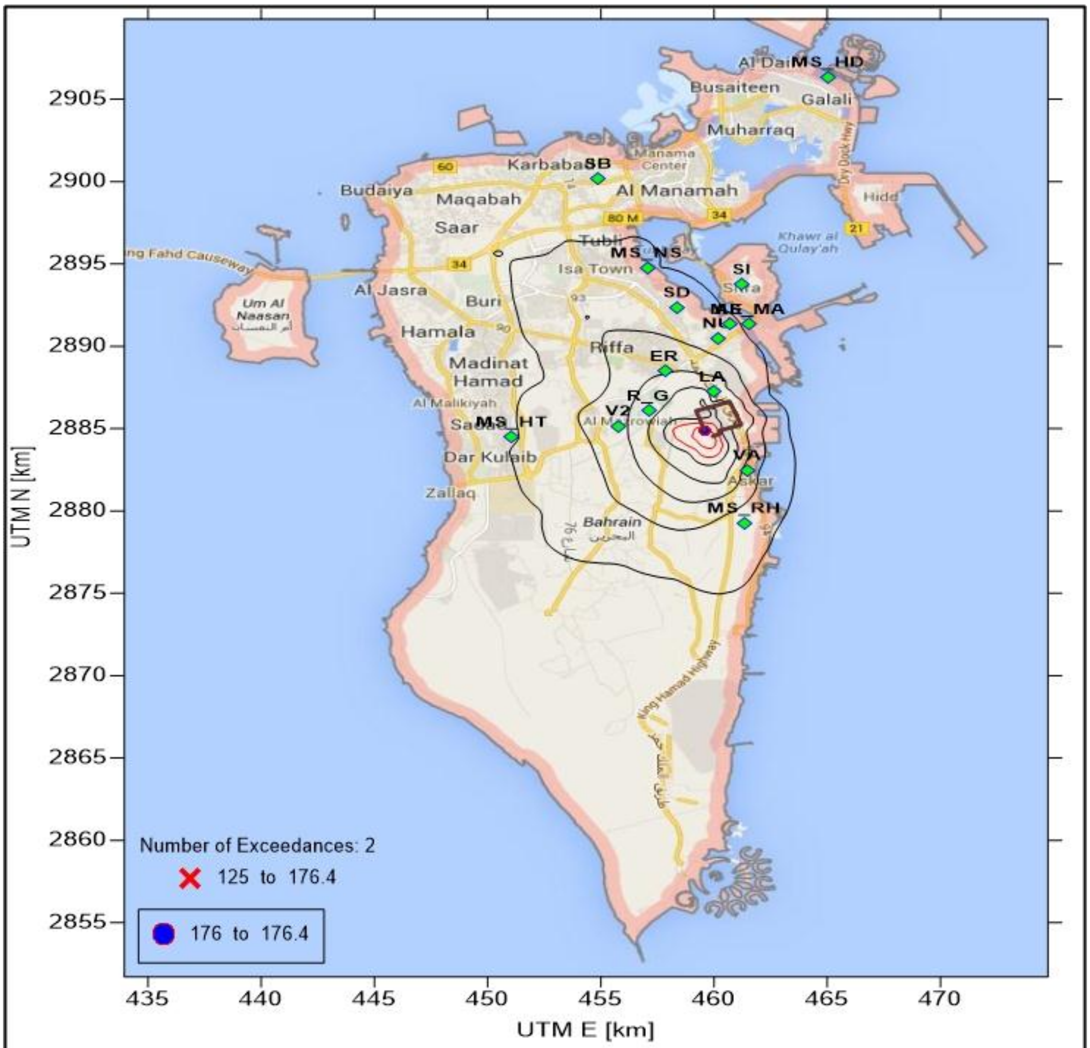
Time Weighted Average - Hourly: 350 ug/m3
Maximum Predicted Concentration: 429 ug/m3

- Plant boundary limit
- Ambient Air Quality Limit
- Receptor Locations
- Maximum Concentration

No.	Location	CODE
1	Ras Hayyan	MS_RH
2	Hidd	MS_HD
3	Maameer	MS_MA
4	Napeeh Saleh	MS_NS
5	Hamad Town	MS_HT
6	Sanabis	SB
7	Villas Askar	VA
8	Villas 2	V2
9	ResidentialArea & Golf Course	R_G
10	Labour Accommodation	LA
11	East-Riffa	ER
12	Ma'ameer	MA
13	Nuwaidrat	NU
14	Al Eker	AE
15	Sanad	SD
16	Sitra	SI

Prepared For:	Figure Title: Hourly Average Concentration - SO_2 Option - A Inclusion of 3- PS5 and discontinuing PS1 and PS2	Date: September, 2014
Prepared By: BiLFINGER TEBODIN	Project: ALBA Potline (6) and Power Plant (PS5) Expansion	Project No: 10921.00

Figure A 1 - Option A- Maximum 1- Hour Concentration – SO_2



LEGEND:

Ambient Air Quality Standards

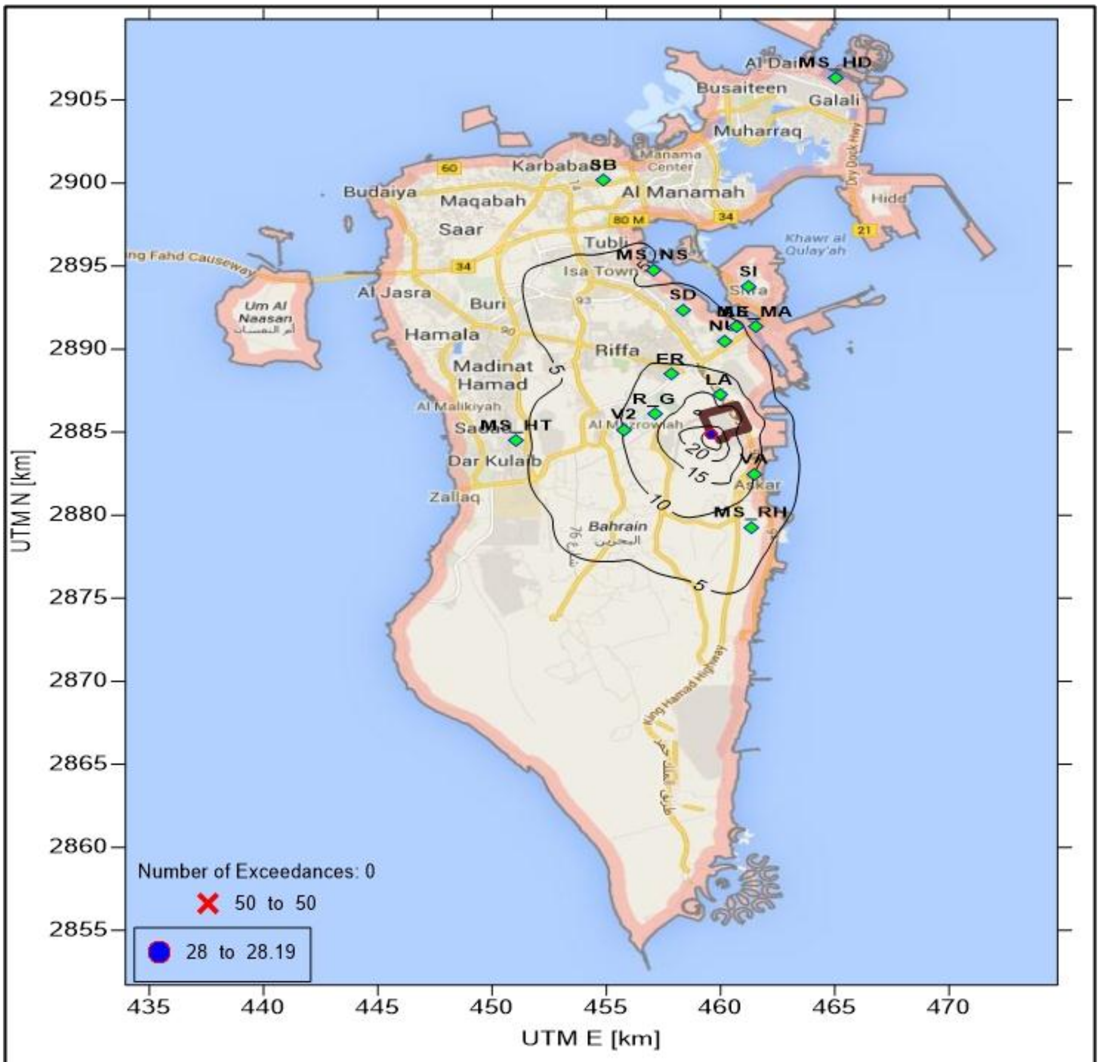
Time Weighted Average - Daily: 125 ug/m3
Maximum Predicted Concentration: 176 ug/m3

Plant boundary limit
Ambient Air Quality Limit
Receptor Locations
Maximum Concentration

No.	Location	CODE	No.	Location	CODE
1	Ras Hayyan	MS_RH	10	Labour Accommodation	LA
2	Hidd	MS_HD	11	East-Riffa	ER
3	Maameer	MS_MA	12	Ma'ameer	MA
4	Napeeh Saleh	MS_NS	13	Nuwaidrat	NU
5	Hamad Town	MS_HT	14	Al Eker	AE
6	Sanabis	SB	15	Sanad	SD
7	Villas Askar	VA	16	Sitra	SI
8	Villas 2	V2			
9	ResidentialArea & Golf Course	R_G			

Prepared For:	Figure Title: Daily Average Concentration - SO_2 Option - A Inclusion of 3- PS5 and discontinuing PS1 and PS2	Date: September, 2014
Prepared By:	Project: ALBA Potline (6) and Power Plant (PS5) Expansion	Project No: 10921.00

Figure A 2 - Option A- Maximum 24- Hour Concentration – SO_2



LEGEND:

Ambient Air Quality Standards

Time Weighted Average - Annual: 50 ug/m3
Maximum Predicted Concentration: 28 ug/m3

Plant boundary limit

Ambient Air Quality Limit

Receptor Locations

Maximum Concentration

No.	Location	CODE
1	Ras Hayyan	MS_RH
2	Hidd	MS_HD
3	Maameer	MS_MA
4	Napeeh Saleh	MS_NS
5	Hamad Town	MS_HT
6	Sanabis	SB
7	Villas Askar	VA
8	Villas 2	V2
9	ResidentialArea & Golf Course	R_G

No.	Location	CODE
10	Labour Accommodation	LA
11	East-Riffa	ER
12	Ma'ameer	MA
13	Nuwaidrat	NU
14	Al Eker	AE
15	Sanad	SD
16	Sitra	SI

Prepared For:	Figure Title: **Annual Average Concentration - SO_2** **Option - A** **Inclusion of 3- PS5 and discontinuing PS1 and PS2**	Date: September, 2014
		Project No: 10921.00
Prepared By:	Project: **ALBA Potline (6) and Power Plant (PS5) Expansion**	

Figure A 3 - Option A- Annual Average Concentration – SO_2

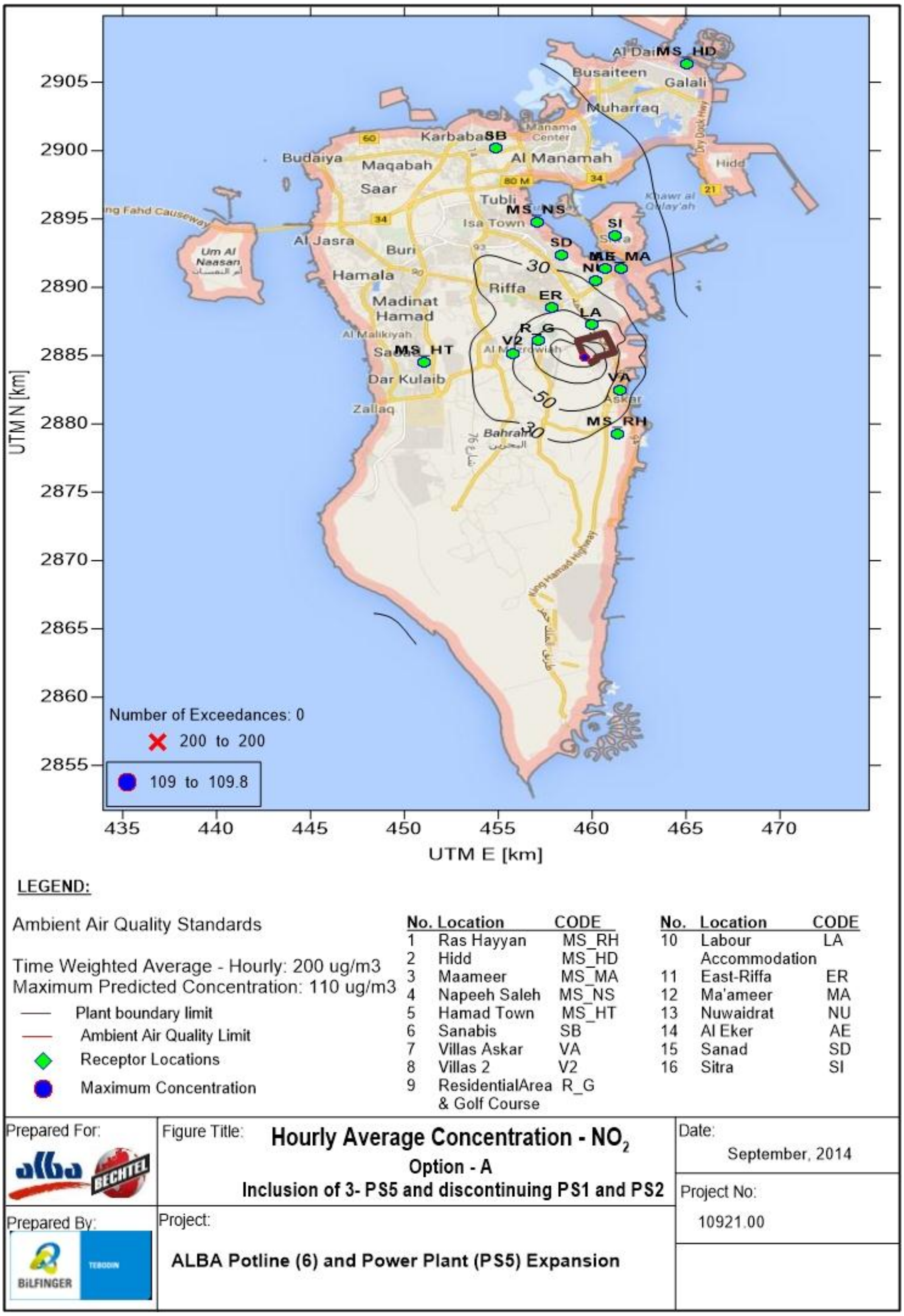


Figure A 4 - Option A- Maximum 1- Hour Concentration – NO_2

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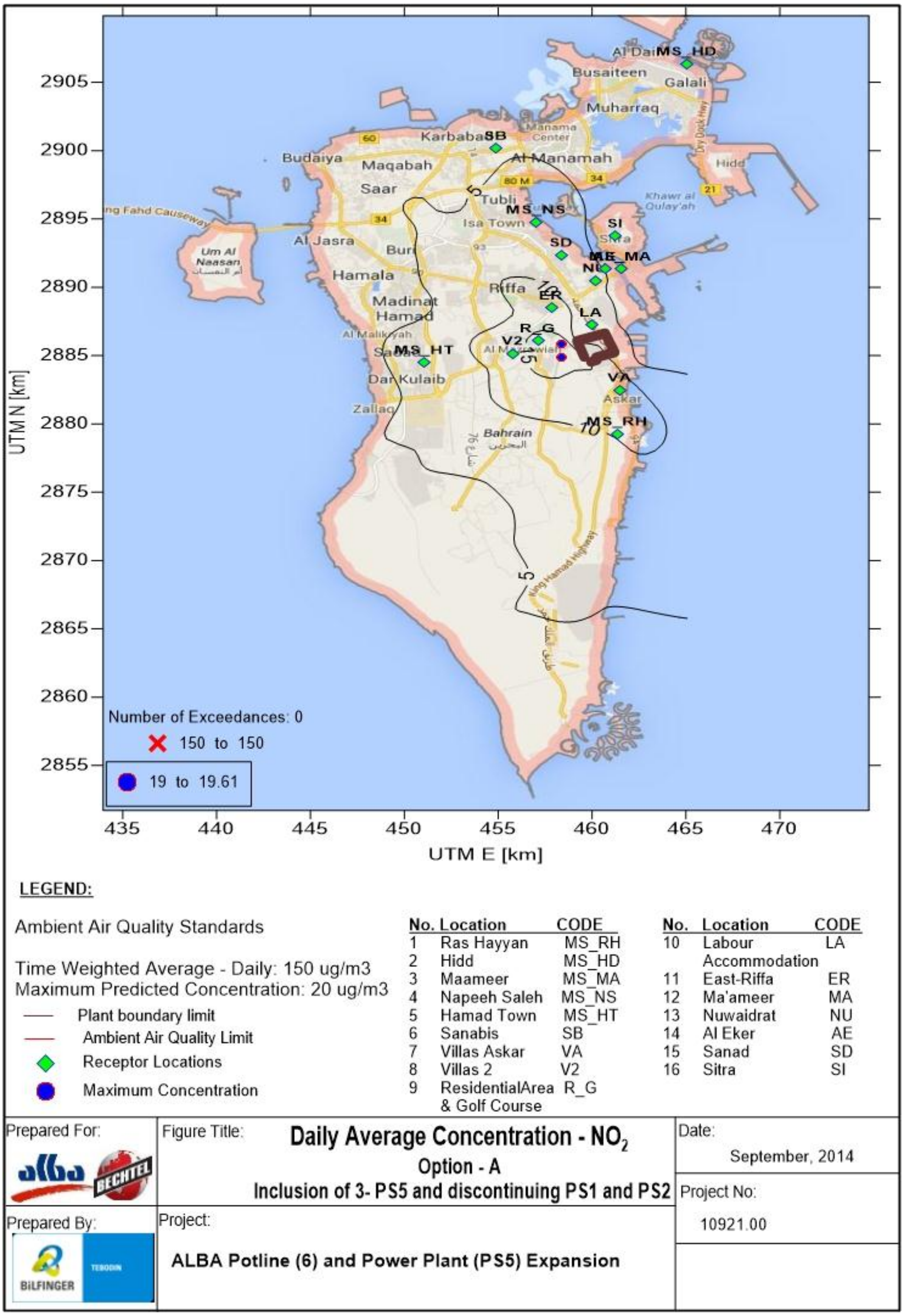
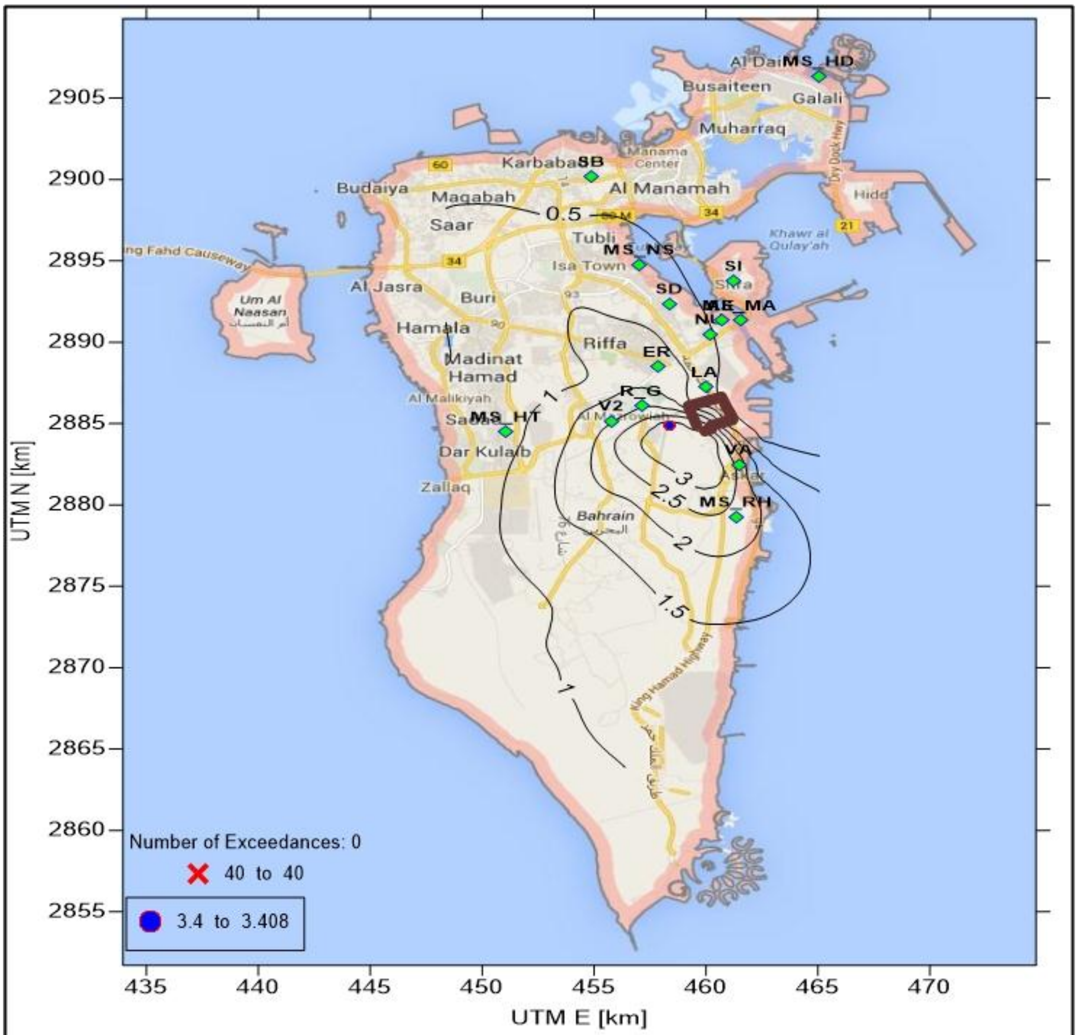


Figure A 5 - Option A- Maximum 24- Hour Concentration – NO_2



LEGEND:

Ambient Air Quality Standards

Time Weighted Average - Annual: 40 ug/m3
Maximum Predicted Concentration: 3 ug/m3

Plant boundary limit
Ambient Air Quality Limit
Receptor Locations
Maximum Concentration

No.	Location	CODE
1	Ras Hayyan	MS_RH
2	Hidd	MS_HD
3	Maameer	MS_MA
4	Napeeh Saleh	MS_NS
5	Hamad Town	MS_HT
6	Sanabis	SB
7	Villas Askar	VA
8	Villas 2	V2
9	ResidentialArea & Golf Course	R_G

No.	Location	CODE
10	Labour Accommodation	LA
11	East-Riffa	ER
12	Ma'ameer	MA
13	Nuwaidrat	NU
14	Al Eker	AE
15	Sanad	SD
16	Sitra	SI

Prepared For:	Figure Title: Annual Average Concentration - NO_2 Option - A Inclusion of 3- PS5 and discontinuing PS1 and PS2	Date: September, 2014
Prepared By:	Project: ALBA Potline (6) and Power Plant (PS5) Expansion	Project No: 10921.00

Figure A 6 - Option A- Annual Average Concentration – NO_2

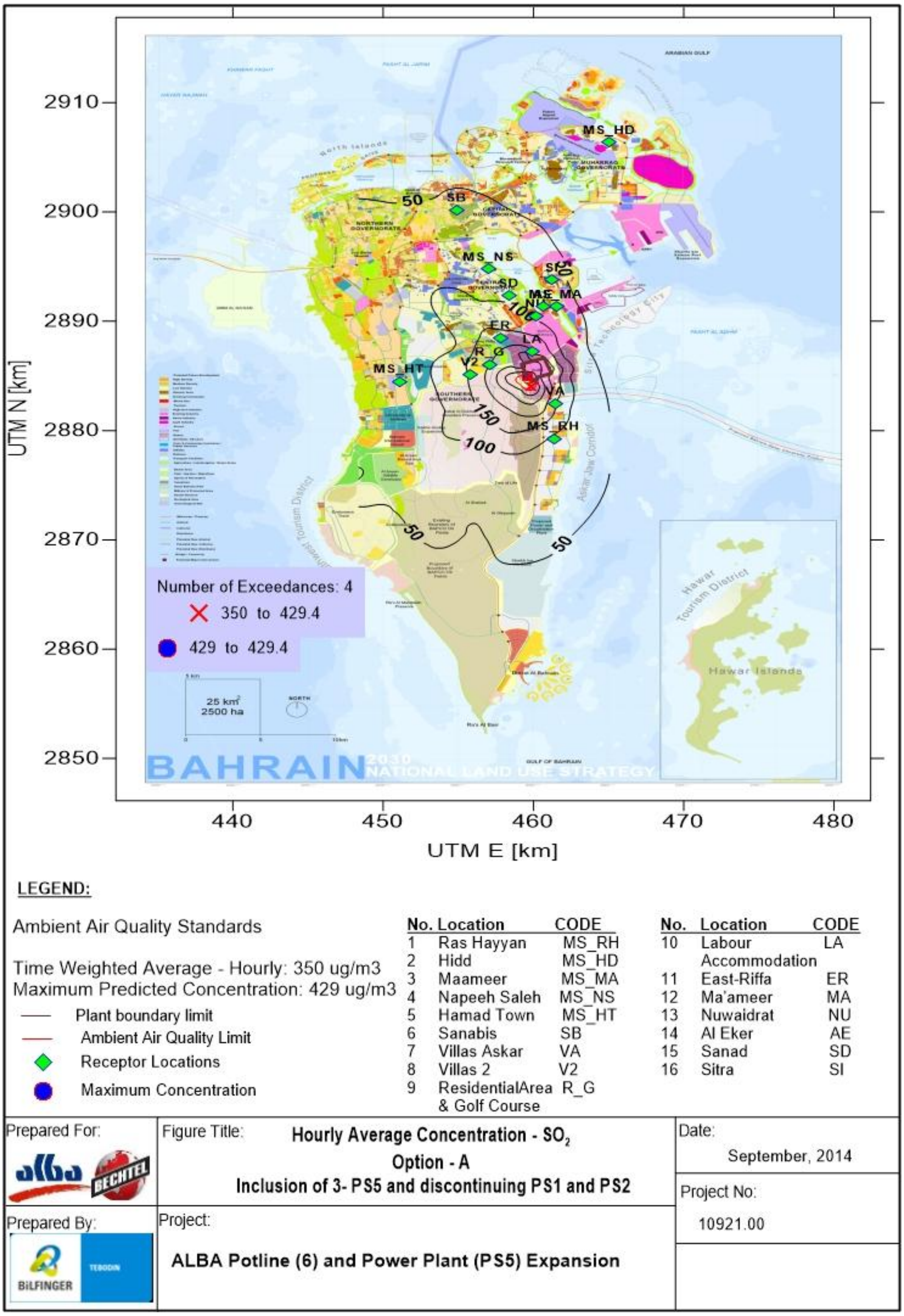


Figure A 7 - Option A- 2030 National Land Use Strategy – Max. 1- Hour Concentration – SO_2

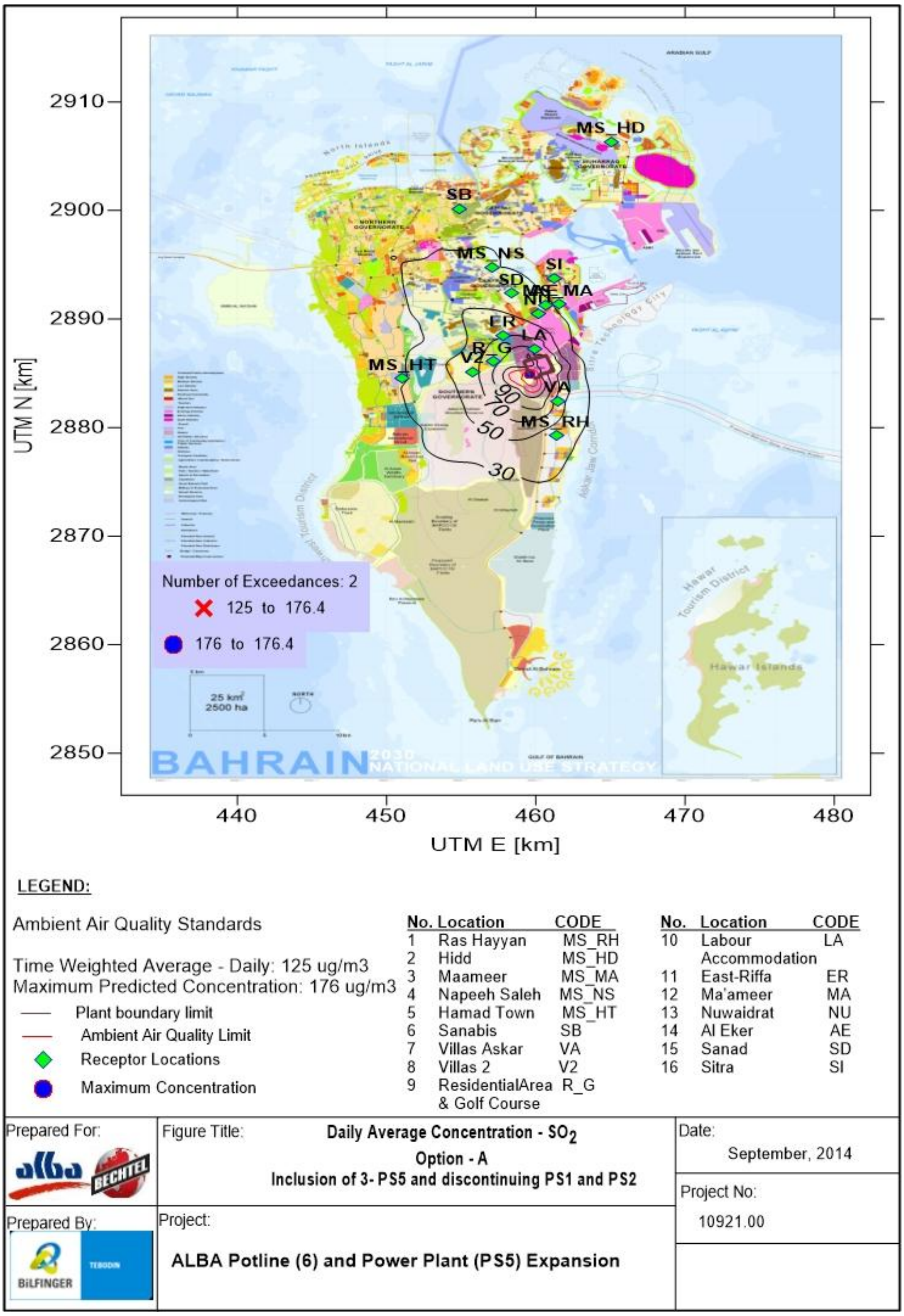


Figure A 8 - Option A- 2030 National Land Use Strategy – Max. 24- Hour Concentration – SO_2

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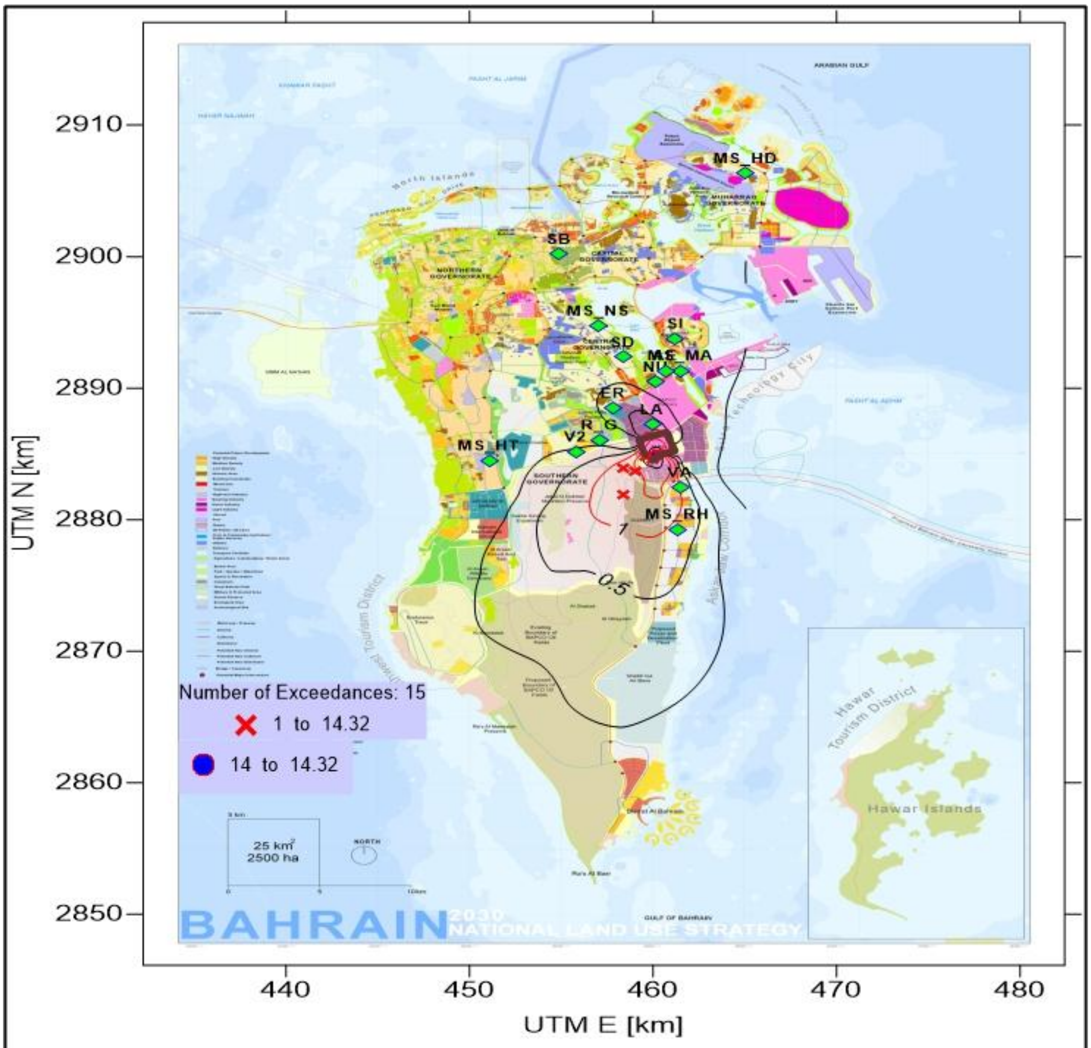

LEGEND:

Ambient Air Quality Standards

Time Weighted Average - Annual: 1ug/m3
Maximum Predicted Concentration: 16 ug/m3

- Plant boundary limit
- Ambient Air Quality Limit
- Receptor Locations
- Maximum Concentration

No.	Location	CODE
1	Ras Hayyan	MS_RH
2	Hidd	MS_HD
3	Maameer	MS_MA
4	Napeeh Saleh	MS_NS
5	Hamad Town	MS_HT
6	Sanabis	SB
7	Villas Askar	VA
8	Villas 2	V2
9	ResidentialArea & Golf Course	R_G

No.	Location	CODE
10	Labour Accommodation	LA
11	East-Riffa	ER
12	Ma'ameer	MA
13	Nuwaidrat	NU
14	Al Eker	AE
15	Sanad	SD
16	Sitra	SI

Prepared For: alba BECHTEL	Figure Title: Annual Average Concentration - Gaseous Fluoride (HF) Option - A Inclusion of 3- PS5 and discontinuing PS1 and PS2	Date: September, 2014
Prepared By: BiLFINGER TEBODIN	Project: ALBA Potline (6) and Power Plant (PS5) Expansion	Project No: 10921.00

Figure A 9 - Option A- 2030 National Land Use Strategy – Annual Average Concentration – HF

Appendix 3 Noise Modelling Methodology

1 Noise Modeling Methodology

1.1 Overview

The noise modelling for evaluation of noise contributions was conducted using SoundPLAN version 7.3 developed by Braunstein & Berndt GmbH, Germany. The model is based on sound pressure wave divergence. SoundPLAN is a Microsoft Windows based software tool, which can accept multiple stationary noise sources.

1.2 Software Simulation

The SoundPlan Software implements the acoustics geometric algorithms that can predict the radiation of sound energy and its propagation in an open or confined space.

The geometric acoustics neglects the wave nature of the acoustic phenomenon, which is treated as an optical phenomenon in which sources emit energy in the model (acoustic rays) in the surrounding space. Sound waves in their propagation, gradually lose energy due to different effects: geometric divergence, uptake of ground, dissipation in the propagation medium, diffraction around obstacles and barriers, etc. These phenomena are evaluated with the equations and the algorithms of International standard ISO 9613, parts I and II.

1.4 Equations

The standard used for the noise assessment is ISO 9613-II:1996, an engineering method for calculating the attenuation of sound during the propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources.

The method predicts the equivalent continuous A-weighted Sound Pressure Level SPL_A under meteorological condition favorable to propagation from sources of known sound emission.

The equivalent continuous octave band Sound Pressure Level at a receiver location SPL_f is calculated for each point source and for the nine octave bands with nominal midband frequencies from 31.5 Hz to 8 kHz from equation:

$$SPL_f = PWL_f + D_C - \left(A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}\right)$$

Where:

PWL_f octave band Sound Power Level in decibel, produced by each equipment;

D_C directivity correction of source in decibel;

A_{div} attenuation due to geometric divergent;

A_{atm} attenuation due to absorption of air (ISO 9613-I:1993);

A_{gr} attenuation due to ground;

A_{bar} attenuation due to barrier;

A_{misc} attenuation due to miscellaneous other effects;

The equivalent continuous A-weighted Sound Pressure Level shall be obtained according to following equation:

$$SPL_A = 10\log\left\{\sum_{i=1}^{n}\left[\sum_{j=1}^{8}10^{0.1\left(SPL_f + A_f\right)_j}\right]\right\}$$

Where:

n is the number of noise source;

j is an index indicating the eight standard octave band midband frequencies from 63 Hz to 8 kHz;

Af denotes the standard A-weighting (see IEC 661).

1.5 Plant Modelling

The noise model for the proposed expansion at Alba was developed as follows:

- Identification of all equipment noise source from PS-5 and PL-6;
- Schematic arrangement of the geometry of the domain area, according to references drawings;
- Assignment of thermo-physical characteristics of the propagation medium: air at temperature of 28°C (average annual onsite) and relative humidity of 75% (maximum value on site);
- Definition of global Sound Power Level in dB(A) for each equipment, according to its dimension and middle Sound Pressure Level in dB(A) on reference surface S, usually at 1.0 m from envelope surface of equipment:

$$PWL_A = SPL_A + 10\log S$$

1.6 Noise Model Set up

The model configuration used in the study is presented in Table 1.

Table 1: Model Setup

Aspect	Model Configuration
Model used	SoundPlan Version 7.3
Terrain Heights	Flat terrain
Source Type	Point sources (19 Nos)
	Line sources (15 Nos)
	Area Sources (5 Nos)
	Industrial Buildings (15 Nos)
Area Usage Type	Industrial
Absorption Area Factor	0.6
Coordinate System	Cartesian
Grid	Uniform grid size of 5 m
Receptor Height	2 m (from ground)

1.7 Noise Emission Inventory

1.7.1 Sources at GTC and FTC

The various noise generating sources identified and utilised for modelling are as presented in Table 2 and Table 3.

Table 2: Noise Data Inventory - Major Noise Emissions Inventory for Normal Steady State Operation of Aluminium Smelter (main equipment only)

#	Generation Source	No. of Sources	Source Location		Nature of Noise Generation	Noise Level Sound Pressure Level
			Easting	Northing	(Continuous / Intermittent)	
1.0	**North GTC - Main ID Fans**	**Total 6**				
1.1	North GTC- Fan No 1	1	459867	2885557	Continuous	Fan casing - 77 dB(A) @ 1m Motor - 81 dB(A) @ 1m
1.2	North GTC- Fan No 2	1	459869	2885546	Continuous	
1.3	North GTC, Fan No 3	1	459872	2885532	Continuous	
1.4	North GTC- Fan No 4	1	459874	2885521	Continuous	
1.5	North GTC, Fan No 5	1	459876	2885510	Continuous	
1.6	North GTC, Fan No 6	1	459878	2885500	Intermittent	
2.0	**North GTC - Stack**	**1**	459903	2885468	Continuous	Sound Power Level at discharge: 103 dB(A)
3.0	**South GTC - Main ID Fans**	**Total of 6**				
3.1	South GTC, Fan No 1	1	460001	2884917	Continuous	Fan casing - 77 dB(A) @ 1m Motor - 81 dB(A) @ 1m
3.2	South GTC, Fan No 2	1	460004	2884905	Continuous	
3.3	South GTC, Fan No 3	1	460006	2884893	Continuous	
3.4	South GTC, Fan No 4	1	460008	2884881	Continuous	
3.5	South GTC, Fan No 5	1	460011	2884869	Continuous	
3.6	South GTC, Fan No 6	1	460013	2884858	Intermittent	
4.0	**South GTC - Stack**	**1**	460037	2884823	Continuous	Sound Power Level at discharge: 103 dB(A)
5.0	**L6 FTC - Main ID Fans**	**Total of 4**				
5.1	Fan No 1	1	459554	2885587	Continuous	Fan casing - 77 dB(A) @ 1m Motor - 81 dB(A) @ 1m
5.2	Fan No 2	1	459548	2885586	Continuous	
5.3	Fan No 3	1	459542	2885585	Continuous	
5.4	Fan No 4	1	459537	2885584	Continuous	
6.0	**FTC - Stack**	**1**	459524	2885579	Continuous	Sound Power Level at discharge: 103 dB (A)
7.0	**Rectifiers**	**Total of 6**				
7.1	Rectifier No 1	1	459685	2885857	Continuous	83 dB(A) @ 1m
7.2	Rectifier No 2	1	459688	2885832	Continuous	83 dB(A) @ 1m
7.3	Rectifier No 3	1	459693	2885807	Continuous	83 dB(A) @ 1m
7.4	Rectifier No 4	1	459697	2885782	Continuous	83 dB(A) @ 1m
7.5	Rectifier No 5	1	459702	2885758	Intermittent	83 dB(A) @ 1m
7.6	Rectifier No 6	1	459707	2885733	Intermittent	83 dB(A) @ 1m

Table 3: Noise Data Inventory - Major Noise Emission Sources for Normal Steady State Operation of Power Block PS-5

Source	Operation Frequency	No. of Sources	LwA per 1/3 octave band (center frequency)										Building Height
		Total	31.5	63	125	250	500	1000	2000	4000	8000	LwA	
CT package													
Inlet	24 Hours/day	Total of 3	120	113	110	100	88	86	76	87	91	98	18.0
Inlet Plenum	24 Hours/day	Total of 3	120	114	111	102	87	89	97	90	86	102	3.5
Turbine compartment vent fan (inside building)	24 Hours/day	Total of 3	108	110	105	103	100	98	104	99	94	108	6.0
Exhaust Diffuser (inside buillding)	24 Hours/day	Total of 3	133	125	114	112	110	104	103	102	97	112	5.0
Load compartment (inside buillding)	24 Hours/day	Total of 3	105	105	105	100	97	94	97	93	92	102	5.0
Accessory compartment (inside buillding)	24 Hours/day	Total of 3	105	106	103	101	98	95	98	95	91	103	3.5
Generator (inside buillding)	24 Hours/day	Total of 3	112	116	112	98	100	102	101	96	93	107	5.0
Turbine compartment vent fan	24 Hours/day	Total of 3	104	102	107	102	98	98	94	95	92	103	8.5
Exhaust compartment vent fans	24 Hours/day	Total of 3	102	101	107	99	96	95	92	92	91	101	8.5
Bypass stack (~35m) rarely in operation	24 Hours/day	Total of 3	129	127	123	121	118	117	112	102	100	121	35.0
CT/ST Fin Fans (shared Location)	24 Hours/day	Total of 54 (18 Per CTG/STG)	104	108	108	105	102	100	97	95	90	105	4.0
STG package (inside metal siding buillding)	24 Hours/day	Total of 3	118	125	121	114	112	110	110	108	104	117	15.0
HRSG Package													
HRSG inlet	24 Hours/day	Total of 3	123	122	115	112	108	101	98	92	88	109	15.0
HRSG body	24 Hours/day	Total of 3	122	118	111	106	100	93	88	86	80	103	27.0
HRSG stack exit (~50m)	24 Hours/day	Total of 3	120	122	122	120	113	100	80	74	73	115	43.0
HRSG stack breakout	24 Hours/day	Total of 3	97	99	101	100	90	89	64	54	60	95	0-50
BFW pumps (One operates at a time)	24 Hours/day	Total of 6 (2 per HRSG)	103	108	115	110	105	105	107	104	95	112	2.0
ACC tower fan noise (per fan) 15 cells per tower	24 Hours/day	Total of 45	107	110	109	106	100	100	95	92	85	105	20.0
CCW pumps (inside STG building, one operates at a time)	24 Hours/day	Total of 6 (2 per STG)	90	90	89	90	88	90	91	82	76	95	2.0
STG transformer	24 Hours/day	Total of 3	110	112	110	108	104	102	100	98	94	108	5.5
CTG transformer	24 Hours/day	Total of 3	110	112	110	108	104	102	100	98	94	108	5.5
Fuel Gas Compressors	24 Hours/day	Total of 3	112	114	114	113	112	110	107	106	105	115	3.5