Environmental and Social Impact Assessment

Jordan India Fertilizer Company (JIFCO)

Volume (I)

MAIN REPORT

Submitted to:

Jordan Phosphate Mines Company (JPMC)

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Study Team

The Environmental Research Centre (ERC) has been providing specialized technical studies and services since 1989 in a number of environmental areas. ERC has a specialized staff in Environmental and Social Impact Assessment (ESIA), it has conducted comprehensive ESIA studies for various major development projects.

The environmental and social impact assessment study of the project was led by the Environmental Research Centre of the Royal Scientific Society (RSS). The biodiversity study, the archeological survey and the marine environment study were conducted by external consultants hired by RSS. The following is a list of contributors to this study. The resumes of all contributors to this study are part of the study report, Annex (1).

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Preface

This report provides the findings of the environmental and social impact assessment (ESIA) study for the proposed Jordan India Fertilizer Co. (JIFCO) project that will be established in Eshidiya/Ma'an Governorate to produce 475,500 tons of phosphoric acid annually. The ESIA was focused on the main issues related to the following valued environmental components (VECs) that were identified in the scoping stage:

- Water Resources
- Biodiversity
- Public Health
- Archeology
- Socio-Economic Conditions
- Occupational Health and Safety
- Marine Environment

This document consists of two volumes as follows:

Volume (I): Main Report

Volume I includes a detailed project description (Chapter 1), in which all project activities and facilities are outlined. Policy, legal framework and consultation are summarized in Chapter 2. The results of the consultations stage are summarized in Chapter 3. The key issues and interactions with the valued environmental components are discussed. The assessment is then presented for each valued environmental component (VEC). The analysis of the impacts and the necessary recommendations to mitigate any significant impacts are provided for each VEC as presented in Chapters 4 to 10. A cumulative impact of all issues caused by all sources in the area of the plants site is discussed in a separate chapter (Chapter 11). Finally an action plan is established which is presented in Chapter 12.

Volume (II): Environmental Management and Monitoring Plans

This volume contains an outline of the proposed mitigation measures and a monitoring program that the company should implement throughout the project phases.

Abbreviations

ACOR	=	American Center of Oriental Research
AFFF	=	Aqueous Film-Forming Foam
AWC	=	Aqaba Water Company
BAT	=	Best Available Technology
BCRL	=	British Council for Research in Levant
C_{max}	=	Maximum Ground Level Concentration
^{o}C	=	Temperature in Celsius
CaO	=	Lime
CEO	=	Chief Executive Officer
CN	=	Curve Number
CO	=	Carbon Monoxide
D	=	Diffusivity
DCDA	=	Double Contact Double Absorption
DH	=	Dihydrate process
DH/HH	=	Di-Hemihydrate process
DO	=	Dissolved oxygen
CRM	=	Cultural Resources Management
dB(A)	=	Decibel (measured with A-weighting)
DM	=	Demineralization
E	=	East
EFMA	=	European Fertilize Manufacturers' Association
EHS	=	Environmental, Health and Safety
EIA	=	Environmental Impact Assessment
ESIA	=	Environmental and Social Impact Assessment
ERC	=	Environmental Research Center
Fig.	=	Figure
HAZOP	=	Hazard and Operability Analysis
HAJ	=	Hydro – Agri Jordan Fertilizer Project
HDH	=	Hemi-Dihydrate process
HF	=	Hydrogen Fluoride
HH	=	Hemihydrate Process
H_2SO_4	=	Sulphuric Acid
$H_2S_2O_7$	=	Olium
H.S.	=	Hydrogen Sulphide
IFC	=	International Finance Corporation
IFFCO	=	Indian Farmers Fertilizer Cooperative
IJCC	=	Indo Jordan Chemicals Company
ILO	=	International Labor Organization
IPCC	=	Intergovernmental Panel on Climate Change

IR	=	Irreversible
JADIS	=	Jordan Antiquities Database and Information System
JIFCO	=	Jordan India Fertilizer Company
JPMC	=	Jordan Phosphate Mines Company
JS	=	Jordanian Standard
KEMAPCO	=	Kimera Arab Potash Company
Kg	=	Kilogram
Km	=	Kilometer
Km^2	=	Square Kilometer
L_{Aeq}	=	Equivalent Sound Pressure Level (measured with A-weighting)
$L_{Ãeq}$	=	Average Equivalent Sound Pressure Level (measured with A-weighting)
m	=	Meter
m^3	=	Cubic Meter
MCM	=	Million Cubic Meter
mg/Nm^3	=	Milligram Per Normal Cubic Meter
$\mu g/m^3$	=	Microgram Per Cubic Meter
$\mu g/Nm^3$	=	Microgram Per Normal Cubic Meter
mm	=	Millimeter
µm	=	Micro meter
MJ	=	Mega Joule
MoEnv	=	Ministry of Environment
MSDS	=	Materials Safety Data Sheets
MT	=	Metric Ton
MTPD	=	Metric Ton Per Day
MT/hr	=	Metric Ton Per Hour
m/sec	=	Meter Per Second
m^3/hr	=	Cubic Meter Per Hour
MW	=	Mega Watt
N	=	North
NE	=	Northeast
NFPA	=	National Fire Protection Association
NMVOCs	=	Non Methane Volatile Organic Compounds
NPK	=	Nitrogen, Phosphor, Potassium
NS	=	No Standard Available
NGOs	=	Non-governmental Organizations
No.	=	Number
NO	=	Nitrogen Monoxide
NO_2	=	Nitrogen Dioxide
NO_X	=	Nitrogen Oxides
NW	=	Northwest

O_2	=	Oxygen
OHS	=	Occupational Health and Safety
OP	=	Operational Policies
PA	=	Phosphoric Acid
PM10	=	Inhalable Particulate Matter with Diameter Equals to or less than 10 Microns
PM2.5	=	Inhalable Particulate Matter with Diameter Equals to or less than 2.5 Microns
PPE	=	Personal Protective Equipment
ppm	=	Part Per Million
P_2O_5	=	Phosphate
R	=	Reversible
^{226}Ra	=	Radium
RDC	=	Recently Died Corals
^{222}Rn	=	Radon
RSS	=	Royal Scientific Society
S	=	Sulphur
SCBA	=	Self-Contained Breathing Equipment
SCSA	=	Single Conversion Single Absorption
SE	=	Southeast
SiF_4	=	Silicon Tetrafluoride
SO_2	=	Sulphur Dioxide
SO_3	=	Sulphur Trioxide
SW	=	Southwest
t	=	Ton
UTM	=	Universal Transverse Mercator
V_2O_5	=	Vanadium pentoxide
VECs	=	Valued Environmental Components
VTC	=	Vocational Training Corporation
TORs	=	Terms of References
W	=	West
WAJ	=	Water Authority of Jordan
WHO	=	World Health Organization
yr	=	Year

ملخص

تنوي الشركة الأردنية الهندية للأسمدة إقامة مجمع صناعي في منطقة الشيدية في محافظة معان لإنتاج حامض الفوسفوريك (H_3PO_4) وذلك عن طريق إنتاج حامض الكبريتيك (H_2SO_4) واستخدام خامات الفوسفات الموجودة في تلك المنطقة. وهذه الشركة هي عبارة عن ائتلاف بين شركة مناجم الفوسفات الأردنية بنسبة 48% وجمعية المزارعين الهندية التعاونية للأسمدة بنسبة 52%. مدة تنفيذ المشروع تبلغ 36 شهرا.

ومن أجل تحديد وتحليل الآثار البيئة والاجتماعية المتوقعة من نشاطات المشروع، فقد تم إجراء دراسة تقييم أثر بيئي واجتماعي شامل من قبل فريق الجمعية العلمية الملكية. حيث تم عقد جلسة تشاورية في مدينة العقبة بتاريخ (2008/2/12)، وتم دعوة ممثلي الجهات الحكومية وغير الحكومية من محافظات معان والعقبة وعمان وممثلي المجتمع المحلي لتدوين ودراسة الاهتمامات والقضايا المتعلقة بنشاطات المشروع والمرتبطة بعناصر البيئة التالية (Valued Environmental Components):

- مصادر المياه
- التنوع الحيوي
- الصحة العامة
- المواقع الأثرية
- الظروف الاقتصادية والاجتماعية
- الصحة والسلامة المهنية
- البيئة البحرية

لقد تم تنفيذ عدة دراسات من اجل عمل قاعدة بيانات وتقييم الاثر الناتج من النشاطات، حيث شملت الدراسات ما يلي:

- نوعية الهواء
- الضجيج
- مصادر المياه
- التنوع الحيوي
- الارث الحضاري والآثار
- الظروف الاقتصادية والاجتماعية

نتائج الدراسة

1- مصادر المياه

جيولوجية منطقة المشروع

يقع المشروع على ارض منبسطة حيث تغطي طبقة رسوبيات الأودية معظم مساحة منطقة المشروع في الشيدية وعلى سماكات قليلة، وتتواجد تلك الطبقة فوق تكوين الموقر، عمان-وادي السير، عجلون السفلي، ومجموعتي الكرنب والخريم. أما جيولوجية موقع خزانات حامض الفوسفوريك في منطقة العقبة فتتكون من رسوبيات الأودية المشتقة من جبال الجرانيت المتواجدة في جهة الشمال والشرق. وبالاعتماد على خارطة التقسيم الزلزالي في الأردن، فان منطقة المشروع في الشيدية تصنف زلزاليا كمنطقة 1A حيث أن احتمالية

خطر وقوع زلزال في تلك المنطقة هي قليلة. ولكن موقع الخزانات في منطقة العقبة فإنها تصنف منطقة نشطة زلزاليا.

مصادر المياه السطحية

يقع المشروع في حوض الجفر، حيث تقدر مساحة الحوض المائي لمنطقة المشروع حوالي 5.5 كم^2 و يميل حوالي 1.2% باتجاه الشمال الشرقي. يصل معدل سقوط الإمطار الهاطلة على حوض موقع المشروع حوالي 14.3 ملم/السنة أي ما يعادل 0.08 مليون متر مكعب/السنة. ويبلغ معدل الجريان السطحي (Runoff) حوالي 0.002 مليون متر مكعب/ السنة (حيث تم اعتماد طريقة (United States Soil Conservation Curve Number). يتبع موقع الخزانات في العقبة إلى حوض وادي اليتم حيث يصل معدل سقوط الإمطار الهاطلة 50-150 ملم/السنة. يتميز هذا الحوض بشدة هطول الأمطار (أقل من ثلاث ساعات) مما ينتج تدفق كثيف في الأودية حاملة كميات هائلة من الرسوبيات مما قد يؤدي إلى أضرار شديدة على المنشات المقابلة للجبال الشرقية. لذلك يجب على الشركة اتخاذ الاحتياطات اللازمة من خلال بناء جدران استنادية للمنشآت المجاورة لمجرى الوادي القريب من الموقع .

المياه الجوفية

تقع منطقة المشروع في الشيدية ضمن حوض الجفر الجوفي، ويعتبر تكوين عمان- وادي السير (B2/A7) من أهم خزانات المياه الجوفية السطحية حيث تتراوح سماكة الخزان ما بين 20 – 25 متر. أما تكويني كرنب والديسي فيعتبر كل واحد منهما خزان جوفي عميق وتفصل طبقة كتيمة ما بين الخزانين . أما منطقة الخزانات في العقبة فتتبع لحوض وادي العربة الجنوبي الجوفي حيث تتدفق المياه الجوفية من جهة الشمال الى البحر الميت جنوبا. إن استهلاك المشروع من مياه الجفر يبلغ 6 مليون متر مكعب في السنة، وبالتالي فإن المجموع الكلي لاستهلاك المصانع في منطقة الشيدية سيبلغ 12.5 مليون متر مكعب في السنة عند نهاية 2011 (بداية تشغيل المشروع). وبناء على الدراسات فإن المياه الجوفية في حوض عمان – وادي السير سوف تستنفد عند نهاية 2037 (حسب دراسات المياه الجوفية في المنطقة)، لأن معدل السحب يعتبر سحبا جائرا. لذا فأن الشركة ستقوم بحفر حوالي 4 آبار من حوض الكرنب / الديسي (خزان مياه جوفية غير متجددة) وبطاقة إنتاجية تبلغ 200 م^3/الساعة، إضافة إلى البئر المتواجد حاليا وذلك لتخفيف الضغط عن حوض عمان – وادي السير . ولقد اجريت شركة استشارية (Scott Wilson Kirkpatrick &Co. Ltd) عام 2000/1999 دراسة هيدرولوجية لمنطقة الشيدية حيث حددت الضخ الامن من المياه الجوفية العميقة مابين 6 – 10 مليون متر مكعب في السنة. بالإضافة إلى ذلك، فإن على الشركة أن تقوم مستقبلا بدراسة جدوى إمكانية استخدام المياه العادمة المنزلية المعالجة الخارجة من محطة تنقية معان ومحطة تنقية مدينة معان الصناعية لاستخدامها في الصناعة وذلك للتخفيف من استخدامات المياه الجوفية.

شملت الدراسة تحليل الأثر المحتمل لتلوث المياه الجوفية بسبب نشاطات مراحل المشروع في منطقة الشيدية، حيث تم حساب الزمن المتوقع لوصول أي انسكابات إلى المياه الجوفية (تكوين الكرنب) المتواجدة على عمق 334 متر بحوالي 99 سنة، مما يعني أن الأثر المتوقع لتلوث المياه الجوفية يعتبر قليلاً. ولكن الأثر المتوقع لتلوث التربة يعتبر عاليا إذا لم يتم اتخاذ الإجراء اللازم لتفادي الانسكاب. ولذلك، يجب على الشركة تبطين أرضية حفرة التجميع (guard pond) بمادة مناسبة مثل بولي اثيلين ذات الكثافة العالية والتدقيق الدوري

عليها. وان تجمع الزيوت المستهلكة في حاويات خاصة وترسل إلى شركة مصفاة البترول الأردنية بطريقة أمنة او تباع الى متعهد مرخص. وان تعمل منطقة احتواء معزولة حول خزان الوقود كافية لاحتواء كامل كمية الوقود المخزنة. أما بالنسبة للمياه العادمة المنزلية الناجمة من مرحلة الإنشاء في منطقة الشيدية فيجب أن تجمع في حفرة مصمتة وأن تفرّغ بشكل دوري لأقرب محطة تنقية للمياه العادمة المنزلية بعد أخذ الموافقات من قبل سلطة المياه باستخدام صهاريج مرخصة أو أن يتم معالجتها في الموقع. أما أرضية منطقة الجبس، فيجب ان تدمك بطريقة هندسية سليمة حيث تضمن أن لا يتجاوز معامل النفاذية حوالي $1x10^{-6}$ m/s. وان تحاط المنطقة بجدران (Dikes) من الجوانب لاحتواء أي تسرب محتمل من منطقة الجبس. يجب تجميع مادة خامس أكسيد الفناديوم (V_2O_5) المستهلكة في حاويات معدنية مغلقة وفي أماكن خاصة وان ترسل إلى المورد الرئيسي.

تم حساب الزمن المتوقع لوصول أي انسكابات إلى المياه الجوفية في موقع الخزانات في منطقة العقبة حيث بلغ حوالي 3 ساعات، مما يعني أن الأثر المتوقع لتلوث المياه يعتبر عالياً جدا. وهذا يوجب على الشركة أن تأخذ بعين الاعتبار المواصفات الأردنية والعالمية في تصميم الخزانات وكذلك يجب عمل منطقة احتواء لمنطقة الخزانات بحيث تستوعب حجم أكبر خزان إضافة إلى 10% من حجمه.

2- *التنــوع الحيوي*

هدفت دراسة التنوع الحيوي إلى تقييم الآثار البيئية المتوقعة على التنوع الحيوي في المنطقتين المقترحتين لإنشاء المشروع في الشيدية والعقبة والمناطق المحيطة وذلك خلال مراحل إنشاء وتشغيل وتفكيك المشروع .

تنتمي منطقة الشيدية إلى النظام البيئي الصحراوي وتمثل النطاق الحيوي الصحراوي العربي. تم تسجيل ستة أنواع من النباتات في المنطقة المقترحة التي تتميز بغطاء نباتي فقير جدا، ومن بين هذه النباتات المتواجدة نبات واحد ذو أهمية وهو نبات الطلح. تتأثر المنطقة المقترحة بدرجات عالية من المؤثرات السلبية على الحياة البرية الحيوانية مما أدى إلى انخفاض تواجد الأنواع الحيوانية في المنطقة إلى درجة عالية. و خلال المسوحات تم تسجيل نوعين من الزواحف، وخمسة أنواع من الطيور الشائعة، وثلاثة أنواع من الثدييات.

تنتمي منطقة العقبة إلى النظام البيئي شبه الاستوائي وتمثل النطاق الحيوي الأثيوبي، حيث تتواجد ضمن وادي من الحصى الجرانيتي والرمل الفقير جدا بالغطاء النباتي. تم تسجيل أربعة أنواع من النباتات. تتأثر المنطقة المقترحة بدرجات عالية من المؤثرات السلبية على الحياة البرية الحيوانية مما أدى إلى انخفاض تواجد الأنواع الحيوانية في المنطقة إلى درجة عالية، و خلال المسوحات تم تسجيل نوع واحد من الزواحف، وخمسة أنواع من الطيور الشائعة، وثلاثة أنواع من الثدييات.

تم اقتراح بعض من الإجراءات الاحترازية لتخفيف الآثار السلبية المتوقعة والمؤثرة مثل: تجنب مسارات الأودية والمياه ذات الغطاء النباتي ما أمكن، زراعة حزام من الأشجار الأصيلة مثل الطرفة حول الموقع وتحديد مدخل للآليات ومنع العمال من الصيد.

3- الصحة العامة

دراسة نوعية الهواء

تم إجراء برنامج لمراقبة نوعية الهواء لمدة شهر في موقع الحد الشمالي الغربي لمشروع الشركة الأردنية الهندية للأسمدة المنوي إنشائه في الشيدية وذلك لتقييم الوضع الحالي لنوعية الهواء في المنطقة المحيطة بالمشروع قبل إقامته. وأيضاً يهدف البرنامج إلى توفير قاعدة بيانات لنوعية الهواء في تلك المنطقة لمقارنة وتحليل التغيرات في نوعية الهواء التي يمكن أن تحدث جراء النشاطات المختلفة للمشروع.

اشتمل البرنامج على قياس مستمر لأهم الملوثات الغازية (ثاني أكسيد الكبريت، أكاسيد النيتروجين، أول أكسيد الكربون) بالإضافة إلى قياس انبعاث الغبار المستنشق (PM10) وسرعة واتجاه الرياح. وتم تحليل قياسات الانبعاثات الغازية والغبار ومقارنتها بالحدود القصوى المسموح بها في المواصفة الأردنية لنوعية الهواء المحيط (JS: 1140/ 2006) وتعليمات مؤسسة التمويل الدولية (IFC). بينت نتائج المراقبة بأن المعدلات الساعيّة واليوميّة لكل من ثاني أكسيد الكبريت (SO_2) وثاني أكسيد النيتروجين (NO_2) بالإضافة إلى المعدلات الساعيّة ومعدلات 8-ساعات لغاز أول أكسيد الكربون لم تتجاوز الحدود المسموح بها في المواصفة الأردنية خلال فترة المراقبة. كما تم أخذ قياسات لحظية لغاز فلوريد الهيدروجين (HF) بواقع خمس قياسات وقد كانت جميعها منخفضة.

بينما أظهرت نتائج الدراسة وجود ثمانية تجاوزات للمعدلات اليوميّة لتركيز الغبار المستنشق (PM10) للمواصفة الوطنية خلال 25.8% من فترة الرصد وأربعة تجاوزات للحدود المذكورة في تعليمات مؤسسة التمويل الدولية (IFC) خلال 12.9% من فترة الرصد. كما بينت نتائج مراقبة سرعة واتجاه الرياح خلال فترة المراقبة أن الرياح الشمالية الغربية، والشمالية والغربية هي الرياح السائدة في منطقة المشروع.

الآثار البيئة المتوقعة على نوعية الهواء والإجراءات الوقائية

من المتوقع خلال مرحلة الإنشاء صدور الغبار جراء نشاطات المشروع المختلفة مثل عمليات الحفر وسير الشاحنات ووجود أكوام مواد الإنشاء في منطقة المشروع، وكذلك من عمليات نقل الكبريت وطحن صخور خام الفوسفات ونشاطات المصنع المختلفة خلال مرحلة التشغيل. أما الانبعاثات الغازية فيتوقع صدورها من عوادم الشاحنات مما يسبب تلوث قصير الأمد في نوعية الهواء خلال مرحلة الإنشاء ومن نقل المواد الخام والمنتجة خلال مرحلة التشغيل إضافة إلى الانبعاثات الصادرة من مصنعي حامض الكبريتيك (SO_2, H_2SO_4 and SO_3) وحامض الفوسفوريك (HF and SiF_4) ومن المرجل SOx, CO, NOx and PM10) (الذي سيتم تشغيله لفترة محدودة عند بداية التشغيل). وتجدر الإشارة إلى أن هنالك خطورة من اشتعال غبار الكبريت الدقيق في حال انبعثت بكميات تجعل تركيزه في الهواء يصل إلى اكثر من (Lower Explosive Limit) وأقل من (Upper Explosive Limit) بوجود مصدر للاشتعال.

إن نتائج النمذجة الرياضية لانتشار الملوثات (SO_2, SO_3, PM10, HF, CO and NOx) من المصنع المنوي إقامته ومنه إضافة إلى المصانع القائمة (SO_2 and HF) تبين أنه لا يتوقع أن يكن هنالك تأثير على سكان أقرب منطقة للمشروع وكذلك الوضع بالنسبة

للمجمع السكني للموظفين حيث انه يبعد حوالي 3.2 كم عن المشروع بعكس اتجاه الرياح السائدة (Upwind).

إن الأغبرة المتصاعدة من عمليات الإنشاء يجب أن يتم تخفيف صدورها بأكبر قدر ممكن باستعمال الإجراءات التالية:

- رش المياه على المناطق المعرضة لتصاعد الأغبرة من أجل التقليل منها.
- تغطية الشاحنات المحملة بمواد الإنشاء (الأتربة والطمم).
- تغطية أكوام الرمل والاسمنت ومحاولة إزالتها أي عدم تخزينها بكميات كبيرة.
- وضع ضوابط لتحديد سرعة سير الشاحنات على الطرق غير المعبدة.

يجب تركيب أجهزة إزالة الغبار المناسبة وذات الكفاءة العالية لجميع الوحدات التي يصدر غبار، ويجب التأكيد على ضرورة التزام المصنع باستمرارية المحافظة على كفاءة أداء أجهزة إزالة الغبار قبل خروجه إلى الهواء المحيط، والمراقبة المستمرة لتركيز الغازات المنبعثة من المصادر المختلفة والتأكد من مطابقة تركيزها لقيم التصميم والحدود المسموح بها.

لتقليل انبعاث الغبار من أماكن تخزين الكبريت والفوسفات يجب أن تكون الجوانب الثلاث بارتفاع مناسب ومبنية بعكس اتجاه الرياح وكذلك يجب التأكد من تغطية الشاحنات التي تنقل الكبريت بشكل يمنع تساقط الكبريت أثناء النقل ومن ثم طحنه بعجلات المركبات والذي يساعد في تكون الغبار، ويجب ان تقوم الشركة باستيراد الكبريت المحبب وليس الناعم.

<u>دراسة الضجيج</u>

تم تنفيذ برنامج مراقبة قياس الضجيج لفترة 6 أيام مستمرة في أقرب تجمع مأهول (نادي العاملين في الإسكان التابع لشركة مناجم الفوسفات الأردنية المساهمة العامة المحدودة في الشيدية) الذي يبعد حوالي 3.2 كم عن حدود الموقع. تم تحليل نتائج القياس ومقارنتها مع التعليمات الأردنية للحد من الضجيج (لعام 2003) ومع تعليمات مؤسسة التمويل الدولية وبيّنت النتائج بأن جميع القراءات كانت ضمن مستويات الضجيج المسموحة في التعليمات الأردنية وتعليمات مؤسسة التمويل الدولية علما بأنه تم أخذ التعليمات الأكثر صرامة.

الآثار المتوقعة والإجراءات الوقائية

خلال عملية الإنشاء والتشغيل للمشروع، سوف يتم استخدام آليات مختلفة بالإضافة إلى الشاحنات مثل المطرقة، الكاسحات والجرافات. من المتوقع بأن الآليات المستعملة سوف تصدر مستوى ضجيج يبلغ الحد الأعلى حوالي 110 ديسيبل عند مسافة 1م من المصدر. وسوف يقل ذلك المستوى بحوالي 6 ديسيبل عند مضاعفة المسافة عن المصدر. أي بمعنى، عند مسافة 3200 م، التي هي المسافة بين حدود المصنع المقترح وحدود منطقة سكن العاملين التابع لشركة مناجم الفوسفات الأردنية المساهمة العامة المحدودة، سوف يصل مستوى الضجيج إلى 39.9 ديسيبل. وبناء على ذلك يتبين أن أثر الضجيج الناتج عن نشاطات المشروع خلال مرحلة الإنشاء ومرحلة التشغيل على سكن العاملين (وهي أقرب نقطة مأهولة من المشروع) سوف يكون معدوما حيث أن مستوى الضجيج في منطقة نادي العاملين أعلى من ذلك بقليل. أما اقرب منطقة مأهولة سكانيا فهي منطقة الجفر والتي تبعد

حوالي 45 كم من حدود موقع المشروع. وبالتالي فان اثر الضجيج الناتج عن المشروع على سكان منطقة الجفر سيكون معدوما.

النفايات الصلبة

بالنسبة للنفايات المنزلية الناتجة من وجود العمال خلال مرحلة الإنشاء وكذلك خلال مرحلة التشغيل، فيجب جمعها في حاويات مغلقة ونقلها إلى أقرب مكب للنفايات بالتنسيق مع الجهات المختصة حيث لا يجوز حرقها قطعيا. أما بالنسبة لمادة الجبس الناتجة فسوف يتم تجميعها في منطقة مخصصة لها بجانب موقع المصنع المقترح ولكن يجب دراسة إمكانية إعادة استخدامها.

المياه العادمة

يجب تجميع المياه العادمة المنزلية الناتجة من العمال خلال فترة الإنشاء في حفرة مغلقة ونقلها إلى أقرب محطة لمعالجة المياه العادمة. أما خلال مرحلة التشغيل فسوف يتم تصريف المياه العادمة المنزلية إلى محطة التنقية التي ستنشأ مستخدمة تقنية الحمأة المنشطة. وسوف يعاد استعمال المياه المعالجة لري حزام الأشجار حول موقع المشروع. أما في موقع العقبة فيجب أن يتم تجميع المياه العادمة المنزلية الناتجة من العمال في مرحلة الإنشاء ومن الموظفين في مرحلة التشغيل في وحدة معالجة أو في حفرة مصمتة لضمان عدم تسربها إلى مياه البحر.

أما حامض الفلوسيليسك المنتج كمادة جانبية فسيتم أخذها من قبل شركة مناجم الفوسفات الأردنية المساهمة العامة المحدودة في العقبة لاستخدامها في مصنع الألمنيوم فلورايد الموجود حاليا.

4- *الإرث الحضاري والآثـــار*

تم إجراء مسح أثري من قبل فريق متخصص بهدف إيجاد قاعدة معلومات عن وجود أي مظاهر تاريخية أو أثرية في منطقتي المشروع (الشيدية والعقبة)، إضافة إلى مراجعة جميع المراجع العلمية ذات العلاقة. أظهرت الدراسة بأنه لا يوجد أي من المواقع الأثرية السطحية في منطقتي المشروع.

أما خلال عمليات الإنشاء، فإنه من الضروري في حال اكتشاف أي مكتشفات أو مواقع أثرية في منطقتي المشروع أن يقوم المقاول بوقف الأعمال الإنشائية وان يتم إبلاغ دائرة الآثار العامة أو أقرب مركز أمني بالسرعة الممكنة لاتخاذ الإجراء اللازم لحماية المكتشف أو الموقع.

5- *الظروف الاقتصادية والاجتماعية*

من المتوقع أن تحدث النشاطات المختلفة للمشروع آثارا ايجابية وأخرى سلبية على الظروف الاقتصادية والاجتماعية. تم خلال الدراسة تقييم هذه الآثار وتم اقتراح الإجراءات التصحيحية لتعظيم الآثار الايجابية وتقليل الآثار السلبية.

الآثار المتوقعة والإجراءات الوقائية

- **التوظيف**

من المتوقع أن يوفر المشروع 1000 فرصة عمل جديدة للأيدي العاملة المهنية وغير المهنية خلال مرحلة الإنشاء، وأيضاً 600 فرصة عمل خلال مرحلة التشغيل. سوف تقوم سياسة التوظيف بالشركة على إعطاء الأولوية ل % 75 من العمال ليكونوا من السكان المحليين خلال مرحلة الإنشاء و ل 40% من العمال خلال مرحلة التشغيل ليكونوا من السكان المحليين، لذلك يوصى بأن تقوم الشركة بالتعاون مع مراكز التدريب المهني الموجودة في محافظة معان لتوفير التدريب المناسب للسكان المحليين الذين لديهم المهارات الأساسية للمهن المطلوبة وأن يتم عمل برنامج تدريبي مهني لتطوير مهارات وقدرات العمال خلال مرحلة التشغيل. وكذلك يجب على الشركة أن تتبع قانون العمل الأردني والدولي فيما يخص سياسة تشغيل الأطفال. وأيضا أن تكون سياسة التوظيف مبنية على أساس الكفاءة.

- **تحسين وازدهار السوق المحلي**

من المتوقع أن يعود المشروع بالفائدة الايجابية على السوق المحلي في منطقة الجفر، لذلك يوصى بان تعطي الشركة أولوية التزود باحتياجاتها العامة خلال مرحلتي الإنشاء والتشغيل ما أمكن للسوق المحلي شريطة توفرها بالجودة والسعر المناسب.

- **الأزمة المرورية والحوادث**

أن عملية نقل المنتج والمواد الخام سوف تزيد عدد المركبات التي تقطع الطريق الصحراوي السريع بما نسبته % 2.6 على كلا الجانبين. لذلك من المتوقع حدوث زيادة طفيفة على حركة السير خلال عملية التشغيل. سوف يكون الأثر السلبي للمشروع على الأزمة المرورية محدوداً شريطة أن يتم التقيد بالإجراءات الوقائية وحسب ما تم توضيحه في تقرير الدراسة.

- **استملاك الأراضي**

تمتلك الحكومة موقع المصنع حيث تم الإعلان على أن هذه المنطقة هي منطقة حرة خاصة، علماً بان شركة الفوسفات حاصلة على حق امتياز ارض المشروع، بحيث يسمح لها بالتنجيم واستخراج خام الفوسفات في المنطقة. بالإضافة إلى ذلك فان أرض المشروع هي أرض غير مستخدمة فعليا من قبل السكان المحليين لذلك لن يكون هناك أي اثر سلبي للمشروع على استملاك أو استخدام الأراضي.

- **السكان الأصليين في الشيدية**

من المتوقع حدوث ازدهار اجتماعي واقتصادي في المنطقة نتيجة لنشاطات المشروع المختلفة، الأمر الذي سوف يساعد على الاستقرار الاجتماعي والاقتصادي في المنطقة، كما سيوفر المشروع لسكان البادية فرص عمل خصوصاً في منطقة الشيدية.

6- *الصحة المهنية*

لقد تم عمل تقييم للآثار المحتملة للمشروع على الصحة المهنية فيما يتعلق بعناصر البيئة مثل نوعية الهواء، الضجيج، النفايات الصلبة والمياه العادمة لكي يتم اتخاذ الإجراءات الوقائية

لتجنب أو تقليل الآثار السلبية على الصحة المهنية وتحفيز الآثار الايجابية. لقد اعتمد التقييم على المعلومات التي زودت بها الشركة فريق الدراسة إلى جانب الاعتماد على مصادر أخرى. هناك تفاعلات كثيرة بين نشاطات المشروع والصحة المهنية خلال مراحل المشروع المختلفة (الإنشاء، التشغيل والتفكيك).

أما بالنسبة إلى الآثار المتوقعة على صحة العمال والموظفين فانه خلال مرحلة الإنشاء والتشغيل سوف يصل مستوى الضجيج داخل حدود المصنع إلى مستويات عالية، لذلك يجب وضع علامات تحذيرية تطلب من العمال استخدام الأدوات الوقائية. كما أنه يجب أن تراجع خطة الطوارئ التي سوف تعد من قبل الشركة وبصورة مستمرة.

7- *البيئة البحرية*

تم إجراء دراسة للبيئة البحرية، حيث شملت الدراسة تقييما شاملا للحالة السائدة لنوعية مياه البحر والرسوبيات والأحياء القاعية وكذلك الأسماك في المنطقة الشاطئية أمام المجمع الصناعي في أقصى جنوب خليج العقبة، البحر الأحمر. بالإضافة إلى ذلك، فقد تم دراسة التأثيرات البيئية وكذلك الإجراءات الواجب اتخاذها من اجل التقليل أو منع الآثار البيئية التي يمكن أن تنتج.

دلت النتائج المتعلقة بالخواص الكيميائية والفيزيائية لمياه البحر أن منطقة الدراسة تسودها الظروف الطبيعية لخواص مياه البحر لمعظم المعايير التي تم تقييمها، وان سرعة التيارات البحرية تتراوح بين 4-15سم/ث وهي مشابهة إلى حد بعيد من الأجزاء الأخرى للشاطئ الأردني من خليج العقبة. يمكن القول أيضا أن الرسوبيات القاعية تتمتع بنسب أكسدة كافية وأنها قريبة من الظروف الطبيعية وان تراكيز الكربون والنيتروجين العضويين هما اقل نسبيا من مثيلاتهما في أجزاء أخرى من الخليج، كما أن تراكيز العناصر الثقيلة في الرسوبيات هي ضمن المعدل الطبيعي المقدر في رسوبيات الخليج وأيضا في بيئات الشعاب المرجانية بشكل عام. أظهرت المعطيات عن التجمعات السمكية في نفس المنطقة عدم وجود تغيرات سلبية جوهرية في تركيب الأنواع وتوزيعاتها بالمقارنة مع أماكن أخرى مشابهة على الساحل الأردني، كما أن الغطاء المرجاني هو اقل بقليل عن أماكن أخرى للساحل إلا أنها لا زالت تحافظ على غطاء مرجاني بحدود 35%، فيما غالبية الأماكن الأخرى على الساحل الأردني تتمتع بغطاء مرجاني يتراوح بين 50-65%.

أما عن التأثيرات البيئية المحتملة والإجراءات الواجب اتخاذها، فمن المعلوم أن حامض الفوسفوريك يعتبر من الأحماض المستقره في ظل الظروف الطبيعية سواء أثناء عمليات التخزين أو المناولة. كما أن الإجراءات المقترحة قد تكون قابلة للتطبيق بسهولة في حال تم الأخذ بالطرق المثلى لعمليات التخزين والمناولة من قبل الشركة. إن ما تم التوصية به سوف يساعد إلى حد بعيد في التقليل ما أمكن من التأثيرات السلبية المحتملة على البيئة البحرية. وعلى غرار ذلك، فان حامض الفلوسيليسيك وكذلك مادة الكبريت الخام هما مادتان يتم التعامل معهما ضمن المجمع الصناعي منذ فترات طويلة دون تسجيل أية حوادث كبيرة وذات تأثير مباشر على البيئة البحرية. بالتأكيد، ومع البدء بالاستثمار الجديد المقترح فان مناولة كميات إضافية من هذه المواد هي أمور متوقعة، وعليه يتطلب ذلك إجراءات إضافية تؤخذ بالاعتبار من أجل منع أو التقليل ما أمكن من الآثار السلبية المحتملة على البيئة البحرية وقد تم توضيح هذه الإجراءات في التقرير .

8- خطة العمل البيئية والاجتماعية

لقد أوضحت دراسة تقييم الأثر البيئي والاجتماعي أن هناك آثارا سلبية متوقعة للمشروع خلال مراحله المختلفة من الإنشاء والتشغيل والتفكيك. لقد تم تقييم هذه الآثار والخروج بحلول ملزمة أو توصيات لإلغاء أو تخفيف تلك الآثار إلى الحد المسموح به حسب القوانين والتعليمات المرعية. إن خطة العمل البيئية والاجتماعية هي عبارة عن أداة إدارة للتأكد من أن جميع الإجراءات المطلوبة قد تم تطبيقها وتنفيذها في الوقت المطلوب، حيث أن خطة العمل البيئية والاجتماعية تحتوي على جدول زمني واضح.

الجدول التالي يوضح القضايا الأساسية والإجراءات الواجب اتخاذها مع تحديد التاريخ الواجب التنفيذ فيه.

الرقم	القضية البيئية	الحل المقترح	تاريخ الإنجاز
.1	تحليل المخاطر والتشغيل (HAZOP)	إعداد (HAZOP)	قبل بداية مرحلة التشغيل
.2	خطة الصحة والسلامة المهنية	إعداد خطة الصحة والسلامة المهنية	قبل بداية مرحلة الإنشاء
.3	خطة الاستجابة في حالات الطوارئ	إعداد خطة الاستجابة في حالات الطوارئ	قبل بداية مرحلة الإنشاء
.4	آلية التظلم	إعداد آلية واضحة للتظلم	قبل بداية مرحلة الإنشاء
.5	تدابير التخفيف فيما يتعلق بالموارد المائية	تنفيذ جميع تدابير التخفيف المتصلة بجميع المسائل المتعلقة بموارد المياه	خلال مرحلتي الإنشاء والتشغيل
.6	تدابير التخفيف المتعلقة بالتنوع الحيوي	تنفيذ جميع تدابير التخفيف المتصلة بجميع قضايا التنوع الحيوي	خلال مرحلتي الإنشاء والتشغيل
.7	تدابير التخفيف المتعلقة بالصحة العامة	تنفيذ جميع تدابير التخفيف المتصلة بجميع قضايا الصحة العامة	خلال مرحلتي الإنشاء والتشغيل
.8	تدابير التخفيف المتعلقة بالآثار	تنفيذ جميع تدابير التخفيف ذات الصلة بجميع قضايا الآثار	خلال مرحلة الإنشاء
.9	تدابير التخفيف بشأن الظروف الاجتماعية والاقتصادية	تنفيذ جميع تدابير التخفيف المتصلة بجميع القضايا الاجتماعية والاقتصادية	خلال مرحلتي الإنشاء والتشغيل
.10	تدابير التخفيف المتعلقة بالصحة والسلامة المهنية	تنفيذ جميع تدابير التخفيف المتصلة بجميع قضايا الصحة والسلامة المهنية	خلال مرحلتي الإنشاء والتشغيل
.11	تدابير التخفيف المتعلقة بالبيئة البحرية	تنفيذ جميع تدابير التخفيف المتصلة بجميع قضايا البيئة البحرية	خلال مرحلة التشغيل
.12	مياه الصرف الصحي المنزلية الناتجة من العاملين ومن سكن العاملين في الشيدية خلال مرحلة التشغيل	تشييد محطة لمعالجة المياه العادمة المنزلية باستخدام تقنية الحمأة المنشطة	قبل بداية مرحلة التشغيل
.13	حامض الفلوسيليسك	تسجيل جميع الكميات التي أنتجت والتي بيعت إلى شركة مناجم الفوسفات الأردنية في العقبة	خلال مرحلة التشغيل

الرقم	القضية البيئية	الحل المقترح	تاريخ الإنجاز
.14	التخلص من العامل المساعد المستنفذ (خامس أكسيد الفناديوم)	تسجيل جميع الكميات التي اشتريت والتي استخدمت من مادة خامس اكسيد الفناديوم	خلال مرحلة التشغيل
		إعادة العامل المساعد المستنفذ (خامس أكسيد الفناديوم) إلى المورد.	خلال مرحلة التشغيل
.15	التخلص من الجبس	انشاء ودك أرضية المنطقة المخصصة بالطريقة المناسبة وإحاطتها بجدار من جميع الجوانب	قبل بداية مرحلة التشغيل
.16	المخاطر التي تمس السلامة أثناء النقل على الطرق العامة	الامتثال للتعليمات الأردنية فيما يتعلق بتنظيم النقل البري للمواد الخطرة	خلال مرحلة التشغيل
.17	بركة التجميع	دك أرضية البركة وتبطينها باستخدام مادة مناسبة مثل البولي ايثلين عالي الكثافة	قبل بداية مرحلة التشغيل
.18	خزانات تخزين حامض الفوسفوريك في العقبة الواقعة في منطقة عالية المخاطر الزلزالية	إتباع لوائح ومدونات التصميم المعتمدة من وزارة الأشغال العامة والإسكان ضد الزلازل	خلال مرحلتي التصميم والإنشاء
.19	حفر آبار مياه	الحصول على رخصة من وزارة المياه والري / سلطة المياه	قبل بداية مرحلة الإنشاء
.20	استهلاك المياه	تدوين كميات المياه المستهلكة وإعلام وزارة المياه والري	خلال مرحلة التشغيل
.21	العمالة المحلية	تسجيل أعداد العاملين في المشروع من العمالة المحلية وكذلك أعداد المتدربين	خلال مرحلتي الإنشاء والتشغيل

Summary

The Jordan India Fertilizer Company (JIFCO) - which is a joint venture between Jordan Phosphate Mines Company (JPMC) with share of 48% and Indian Farmers Fertilizer Cooperation Ltd with share of 52% - will establish an industrial complex in Eshidiya/Ma'an governorate to produce phosphoric acid for export purposes by producing sulphuric acid and using the phosphate ore from that area. The duration of the construction phase will be 36 months.

To identify and analyze the potential impacts of the proposed project, a comprehensive environmental and social impact assessment was prepared by the Royal Scientific Society. The scoping phase involved consultations with representatives from local communities, non-governmental organizations and regulatory authorities in addition to a major scoping session held in Aqaba on 12/2/2008. The following valued environmental components were identified:

- Water Resources.
- Biodiversity.
- Public Health.
- Archeology.
- Socio-economic Conditions.
- Occupational Health and Safety.
- Marine Environment.

To determine baseline data and to facilitate impact assessment, a number of different field studies were carried out including:

- Air Quality.
- Noise.
- Water Resources.
- Biodiversity.
- Cultural Heritage and Archeology.
- Socio-economic Conditions.

Major Findings

1. Water Resources

Geology of Project Site

The study area in Eshidiya is relatively flat and covered with recent sediments of sand. The formations in the study area consists of Muwaqqar and Amman-Wadi Sir formations, and lower Ajlun, Kurnub, and Khreim Groups. The geology of the southern part of Aqaba area consists entirely of granular sedimentary deposits which are derived from the granite mountains north and east of the area. The project site in Eshidiya area is located within zone 1 which is characterized as low seismic hazard. However, the location of the storage tanks in Aqaba area is characterized as high risk of seismic hazard.

Surface Water Resources

The project site in Eshidiya is located in Al-Jafer catchment area with its sub-catchment area estimated at about 5.5 km^2 and sloping at about 1.2% toward northeast direction. The annual average rainfall over the project site sub-catchment area is around 14.3 mm which is equivalent to 0.08 MCM. The runoff is estimated at 0.002 MCM by using United States Soil Conservation Curve Number method. The storage tanks in Aqaba area belongs to Wadi Yutum catchment area where the annual average rainfall over the storage site ranges from 150 mm 50 mm. The rainfall occurs accidentally with short durations, normally lasting less than three hours and lead to flash floods along the short side wadis coming from the eastern highlands. Therefore, the company shall construct gabions along the side of the wadi near the storage tanks in Aqaba to minimize the flood impact on the storage tanks.

Groundwater Resources

The main groundwater aquifer in the project site in Eshidiya area is Amman-Wadi Sir aquifer (B2/A7) formation with a total thickness of 20 - 25 m. Kurnub and Disi form the deeper aquifers, which are separated from each other by thick aquitards. The storage tanks site in Aqaba area is located in southern Wadi Araba aquifer where the groundwater flows from the north to the Red Sea in the south. Regarding the proposed project, water requirement of the JIFCO project in Eshidiya is about 6.0 MCM/year and therefore the total abstraction of water by all industries in this area will be 12.5 MCM/year at the end of the year 2011 (year of starting the operation of JIFCO project). Considering the water consumption at the rate of 12.5 MCM/year, the Amman-Wadi Sir aquifer

will run out by the year 2037 because the abstraction rate is over the safe yield. Hence it is proposed that JIFCO shall exploit water from the deeper Kurnub/ Disi aquifer at Eshidiya, which is a nonrenewable one, by drilling about 4 new wells in addition to the existing one, each pumping about 200 m^3/hr. This will reduce depletion of the Amman-Wadi Sir aquifer and will last for many more years. A study was done by JPMC through the consultant Scott Wilson Kirkpatrick & Co. Ltd in the year 1999/ 2000 by deep exploratory drilling of groundwater resources in Eshidiya region; it concluded a conservative estimate of production from the deep aquifer to be in the range of 6 to 10 MCM per year. This will provide sufficient amounts covering the project needs. However, to reduce consumption from such a resource, the company shall use the excess amount of the treated domestic wastewater from the project as well as study in future the possibility to reuse the treated domestic wastewater from Ma'an municipal treatment unit and the planned treatment unit of Ma'an Industrial Zone.

By implementing a mathematical equation on the formations in the project site in Eshidiya that is considered as homogenous up to the top of the Kurnub formation at the depth 334 m, the time needed for pollutant to reach the water table will be about 99 years. This concluded that the risk of contamination of the water table is considered low, but the risk of contamination of the soil is high. Therefore, guard pond shall be lined by using a proper lining material such as high density polyethylene material and shall be inspected regularly. The spent lubricating oil shall be collected in special containers and transported in a safe manner to Jordan Petroleum Refinery Company or sold to the licensed collector of used oil. The oil storage tank shall be provided with a properly lined containment area capable of holding the whole tank volume. During the construction phase, the domestic wastewater shall be collected in an impermeable reinforced (sealed) tank and has to be disposed to the nearest municipal wastewater treatment plant using licensed vacuum tanks and following the appropriate environmental regulations or to be treated at the site. The floor of the gypsum stacking area shall be constructed and compacted in a proper way using proper material to obtain the soil permeability not larger than $1x10^{-6}$ m/s and shall be contained by dike from all sides to prevent any spill. The spent vanadium pentoxide catalyst (V_2O_5) shall be sealed in steel or plastic drums and stocked in designated area and then it shall be returned to the supplier.

In Aqaba, the travel time for pollutant to the water table in the storage tanks site in Aqaba area is about 3 hours. This means that the risk of sea water contamination is very high. Therefore, phosphoric acid storage tanks

shall be designed according to the local and international codes against the seismic hazard and the tanks should be provided with a properly lined containment area capable of holding the largest tank volume plus 10% of its volume.

2. Biodiversity

A biodiversity study was conducted for the project. The study aimed to determine the existing conditions and to assess the environmental impacts of the project on the biodiversity at both proposed areas in Eshidiya and Aqaba areas, during the construction, operation and decommissioning phases.

As a summary, the following results were obtained:

Eshidiya Area
Flora: The proposed location is characterized by the Saharo – Arabian biogeographic zone. The area represents the Desert Ecosystem. The total number of recorded plant species is six species in an area that is poor with natural vegetation, one of these species is of national conservation importance, which is Acacia.

Fauna: The proposed location has high levels of disturbance and habitats destruction. The number of fauna species among the target groups was low. The study recorded two species of reptiles, five species of common birds and three species of mammals.

Aqaba Area
Flora: The proposed location is characterized by the sub-tropical biogeographic zone. The area represents sub-tropical Ecosystem. The total number of recorded plant species is four species in an area that is poor with natural vegetation.

Fauna: The proposed location has high levels of disturbance and habitats destruction in the site. The number of fauna species among the target groups was low. The study recorded one species of reptiles, five species of common birds and three species of mammals.

The study team has proposed proper mitigation measures for the significant expected impacts. For example construction should avoid shallow depressions that have vegetation as much as possible, green built is

recommended to be of native canopy trees such as tamarisk trees at the borders of the plant in Eshidiya with defined access to machineries and to prohibit workers from hunting.

3. Public Health

Air Quality Study

A monitoring program for a period of one month was conducted at the northwest border of the proposed JIFCO project site in Eshidiya; downwind the existing industrial activities since the prevailing winds in this area are north and west winds. The programs were undertaken to provide the data for the current assessment and to enable comparing/analyzing future changes in air quality that could result from the project different activities.

The monitoring program included continuous monitoring of air pollutants (SO_2, NO_x, NO, NO_2, CO and PM10) that represent the main air pollutant emissions from the JIFCO different activities, in addition to monitoring of weather parameters; wind speed and wind direction. In addition, five-spot measurements of HF were conducted in the ambient air of the monitoring site. The obtained baseline ambient air quality monitoring results were compared with the maximum allowable limits specified in the Jordanian air quality standards (JS: 1140/2006) and WHO ambient air quality guidelines (International Finance Corporation (IFC) regulations).

Results of air quality monitoring program showed that SO_2 and NO_2 hourly and daily averages, in addition to CO hourly and 8-hours averages did not exceed the limits specified in ambient Jordanian standards as well as the IFC regulations.

Eight PM10 exceedances were recorded to the daily limit specified in ambient air quality Jordanian Standards (25.8% of the monitoring time), and four PM10 exceedance were recorded to the daily limit specified in IFC regulations (12.9% of the monitoring time). Results of wind speed and wind direction monitoring showed that the prevailing wind directions were northwest (NW), north (N) and west (W) during the monitoring period.

Potential Impacts and Mitigation Measures

Project construction activities would generate substantial amounts of dust, which might have significant impact if not mitigated in a safe manner. In addition, air pollutants may be emitted by vehicles and other construction equipments causing short-term degradation of the air quality at the construction areas and the transportation roads.

The transportation of the raw materials, loading, storage in the site and conveying from the process as well as the milling process could emit dust. In addition, if fine sulphur particles are emitted and their concentrations in the air are between the lower and upper flammable limits of sulphur, this could cause fire hazard in the existence of an ignition source.

The tail gases from project different processes stacks are sulphur dioxide (SO_2), acid mist (H_2SO_4 and sulphur trioxide SO_3), and fluorine gases (mainly the hydrogen fluoride (HF) and the silicon tetrafluoride (SiF_4)), while (SO_2, CO, PM10 and NO_x) are expected from the burning process at the start-up boiler that will be operated for few days during the sulphuric acid plant start-up.

The air pollution dispersion modeling of most emissions (SO_2, SO_3, PM10, HF, CO and NO_X) show that the impact of the company alone or in cumulation with the existing companies will not affect the inhabitants, taking into consideration that there is no nearby community in downwind or upwind the project, and that the employees complex lies upwind the project at a distance of around 3.2 km and thus it will not be affected.

Dust resulting from the construction activities should be minimized as much as possible for example through water slightly all active construction areas to reduce dust generation, cover all trucks hauling soil, sand, and other loose materials, cover stockpiled soils, sand and cement, and try to remove them promptly and strictly limit truck speed on unpaved road.

The suitable type of de-dusting system that is reliable and of high efficiency shall be installed in all dust emission points.

It is important, not only to install de-dusting systems such as cyclones and bag filters, but also to apply regular maintenance and check of the performance of the installed dust protection equipments.

To reduce the dust emission from material storage areas, the phosphate rock and sulphur stockyards walls shall be high enough and built against the prevailing wind direction.

Cover well all the trucks that will haul the sulphur granules from Aqaba to Eshidiya to prevent the sulphur spillage during transportation and the possibility of grinding it by the vehicles. The company shall import the granular sulphur not the fine one.

Noise Study

A noise monitoring program (6 days) was conducted at the nearest occupied area (worker club in the town site of JPMC in Eshidiya) at a distance of 3.2 km from the proposed site of the plant of the Jordan India Fertilizer Company. The monitoring results were compared with the permissible limits of equivalent sound level of the Jordanian Noise Regulations for 2003 and with the International Finance Corporation. The noise monitoring results showed that the existing background noise levels are within the standard limits, the more strict regulations were considered.

Potential Impacts and Mitigation Measures

During the construction and operation of the project, different types of excavation and construction machines will be used such as jackhammers, graders, backhoes, heavy trucks and tankers. It is anticipated that these machinery give a maximum noise level of 110 dB(A) at the operator. If these vehicles are operating at the boundary, this level will be reduced by 6 dB(A) by doubling the distance. At a distance of 3200 m which is the distance between the border of the proposed plant site and the border of the town site of JPMC, the free field noise level will be attenuated to a value of 39.9 dB(A). This means that the project activities resulting from machines will not contribute in increasing the existing background noise levels at the currently closest occupied site. The same can be said during the operation phase. The nearest real community (residential area) is Al-Jafer, which is located at a distance of 45 km from Eshidiya site. Al-Jafer will not be impacted by the noise of the project.

Solid Waste

The domestic solid waste generated by the workers during construction and operation phases shall be collected in closed containers and transported to the nearest authorized solid waste disposal site with prior coordination with the relevant authorities. Burning of solid waste in open areas is strongly prohibited. Gypsum will be piled in a prepared adjacent area east of the plant area but the possibilities to reuse it shall be explored.

Wastewater

Domestic wastewater generated from the workers during construction phase shall be collected in a sealed pit or containers and transported to the nearest wastewater treatment plant. During the operation phase, the generated domestic wastewater will be treated in an activated sludge treatment plant which will be constructed in Eshidiya site. The treated wastewater will be used to irrigate the green belt which will be planted around the Eshidiya site. For Aqaba site, the company shall establish a treatment unit or a sealed pit to handle the domestic wastewater generated during construction and operation phase in order to ensure zero discharge to the sea. The produced by-product (fluosilicic acid) will be used by the JPMC in Aqaba to produce aluminum fluoride.

4. Cultural Heritage and Archeology

An archeological survey was undertaken to determine the baseline. The survey included the phosphoric and sulphuric acid plants site in Eshidiya as well as the phosphoric acid storage tanks site in Aqaba. Additionally, most of the available references related to the study area were reviewed.

As a result of the archeological survey, the existing information proved that no surface antiquities exist at the project sites. Therefore, there is no potential impact with regard to surface antiquities destruction. Still, precaution and management measures should be taken into consideration regarding the need to conserve any chance find sites during construction activities. So, it is essential during the construction phase to provide strict instructions to the contractor to pause construction work and excavations in case of discovering any antiquities or archeological item. Such discoveries shall be reported immediately to the Director of Department of Antiquities or to the nearest General Security Center. The Department of Antiquities in

such cases will assess and recommend certain measures to protect the found items.

5. Socio-Economic Conditions

The different activities during the project life are expected to cause some negative and positive impacts on the socio-economic conditions. Socio-economic study presents evaluation and assessment of these impacts, and recommendations of appropriate mitigation measures to enhance positive impacts and to reduce the negative ones.

Potential Impacts and Mitigation Measures

- Employment

  The project will create 1000 job opportunities during the construction phase and 600 new job opportunities during the operation phase. The company will give the priority for 75% of the employees during the operation phase and for 40% of the employees during the construction phase to be from the local community. In order to make the local employment more successful, it is recommended that JIFCO arranges with the vocational training center in Ma'an governorate to build and upgrade the capacity of the potential local workers, having basic qualification, on the skills jobs needed by the project. The company shall follow the Jordanian/International regulations regarding child labor; also the employment procedure shall be established according to an approval criterion (such as the qualification is one of the main criteria).

- Business prosperity

  In order to enhance the positive impact on local business, it is recommended that the company get supplies, food, spare parts (if available having requisite quality and competitive price) from local stores during both construction and operation phases.

- Traffic congestion and accident

  The transportation of product and raw materials will increase the daily number of vehicles passing through desert highway by 2.6% for each side. Thus, it is expected that a slight increase in traffic flow will take place during the operation period. The negative impact of traffic

congestion will be limited, providing that proper measures will be adopted as mentioned in the study.

- Land acquisition

  The project land in Eshidya is currently owned by the government and it is declared by the government as a free zone area. JPMC has licensed to mine, exploit, produce and market phosphate and its product in this area. The land area for the project is not used by local population. So, no physical or economical displacements are required.

- Indigenous people at Eshidiya

  The establishment of this project is expected to raise the socio-economic activity including the business prosperity in the area. This will aid in overcoming current degrading and debilitating situation since it will encourage the Bedouin to settle and get suitable jobs.

6. Occupational Health

An assessment of the project potential impacts related to the relevant environmental components and issues such as air quality, noise, solid waste and wastewater is done in order to set the necessary mitigation measures to avoid or reduce negative impacts on the occupational health and enhance the positive ones. The assessment is based on information provided by the company and the collected data from other related sources.

There are a lot of interactions between the project activities and the occupational health and safety during all phases of the project (i.e. construction, operation and decommissioning phase).

During construction and operation phases, the noise generated at certain places inside the project area will reach high level. Therefore, warning signs will be posted indicating hearing protection is required because the permissible noise level is exceeded. During operation phase, emergency plans shall be prepared by the company and shall be reviewed by the management staff frequently.

7. Marine Environment

Marine environment study was conducted as part of this project. The study presents a comprehensive ecological evaluation and the current status of water quality, bottom sediments, benthic habitats and fish at the coastal area in front of the Industrial Complex at the southern most portion of Aqaba Gulf, Red Sea. In addition, it summarizes the possible environmental impacts and the important mitigation measures required.

Results on chemical and physical features of the investigated site indicated the prevalence of ambient Aqaba seawater conditions for most parameters and that the dominant water current speed is between 4.0 to 15.0 cm/sec which is similar to the entire Jordanian coast. Bottom surface sediments are adequately oxygenated and the concentrations of organic carbon and organic nitrogen are moderately low compared to other parts of the Gulf of Aqaba. The concentrations of heavy metal are in the normal range of similar sediments from both, the Gulf of Aqaba and other coral reef environments. Fish community parameters revealed no major negative change in species composition and species distribution. The conditions are nearly similar to those observed in other sites along the Jordanian coast. Hard coral cover changed slightly but keeping the same trend with highest cover of 35% which is lower than other sites along the Jordanian coast with coral cover range 50% to 65%.

The possible impacts and the necessary mitigation measures presented in this study suggest that phosphoric acid is stable under normal conditions of storage and handling. Measures to prevent or minimize its possible impacts to the environment could be achieved if the company allows best handling and storage processes of the product following the recommended measures mentioned in the report. Flousilicic acid as well as sulphur are being handled at the site since quite long time and no sever incidents of spillage have been reported. Certainly, with the new venture the handling of additional quantities of these products are expected and that additional measures should be considered in order to keep or minimize the impacts to the lowest level possible.

8. The Environmental and Social Action Plan (ESAP)

The environmental and social impact assessment of JIFCO project has identified a number of potential impacts that are likely to arise during construction, operation and decommissioning phases of the planed project. The impacts were assessed and mitigation measures were set to be implemented according to the relevant laws and regulations. The purpose of the ESAP is to identify the set of mitigation measures to eliminate or reduce the potential adverse impacts of the project on the environment and societies as low as reasonably practicable, and to ensure that the mitigation measures are implemented effectively and on time. ESAP is a tool for management which contains a clear schedule. The following table shows the key environmental and social action items for the JIFCO project during different phases.

No.	Issue	Proposed Action	Completion Date
1.	Hazard and Operability Analysis (HAZOP)	Prepare HAZOP	Before plant start-up
2.	Occupational Health and Safety Plan (OHS)	Prepare an OHS plan	Before start of construction
3.	Emergency Response Plan (ERP)	Prepare ERP	Before start of construction
4.	Grievance Mechanism	Prepare a clear grievance mechanism	Before start of construction
5.	Mitigation measures regarding water resources	Implement all mitigation measures related to all water resources issues	During construction and operation
6.	Mitigation measures regarding biodiversity	Implement all mitigation measures related to all biodiversity issues	During construction and operation
7.	Mitigation measures regarding public health	Implement all mitigation measures related to all public health issues	During construction and operation
8.	Mitigation measures regarding archeology	Implement all mitigation measures related to all archeology issues.	During construction
9.	Mitigation measures regarding socio-economic conditions	Implement all mitigation measures related to all socio-economic issues	During construction and operation
10.	Mitigation measures regarding occupational health and safety	Implement all mitigation measures related to all occupational health and safety issues	During construction and operation
11.	Mitigation measures regarding marine environment	Implement all mitigation measures related to all marine environment	During operation

No.	Issue	Proposed Action	Completion Date
12.	Domestic wastewater generated from workers and labor camp during operation phase	Construct an activated sludge wastewater treatment plant	Before plant start-up
13.	Fluosilicic acid	Record all quantities produced or sold to JPMC in Aqaba	During operation
14.	Disposal of the spent catalyst (vanadium pentoxide)	Record the amount of vanadium pentoxide purchased and the amount used	During operation
		Send all of spent catalyst (vanadium pentoxide) back to the supplier	During operation
15.	Gypsum disposal	Construct and compact the disposal area in a proper way and contained by dikes in all sided	Before plant start-up
16.	Safety hazards during transportation on public roads	Comply with the Jordanian Regulation for Hazardous Material Transportation by road.	During operation
17.	Guard pond	Compact the ground of the guard pond and use a proper lining material such as high density polyethylene (HDPE)	Before plant start-up
18.	Storage tanks in Aqaba located in high risk seismic zone	Follow the regulations and design codes of the Ministry of Public Works and Housing against earthquakes	During design and construction
19.	Drilling bore wells for water	Get license from Jordan Water Authority, Ministry of Water and Irrigation	Before start of construction
20.	Water consumption	Report to the Ministry of Water and Irrigation	During operation
21.	Local employment	Record the number of people from local communities trained and employed by the company	During construction and operation

Table of Content

1. PROJECT DESCRIPTION

1.1 Purpose and Need of the Project

The economy of Jordan is growing steadily owing to the successful economic reform program, as well as the continuous encouragement of both local and foreign investments. This represents a basic pillar in supporting the national economy and achieving sustainable economic development in a way that meets the national vital interests and achieves political, social, and economic and security stability.

It is well known that Jordan is very rich in its phosphate deposits. It was reported that the first discovery of phosphate deposits in Jordan took place as early as 1894. However, scarcity of capital, unavailability of technology and international political developments came in the way of commercial production. The total phosphate ore reserves at the beginning of 1999 were estimated to be 1.7 billion tons. Out of this, Eshidiya mine contains 1.5 billion tons. Jordan exports about 65 per cent of its phosphate production. Whereas the remaining amount of phosphate production is utilized for domestic consumption.

Of Jordan's $1.91 billion in exports in 2001, stone, cement, fertilizers, phosphate rock, phosphoric acid, potash, and sulphuric acid accounted for $541 million.

Following all of these facts, an agreement was signed between the Jordan Phosphate Mines Company (JPMC) and the Indian Farmers Fertilizer Cooperative (IFFCO)", to form a Joint Venture "Jordan India Fertilizer Company, (JIFCO) to build a plant for the production of phosphoric acid in Eshidiya / Ma'an governorate with a capacity of about 475,500 tons per year.

Such big project is expected to increase Jordanian competitiveness in production, management, marketing and know how transfer. It will also decrease the level of unemployment through creating new job opportunities for local people during the different phases of the project.

1.2 Project Location

The project will consist of two major sites:

Site (1): Eshidiya/Ma'an governorate
This site will include the phosphoric acid and sulphuric acid plants which will cover an area of about 1.7 km^2 and also it will include the gypsum disposal site that will cover an area of about 1.7 km^2. The area was chosen as the best location to build the plants due to what was previously mentioned that Eshidiya mine is the biggest reserve of phosphate ores in Jordan as well as this area is declared by the government as a free zone area for phosphate chemical industries. Eshidiya is located in the south of Jordan; approximately 250 km south of Amman and 180 km north east of Aqaba. The nearest city is Ma'an, which is about 75 km from Eshidiya project site. Al-Jafer area is about 45 km from the project site. Eshidiya is part of the southern Badiyah and it is connected to Ma'an, Amman and Aqaba by a surface road, see Figs. (1.1), (1.2) and (1.3)

The coordinates of the plant site are as shown in Table (1.1). Fig. (1.4) shows the plants site and the gypsum stacking area as well as the existing projects in Eshidiya area.

Table (1.1): Coordinates of site (1)

Point No.	North	East
1	923850	259300
2	922150	259300
3	922150	261300
4	923850	261300

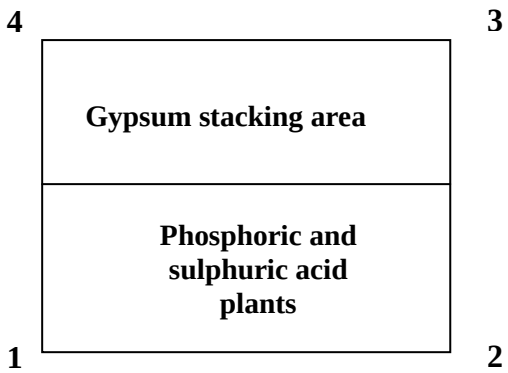


Fig. (1.1): Map of Jordan showing the location of the plants in Ma'an and storage tanks in Aqaba.

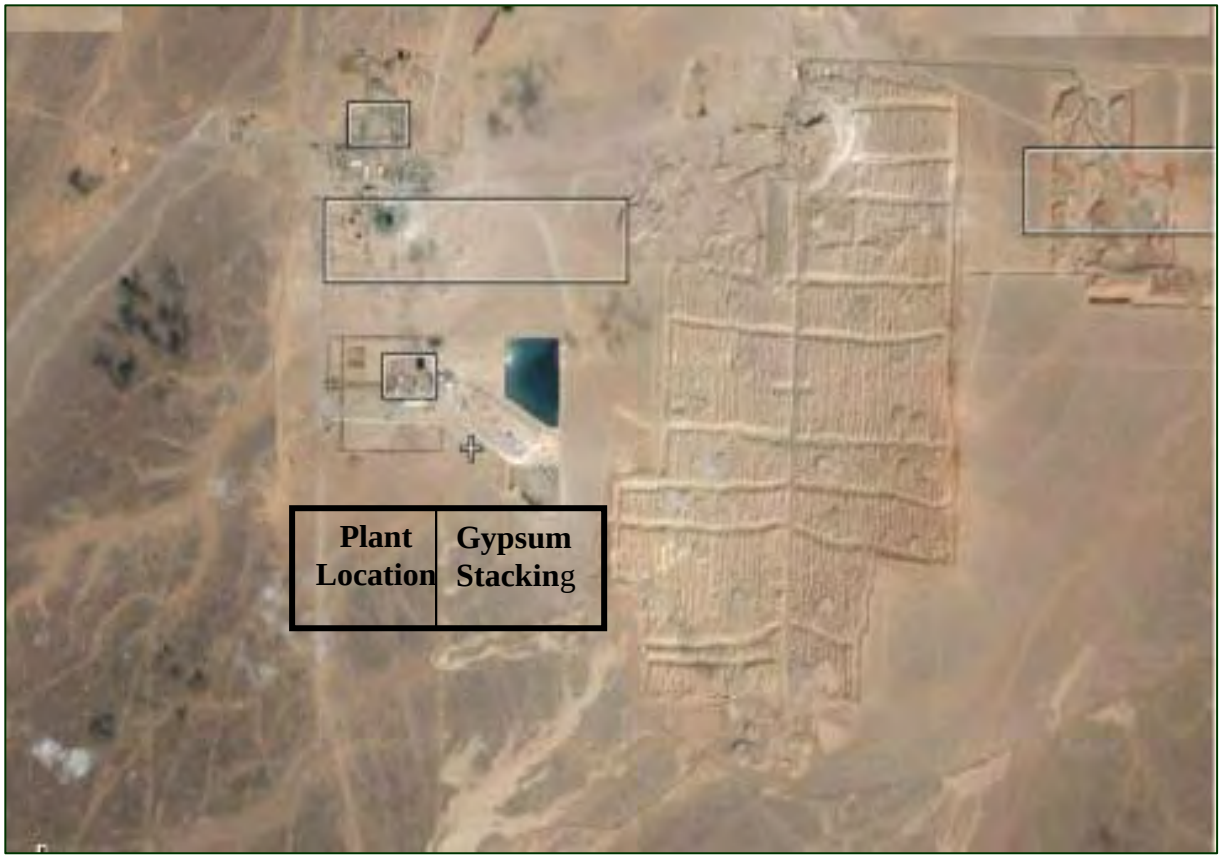


Fig. (1.2): Topographical map showing the location of the plant in Ma'an

Fig. (1.3): Phosphoric acid and sulphuric acid plants location at Eshidiya/ Ma'an governorate

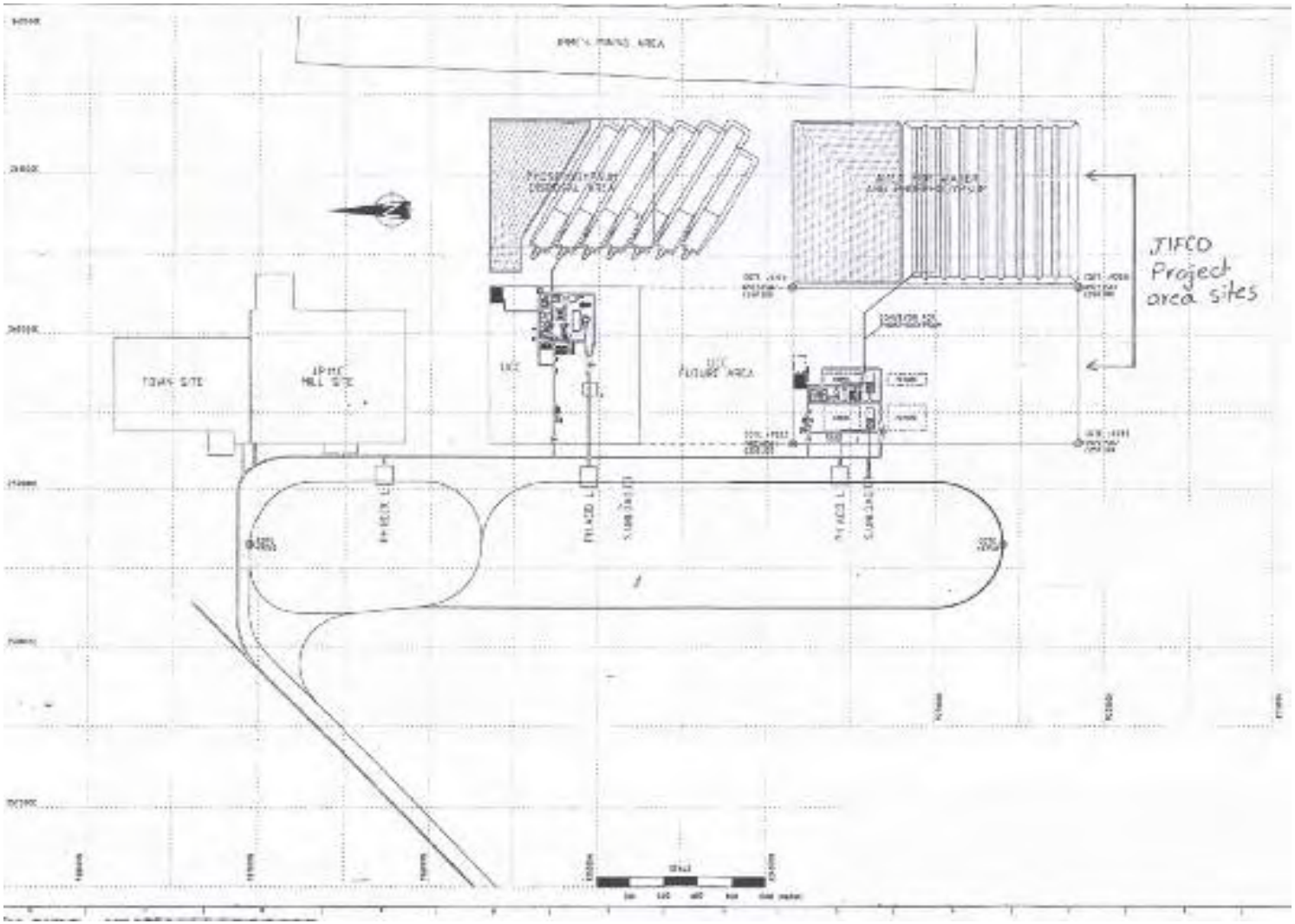


Fig. (1.4): Plants location and the existing projects

Site (2): Aqaba governorate

Storage tanks for storing the phosphoric acid product will be built in Aqaba in the industrial zone near the southern seaport at about 1.5 km west of the shore and near the current existing storage tanks that belong to the Indo Jordan Chemicals Company (IJCC). This area will include 7 storage tanks with a capacity of 10,000 tons each. Aqaba, which is a coastal town is considered strategically important to Jordan as it is the country's only seaport. Fig. (1.5) shows the location of site 2. The coordinates of the storage tanks are as shown in Table (1.2).

Table (1.2): Coordinates of site (2)

Point No.	East	North
1	303788	251246
2	303788	251030
3	303727	251247
4	303725	251117
5	303611	251119
6	303611	251030

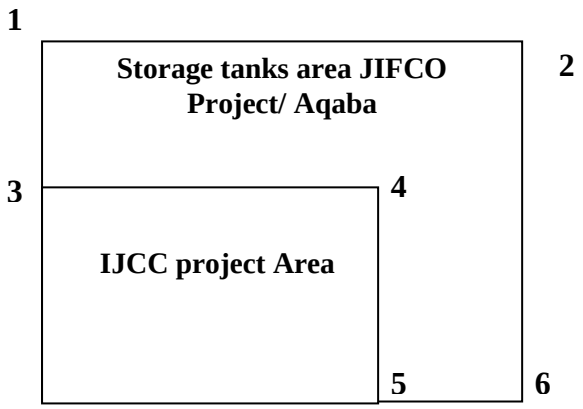


Fig. (1.5): Location of phosphoric acid storage tanks

1.3 Major Project Components and Facilities in Eshidiya

The proposed chemical complex at Eshidiya will consist of the following:

- Rock phosphate storage and handling.
- Phosphoric acid plant.
- Handling and disposal of gypsum.
- Sulphur storage and handling.
- Sulphuric acid plant with a co-generation power plant.
- Storage tanks of weak and strong phosphoric acid and sulphuric acid.
- Recovery and storage of fluosilicic acid.
- Maintenance workshops and a laboratory.

- Office facility.
- Housing and medical facilities.
- Utilities

  - Water demineralization facility
  - Start-up boiler
  - Air compressors, receivers and drying unit.
  - Electrical grid connection.
  - Storage for raw and fire water, demineralised water, condensate and guard pond.

In addition to that, the project will have a facility for storage and handling phosphoric acid in Aqaba.

1.4 Plant Capacity and Manpower

As mentioned earlier, the project will comprise a large integrated single stream phosphoric acid and sulphuric acid complex in addition to a storage facility that will be located in Aqaba. The total time schedule for completion of the project is estimated at 36 months (about 3 years); 33 months for mechanical completion and 3 months for pre-commissioning and commissioning activities. The plants capacity and the manpower needed for the project are as follows:

- The phosphoric acid plant will have a capacity of 1,500 MTPD (metric tons per day) as 100% P_2O_5 (475,500 tons per year)
- The sulphuric acid plant capacity is about 4,500 MTPD (1,426,500 tons per year).
- During the operation phase, the total number of personnel required for the corporate office, operating different plants and establishments including maintenance, administration and services is around 600 employees where 75% will be local employees and 25 % expatriates. While during the construction phase, 60 % of workers will be expatriates and 40 % will be local workers. Table (1.3) below summarizes the main important figures for the project.

1.5 Phosphoric Acid Plant

Phosphoric acid is also known as orthosphoric acid. It is a mineral (inorganic) non toxic acid having the chemical formula of H_3PO_4. The pure anhydrous phosphoric acid is a white solid at room temperature and pressure. It melts at 42.35 °C to form a clear colorless, odorless and nonvolatile viscous liquid. It is a very polar molecule; therefore it is highly soluble in water.

Table (1.3): Summary of important information of the project

Location	Eshidiya, Jordan
Phosphoric acid plant capacity	1,500 MTPD P_2O_5
Annual production capacity	0.475 million MT P_2O_5
Sulphuric acid plant capacity	4,500 MTPD
Working days per year	317 for H_3PO_4 and 330 for H_2SO_4
Power Co-generation	26 MW
Annual requirement of raw material	
Rock phosphate	1.90 million MT
Sulphur	0.5 million MT
Project capital cost	570 Million USD
Project time schedule	3 years (36 months)

Phosphoric acid is used in the manufacturing of fertilizers, phosphate salts, beverages, polyphosphates, detergents, activated carbon, animal feed, ceramics, dental cement, pharmaceuticals, soft drinks gelatin, rust inhibitors, wax and rubber latex.

1.5.1 Phosphoric acid production

Phosphoric acid can be made in two ways; the wet process and the thermal (furnace) process. Thermal process of phosphoric acid is of a much higher purity and is used in the manufacturing of higher grade chemicals, pharmaceuticals, detergents, food products, beverages and other non fertilizer products. This process has been abandoned because of the amount of energy needed.

On the other hand, the wet process of phosphoric acid is characterized by relatively high production volume, low cost and low purity. Thus, it is considered as the only economic alternative way to produce phosphoric acid. The share of wet phosphoric acid amounts to 95% of the total phosphoric acid in Western Europe. It is used primarily in the production of fertilizers (approximately 80%) and animal feed supplements (8%).

1.5.2 Wet process principles

Phosphoric acid is produced from the reaction of phosphate rock with sulphuric acid. When the rock is treated with strong sulphuric acid, the rock-

lattice is destroyed and the components pass into solution. In the wet phosphoric acid process, phosphate rock may first need grinding to obtain fine rock particles. The rock is then dissolved in phosphoric acid and sulphuric acid. Besides dissolving the rock, sulphuric acid is added to precipitate the calcium present as calcium sulphate. During the reaction, cooling is required as the overall reaction is exothermic. After conversion of the rock, the calcium sulphate and phosphoric acid are separated by filtration. To produce merchant-grade phosphoric acid (52-54%), additional concentration of the product acid is usually required. The overall reaction can be represented by the following reaction equation:

$$Ca_{10}(PO_4)_6F_2CaCO_3 + 11\,H_2SO_4 + 11\varphi H_2O \longrightarrow 6\,H_3PO_4 + 11CaSO_4\varphi H_2O + 2\,HF + CO_2 + H_2O$$

Where φ is 0, 1/2 or 2 for calcium sulphate formed in anhydrate, hemihydrate or dihydrate form.

The process operating conditions are generally selected so that the calcium sulphate will be precipitated in either dihydrate ($CaSO_4.2H_2O$) or hemihydrate ($CaSO_4.½H_2O$) form; 26-32% P_2O_5 at 70-80 °C for dihydrate precipitation and 40-52% at 90-110 °C for hemihydrate precipitation.

1.5.3 Wet phosphoric acid production processes

There are four major processes commonly used in the manufacturing of phosphoric acid, where the suitability of each process depends on the analysis of specific rock as well as other considerations:

a) Dihydrate process (DH)
b) Hemihydrate process (HH)
c) Hemi-Dihydrate process (HDH)
d) Di-Hemihydrate process (DH/HH)

1) <u>Dihydrate process (DH)</u>

Most phosphoric acid plants in the world operate the dihydrate process. In this process, most phosphate rocks need particle size reduction through the application of ball or rod mills. The phosphate rock is converted by reaction with concentrated sulphuric acid. The operating parameters are controlled in such a way that the reaction temperature is maintained at about 75-85 °C where dihydrate crystals of calcium sulphate ($CaSO_4.2H_2O$) are formed. The process produces phosphoric acid of 26-32% P_2O_5. Due to the low strength of the product acid, significant concentration is needed to produce a merchant-grade acid. Also, Dihydrate process is adaptable to a wide variation in rock phosphate quality.

The Dihydrate process comprises four stages (see Fig. (1.6))

a) Rock grinding
b) Reaction
c) Filtration
d) Concentration

Rock grinding

Some grades of commercial rock do not need grinding, their particle size distribution being acceptable for a dihydrate reaction section (60-70% less then 150 µm). Other phosphate rocks need particle size reduction by ball or rod mills. Both mills can operate with wet or dry rock.

Reaction

The reaction system consists of a series of separate agitated reactors where ground rock phosphate is fed to the reactor then it is reacted with dilute sulphuric acid. Agitators are provided for proper mixing for the reaction. The heat evolved during reaction is constantly released by vaporization of water during the vacuum flashing of the attack slurry in flash cooler.

Filtration

The phosphoric acid slurry that leaving the ageing tank (digestion tank) is then fed to a filter. This stage separates the solid (calcium sulphate dihydrate “gypsum") from the liquid (phosphoric acid). The initial separation must be followed by at least two stages of washing, to ensure a satisfactory recovery of soluble P_2O_5 remaining in the cake. It is only possible to achieve the desired degree of separation at a reasonable rate if the filtration is either pressure or vacuum assisted and in practice vacuum is always used. The remaining liquid must be removed from the filter cake as far as possible at the end of the washing sequence. The cake must then be discharged and the cloth efficiently washed to clear it of any remaining solids which might otherwise build up and impair filtration in subsequent cycles. Five tons of gypsum are generally generated for every ton of acid produced.

Concentration

The feed acid that has an acid concentration of around 28% is concentrated in vacuum evaporation system to obtain merchant grade acid of about 52-54 % P_2O_5.

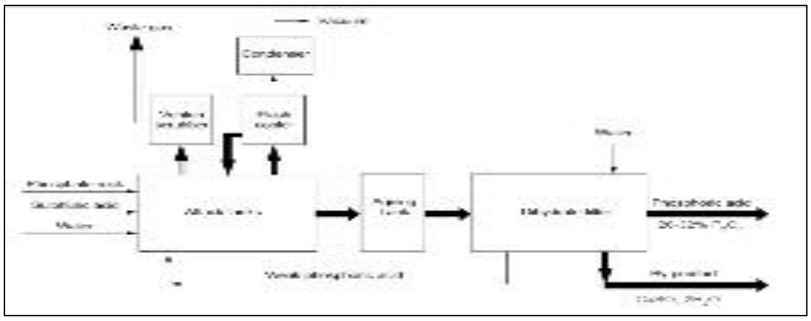


Fig. (1.6):

Diagram of the dihydrate process

2) <u>Hemihydrate process (HH)</u>

In the hemihydrate process, coarser rock than in DH process can be used. So, grinding may not be necessary, apart from that, the process stages of the hemihydrate process are similar to those of DH process.

It is possible to produce 40-52% P_2O_5 acid directly, with consequent valuable savings in energy requirements. The hemihydrate process comprises three stages, see Fig. (1.7)

a) Reaction
b) Filtration
c) Evaporation

The process is operated at temperatures of 90-100 °C where hemihydrate crystals of calcium sulphate ($CaSO_4.1/2H_2O$) are formed. In HH process the sulphuric acid consumption per ton of rock is lower than in DH process. However, the consumption per ton of P_2O_5 may not be different due to a lower P_2O_5 yield of HH process. The quality of the calcium sulphate produced by hemihydrates process is lower than that produced by DH process. This is not only because of a higher P_2O_5 content, but also because of a higher level of impurities such as fluorine and heavy metals. Also, as less sulphuric acid is used and more impurities end up in the calcium sulphate, the acid produced by HH process is generally purer than the acid produced by DH process. But it is also worthy to mention that hemihydrate process is used only in limited quality of rock phosphate and any variation in the quality of rock will lead to process upsets.

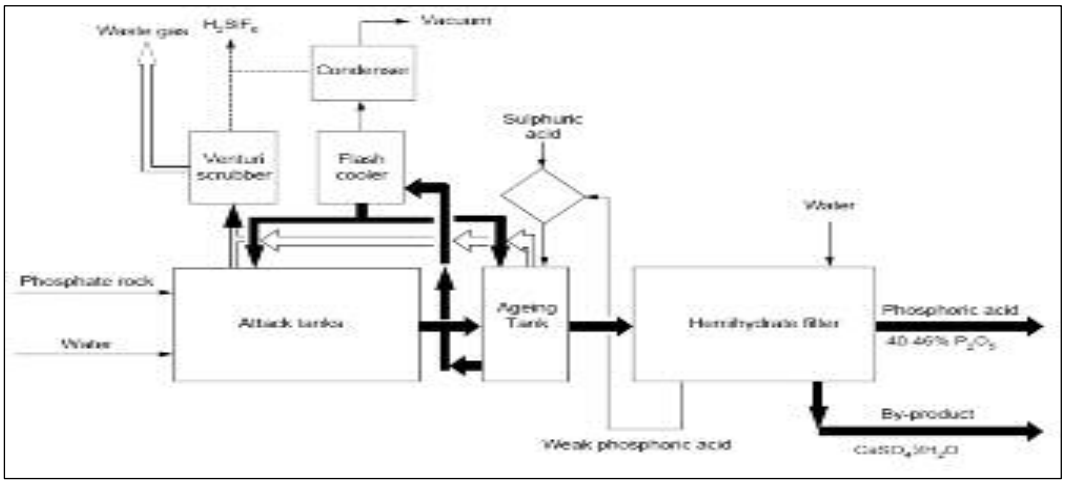


Fig. (1.7): Diagram of the hemihydrate process

3) <u>Hemi-Dihydrate process (HDH) (double stage filtration)</u>

In this process it is possible to produce a concentrated acid directly (40-52% P_2O_5) and the process reaction takes place under HH conditions. The HH and product acid are separated by filtration before recrystallization to DH. After recrystallization DH is filtered and washed. The acidic filtrate from the second stage is reused as washing fluid in the first stage.

4) <u>Di-Hemihydrate process (DH/HH) (double stage filtration)</u>

The process produces relatively pure gypsum and a moderate strength phosphoric acid (32-35% P_2O_5). In this process, initial reaction takes place under DH conditions, after which DH and product acid are separated in the first filtration stage. Subsequently, DH is recrystallized to HH. This conversion requires the input of heat (by steam). Finally, HH is filtered and washed in a second filtration step.

1.5.4 Advantages and disadvantages of the different wet process

Following are the main advantages and disadvantages of the different wet process to produce phosphoric acid by using sulphuric acid and phosphate rocks as main raw materials.

1.5.5 Process selection

Since the plant will be designed to process low grade/sub commercial rock phosphate and since there is variation in the quality of rock phosphate from mine to mine. The technology will be based on the dihydrate process. This is also beneficial taking into account the benefits of the process mentioned before in addition to its high capacity, predictable performance and long track

record of experience as well as due to its ease of operation and the need of single stage filtration which reflect the environmental issues. Precisely the Prayon dihydrate process technology was selected for this project.

Table (1.4): Advantages and disadvantages of the different wet process for producing phosphoric acid

Dihydrate Process	
Advantages	**Disadvantages**
• Flexibility of rock source • Wet rock grinding possible • Simple design • Single stage filtration • Ease of operation/ shut-down • Low maintenance cost and high operating factors. • Easy transport of gypsum	• May require rock grinding • Produces acid at 26-32% P_2O_5 • P_2O_5 efficiency 94 -96% • Normally, requires steam for evaporation • Requires weak acid storage and evaporation
Hemi hydrate Process	
• Uses coarse rock • Ease of operation • Produces strong acid directly (40-48% P_2O_5) • Single stage filtration • Evaporation heat requirements are reduced due to the fact that an acid high in concentration is produced	• Limited number of rocks processed industrially • Low P_2O_5 efficiency 91 - 92% • Risk of corrosion due to a higher temperature and higher acid concentration • Care required in design and shut-down
Hemi- Dihydrate Process (HDH)	
• Uses coarse rock • Produces strong acid directly (40-42% P_2O_5) • High P_2O_5 efficiency (96%) • Low sulphuric acid consumption • Produces a purer gypsum	• Limited number of rocks processed industrially • Two-stage filtration, lower utilization. • Care required in design and shut-down • High capital cost
Di-Hemihydrate Process (DH/HH)	
• Flexibility of rock source • Higher acid strength (32-36% P_2O_5) • High P_2O_5 efficiency (96%) • Produces a purer hemihydrate • Gypsum may be used directly	• Normally, requires rock grinding • Requires steam for evaporation • Require final re-hydration • Require sophisticated materials of construction • Care required in design and shut-down • High capital cost

1.6 Phosphoric Acid Process Description

Major raw materials needed

Phosphate rock: The annual requirement is about 1.9 million tons. Phosphate rock will be supplied from JPMC mines in Eshidiya by trucks.

Sulphuric acid: All the quantity that will be produced from sulphuric acid will be pumped to the phosphoric acid plant for continuous consumption as per demand (4,500 tons/day).

Raw water: The water will be supplied from wells drilled by JIFCO from the surrounding wells located in Eshidiya. The total consumption of water is expected to be about 19,000 m^3/day (6.0 million cubic meter annually). Phosphoric acid plant consumption of water will be about 416 m^3/h (9,996 m^3/day). To view the detailed water balance for this project, please refer to Fig. (1.15).

Limestone: The limestone will be used for neutralizing the off grade fluosilicic acid produced from the phosphoric acid plant if required. About 500 metric tons annually will be used.

Phosphate rock storage and handling

Phosphate rock will be stored in an open storage of capacity 20,000 MT. The storage will have flooring and retaining wall on three sides. There will be an unloading hopper for unloading rock phosphate received through trucks and a conveyor with stacking arrangement. A telescopic chute will be provided at the discharge of the conveyor to minimize emission of dust. Reclamation of the rock phosphate from the storage will be through an underground conveyor. Openings will be provided at different locations of the storage for feeding rock phosphate to the underground conveyor. Phosphate rock will be then transferred to be fed to a ball mill for grinding then it will be stored after screening. ***See process flow diagram of the phosphoric acid plant, sheet (1) at the end of this chapter***.

Fig. (1.8): Ball mill used for rock grinding

Fig. (1.9): Steel balls used for grinding inside the ball mill

<u>Reaction, digestion and filtration</u>

Recalling the reaction of phosphoric acid production:

$$Ca_{10}(PO_4)_6F_2CaCO_3 + 11\,H_2SO_4 + 11\varphi H_2O \longrightarrow 6\,H_3PO_4 + 11CaSO_4\varphi H_2O + 2\,HF + CO_2 + H_2O$$

Stored ground rock, sulphuric acid and recycled diluted phosphoric acid obtained from phospho-gypsum cake are all fed to an attack tank (reaction tank). The tank is divided into 8 agitated compartments and is made of concrete and protected with rubber lining that are covered with carbon bricks on the bottom and walls. During this reaction, a large amount of slurry is formed and heat is generated as well. The major part of heat is removed from the system by water vaporization in the flash cooler. The water vaporization cools down the reaction slurry. Vapors from the flash cooler are condensed partly then they are scrubbed with water coming from the scrubber. It is necessary to recycle to the reaction tank a definite amount of phosphoric acid to ensure the correct concentration of solids in the reaction tank. The air contaminated by acid vapors is washed in a fume scrubber before being released to the atmosphere. The reaction slurry moves to a digestion tank where all the conditions for the growth of phospho-gypsum crystals and the de-saturation of the solution are provided. ***See process flow diagram of the phosphoric acid plant, sheet (2) at the end of this chapter.***

The matured slurry is then sent to the filtration stage, where the phospho-gypsum crystals are separated from the phosphoric acid and then the phospho-gypsum crystals are washed to recover the P_2O_5 remaining in the cake. When the product acid is wholly drained from the cake, atmospheric air passes through the cake and helps to further drain the cake. A hood covers most of the filter area to capture the vapors which are washed before being released to the atmosphere. The filter cake from all filters will be discharged to a gypsum disposal area. The filter acid is then fed to weak acid storage tanks, where it is

then moved to the concentration units. ***See process flow diagram of the phosphoric acid plant, sheet (3) at the end of this chapter.***

Fig. (1.10): Filtration process

Concentration

The plant will have four identical concentration lines, 3 lines are operating and 1 line as stand-by. These units are of the "forced circulation" type and are designed for parallel operation. Every line is considered as a concentration loop where it consists mainly of: flash chamber, graphite tube heat exchanger, circulation pumps, fluorine scrubber, evaporator pre-condenser and a final condenser. Weak acid is supplied from storage via a pump to the concentrated acid stream. The acid passes progressively through the heat exchanger and then through the evaporator, where the heat supplied in the heat exchanger is dissipated by evaporation of water under vacuum. The phosphoric acid flows in the tubes and is heated by low-pressure steam condensing on the shell side. The concentrated acid overflows from the evaporator by gravity to a pump then it is transferred to storage tanks. Vapors leaving the flash chamber contain fluorine as HF and SiF_4. In order to prevent fluorine pollution of the cooling water to the maximum possible extent, the fluorine is recovered through a fluorine scrubber where water stream comes in contact with the vapor stream. During this circulation loop, fluorine concentration increases until it reaches the preset concentration between 16 to 20 % by weight H_2SiF_6. As soon as the specific gravity corresponds to the preset concentration is reached, the fluosilicic acid solution is stored in a storage tank. The fluosilicic acid shall be supplied to JPMC/Aqaba Industrial Complex for the production of aluminum fluoride. The concentrated acid originating from the identical concentration lines is finally transferred to agitated clarifier storage tanks. ***See process flow diagram of the phosphoric acid plant, sheet (4) at the end of this chapter.***

There is an acidic cooling tower which consists of several parallel induced draft cells. It is used to cool the recirculating streams of hot water coming from phosphoric acid plant. The cooling water circuit operates in a closed loop between the cooling tower and a set of condensers in reaction, filtration and concentration areas.

Fluosilicic acid

The fluosilicic acid production will be about 200 tons/day (20% concentration). JPMC will transport this acid to their aluminum fluoride plant in Aqaba. The aluminum fluoride plant in Aqaba of JPMC is running at 50% capacity now (200 tons/day) and will run at full capacity after receiving fluosilicic acid from JIFCO. JPMC has four storage tanks of a capacity of 2000 tons each. The storage tanks made of carbon steel with rubber lining from inside. The storage tanks are surrounded with containment area to handle any spells or leaks.

Phosphoric acid storage and handling at plant site

Phosphoric acid will be received from captive plant. Then the acid will be stored in two storage tanks each of 10,000 tons.

1.7 Phosphoric Acid Storage and Handling Facility at Aqaba

The phosphoric acid storage yard near the port will be located east north of the existing tanks that belong to the Indo Jordan Chemicals Company. This storage yard shall consist of five storage tanks of capacity 10,000 MT each. Fig. (1.11) shows the proposed site for these tanks, as well as the existed storage tanks that belong to Indo Jordan Chemicals Company.

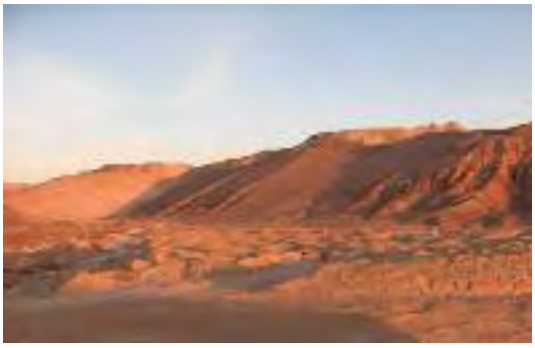


Fig. (1.11): Phosphoric acid storage tanks site located near the existing tanks.

The material of construction of these tanks will be of mild steel with rubber lining from inside. The tanks and pump area will be provided with acid proof brick lining. In case of any spillage of acid due to leakage, the tank and pump area shall be provided with water connections to clean the acid spillages and for flushing the lines during maintenance. The acidic water generated during washing operation shall also be collected in a sump and will be pumped back

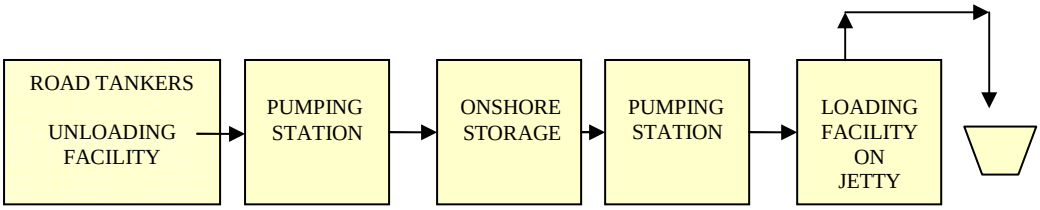
to the storage tank. Storage at Aqaba will be provided with Agitators and hence no accumulation of sludge in these tanks.

Phosphoric acid handling system

The following systems will be established on onshore and at the jetty for the export of phosphoric acid:

- Manifold bay for unloading phosphoric acid from road tankers.
- Phosphoric acid pumping station for unloading from road rankers and transfer to storage tanks.
- Onshore storage tank yard.
- Phosphoric acid pumping station for loading phosphoric acid on the ships from the storage tanks.
- Loading facilities on the jetty (pipeline, manifold and hoses for loading phosphoric acid from the jetty to the ships).
- Water envisaged to be used for process purposes like flushing pipelines, pumps, and administrative purposes.
- Eye washers and safety showers for personnel safety.
- Slop tank for collecting line, pump and tank drains/washings.
- Operator room.

All the facilities for handling phosphoric acid system will be designed to operate both in summer as well as in winter months. The phosphoric handling system can be schematically described with the following block diagram:



Road tankers for transportation

The road tankers of 35 MT having bottom discharge nozzles and with no provision of compressed air on the tanks to be utilized for unloading purposes. The road tanker will be made of stainless steel or with carbon steel with rubber lining from inside. Trucks transporting the phosphoric acid will be cleaned at Plant Site at Eshidiya. The effluent generated due to washing will be recycled back to the process.

1.8 Comparison between Project Technology and Best Available Technology Figures for Phosphoric Acid Production

The following table presents a comparison between the project technology figures and the Best Available Technology (BAT) figures regarding water and electrical consumption.

Table (1.5): Comparison between the project figures and BAT

Items in Phosphoric Acid Plant	Company Figures (per ton of P_2O_5)	BAT Figures* (per ton of P_2O_5)
Water consumption (m^3)	6.60	4-7
Electrical power consumption (kWh)	175	120 -180

*: Booklet No. 4 of 8: Production of phosphoric acid, EFMA European Fertilize Manufacturers' Association, 2000.

1.9 Environmental Hazards Associated with Wet Process Phosphoric Acid Production

Solid wastes

Gypsum is an unavoidable solid waste in wet phosphoric acid production. The disposal of gypsum will be on land near the plants site and next to the current existing gypsum disposal site that belongs to Indo Jordan Chemicals Company. The disposal site will occupy an area of around 1.7 km^2. It is expected that 2.8 million metric tons of gypsum will be generated annually, see Fig. (1.12).

The alternative to disposing of gypsum is to make use of it in some way. However, the basic problem with this is that the consumption rate for these uses is normally many times smaller than the production rate of the waste.

Fig. (1.12): Proposed gypsum disposal site

Liquid wastes

The proposed project shall have in-built effluent recovery system to collect the effluent generated in the plant and recycle to the process. The occasional effluent generated shall be stored in a guard pond of a capacity = 25,000 m^3, from where it shall be transferred at a control rate to the process. The fluosilicic acid produced shall be supplied to JPMC for the production of aluminum fluoride. Any off-grade fluosilicic acid produced shall be recycled into the phosphoric acid plant. Any remaining amount off-grade fluosilicic acid will be neutralized with limestone. Calcium silicate produced while neutralization the fluosilicic acid will be in wet form and will be disposed in designated area in the gypsum disposal area. The liquid will be recycled to the process.

Emissions

Major emissions from wet process acid production include gaseous fluorides; mostly silicon tetrafluoride (SiF_4) and hydrogen fluoride (HF). 10-15% of the fluorine contained in the phosphate rock is released during the acidulation and filtration stages. In general, part of the fluorine from the rock is precipitated out with the gypsum, another part is leached out with the phosphoric acid product and the remaining portion is vaporized in the reactor or evaporator. The reactor in which phosphate rock is reacted with sulphuric acid is the main source of emissions. Fluoride emissions accompany the air used to cool the reactor slurry. Acid concentration by evaporation is another source of fluoride emissions, approximately 20 to 40 percent of the fluorine originally present in the rock vaporizes in this operation. These gases will be collected by the ventilation system and then routed to a fume scrubber, where a re-circulating water stream scrubs away the fluorine from gases. The secondary emission is dust that will originate from the unloading, handling and grinding of phosphate rock. The necessary dust controlling equipment will be installed to comply with the IFC and national regulations.

1.10 Sulphuric Acid Plant

Sulphuric acid, H_2SO_4, is a strong mineral acid. It is soluble in water at all concentrations. Sulphuric acid has many applications and it is one of the top products of the chemical industry. It is used directly or indirectly in nearly all industries and is a vital commodity in any national economy.

Most of sulphuric acid uses are actually indirect in that the sulphuric acid is used as a reagent rather than an ingredient. The largest single sulphuric acid consumer by far is the fertilizer industry. Other uses include ore processing, oil refining, wastewater processing, chemical synthesis and metal processing.

1.10.1 Sulphuric acid production

The fundamental steps in production of sulphuric acid are:

- Production of SO_2 bearing gases through sulphur burning

  $S + O_2 \rightarrow SO_2$

- Conversion of SO_2 to SO_3

  $SO_2 + 1/2\ O_2 \rightarrow SO_3$

- Absorption of SO_3 for production of sulphiric acid

  $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$
  $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

Burning sulphur, SO_2 conversion and SO_3 absorption are exothermic processes. This means that from a technical point of view, installations for utilizing energy produced are of great importance for the production of sulphuric acid.

1.10.2 Process selection

There are two processes for manufacturing of sulphuric acid and Table (1.6) shows the comparison between the two processes. The two processes are:

1) Single Conversion Single Absorption (SCSA)
2) Double Contact Double Absorption (DCDA)

Table (1.6): Comparison between SCSA and DCDA processes

Process	SO_2 Content in Feed Gas (vol %)	Conversion Rate, daily Average	State of the Art Emission for New Plants, SO_3
SCSA	6-10 3-6	98.5% 97.5% - 98.5%	0.4 kg/te
DCDA	6-12	99.7%	0.15 kg/te

Double contact double absorption is considered as the Best Available Technology (BAT) for new plants. The principle of the process is to increase the overall conversion efficiency to SO_3 and decrease the quantity of SO_2 released to atmosphere. Looking at the table above we notice that double absorption leads to conversion rates of 99.7%, which is the highest compared to other processes. Thus, this process was selected for the production of sulphuric acid for this project.

1.10.3 Double contact double absorption (DCDA) process description

Major raw materials needed

Sulphur: The annual requirement will be about 0.5 million tons. Sulphur will be imported by sea or land to Aqaba by JPMC, and then it will be transported by trucks to the plant.

Lime (CaO): It will be used for the neutralization of sulphur acidity before melting, and it will be supplied from the local market.

Raw water: Sulphuric acid plant consumption of water will be about 370 m^3/h (8,868 m^3/day). To view the detailed water balance for this project, please refer to Fig. (1.15).

Sulphur storage and handling

Elemental sulphur will be transported to the plant site by road. Then it will be stored in an open storage of capacity 30,000 MT. Concrete flooring will be provided at the storage area with retaining walls on three sides. The approximate size of the storage area shall be 140 m x 75 m and the height of retaining wall shall be about 2.5 m to 3 m. Sulphur will be unloaded directly from trucks at the storage area. Reclamation of sulphur from the storage for transfer to plant will be through conveyor. From the storage a pay loader shall feed sulphur to the reclaim conveyor. The sulphur storage area will be provided with fire hydrants and portable spray systems.

Sulphur melting and filtration

Sulphur from storage will be then fed to melting tanks. Lime is injected to the sulphur for neutralization of acidity before melting. After that it will be filtered and stored in a molten sulphur storage tank. ***See process flow diagram of the sulphuric acid plant, sheet (5) at the end of this chapter*.**

Fig. (1.13): Sulphur melting process

Fig. (1.14): Sulphur filtration process

Sulphur burning

Clean molten sulphur is burnt with dried air (coming from the drying tower) in refractory lined furnace to produce sulphur dioxide (SO_2) at a temperature of about 1100 °C, SO_2 is then sent to a waste heat boiler for cooling to a temperature of about 425 °C which is considered as the optimum temperature for conversion to SO_3.

SO_2 conversion to SO_3 and SO_3 absorption

Conversion of SO_2 to SO_3 follows gas phase equilibrium. Without a catalyst, the reaction needs a very high temperature and since the equilibrium favors SO_2 conversion a catalyst will be needed. Vanadium pentoxide (V_2O_5) is used as the catalyst at a temperature of 410 °C – 430 °C. The conversion of SO_2 to SO_3 takes place over four beds of V_2O_5 catalyst. Partly converted gas leaving the first catalyst bed is cooled in a steam super heater; the cooled gas enters the second catalyst bed for additional SO_2 conversion. Cooling after second and third pass is carried out by heat exchange with gas returning from the intermediate absorber. The first absorption takes place after the converter third pass and the final absorption after the converter fourth pass. Gas exiting the fourth bed is cooled by a final economizer to a temperature suitable for a complete SO_3 absorption. ***See process flow diagram of the sulphuric acid plant, sheet (6) at the end of this chapter.***

Sulphric acid is obtained by absorption of SO_3 in water and this is an exothermic reaction, thus heat must be continuously removed from the acid. This is carried out in shell and tube type coolers. Acid produced in the absorption tower is diluted with demineralized water to the desired acid concentration which is usually about 98.5%. The produced acid is then sent to acid coolers to be cooled to a final temperature suitable for storage. The entire area handling sulphuric acid including foundation diked area, pump bay and

drain tank pit shall be lined with acid resistant bricks. ***See process flow diagram of the sulphuric acid plant, sheet (7) at the end of this chapter.***

Sulphuric acid storage and handling

Sulphuric acid from the sulphuric acid plant shall be stored in three storage tanks each of 10,000 MT. Sulphuric acid will be pumped to phosphoric acid plant for continuous consumption as per demand.

1.11 Comparison between Project Technology and Best Available Technology Figures for Sulphuric Acid Production

The following table presents a comparison between the project technology and the best available technology figures regarding energy generation/consumption, water consumption and air emissions for H_2SO_4 production.

Table (1.7): Comparison between the project and BAT

Items in Sulphuric Acid Plant	Company Figures (per ton of H_2SO_4)	BAT Figures* (per ton of H_2SO_4)
Energy output (MJ)	3,858	2,500
Water consumption (m^3)	1.97	Not available
Emissions to air (kg)		
SO_2 (kg SO_2/ton 100% H_2SO_4)	2	1.5-3.9
SO_3	0.075	0.1

*: Booklet No. 3 of 8: Production of Sulphuric Acid, EFMA European Fertilize Manufacturers' Association, 2000.

1.12 Environmental Hazards Associated with Sulphuric Acid Production

- As solid waste, the spent vanadium pentoxide catalyst (V_2O_5) should be carefully dealt with since it is on the hazardous substances list. At present, the spent catalyst is difficult to dispose of safely. Vanadium metal is poisonous. Generally, the spent catalyst is sealed in steel or plastic drums and stocked in old mines, or encased in concrete. The recommended airborne exposure limit is 0.05 mg/m^3 averaged over an 8-hour work shift for respirable vanadium pentoxide dust or fume. For this project, it will be returned to the supplier.

- Some solid waste will be generated from the sulphur filtration process which is the filter cake. This waste will be mixed with some of the gypsum and then disposed on land in the gypsum disposal area.

- SO_2 emissions may originate from bad conversion efficiency and gas bypassing (acid cross bleed or convector). SO_3 emissions may originate in case of bad absorption efficiency and vapor pressure of sulphuric acid. H_2SO_4 emissions may as well originate from mist formation, vapor pressure or problems in the tower design. The company will install the necessary equipment to comply with IFC and national regulations and requirements.

- During storage and handling of sulphuric acid, leaks may have an impact on the soil or on water.

1.13 Eshidiya Utilities Facilities

1.13.1 Water supply

The total water requirement for the project during normal operation will be about 19,000 m^3/day (6.0 million m^3/year). JPMC has water extraction rights for all its present and future requirements at Eshidiya. The project will use the wells which are located between 15 km and 25 km north of Eshidiya mines and has a capacity of 18 million m^3 annually and a life of more than 25 years. However, this capacity is not sufficient to meet the total demand of the project, and hence JIFCO will drill about 4 new wells in addition to the existing one, each with a capacity of about 200 m^3/hr to meet the water demand for the project.

The water that will be used in the project will be distributed from the storage tank to the demineralized water system, potable water system (which will be sent to a sand filter then chlorinated before use), phosphoric acid plant, sulphuric acid cooling tower, see Fig. (1.15).

1.13.2 Demineralized water

A demineralization (DM) unit will be used to produce demineralized water for steam generation in boiler. The water used for steam generation will be further treated by passing it through an activated carbon filter to remove residual chlorine, then through a strong acid cation exchanger, and then through a degasser tower followed by strong base anion exchanger. The recovered condensate from the sulphuric acid and phosphoric acid plant will be polished in the condensate polishing unit before sending to DM water storage tank of a capacity of 2,500 m^3. The capacity of demineralized water plant shall be about 90 m^3/hr.

1.13.3 Domestic waste water

Domestic wastewater that will be generated from the project in Eshidyia (around 300 m^3/day) will be collected and treated in an activated sludge unit. The reclaimed water will be reused for irrigation of the green belt around the plant site.

1.13.4 Cooling towers

Two cooling water systems will be used; one for phosphoric acid plant and the other for sulphuric acid plant and turbo generator.

1.13.5 Auxiliary boiler

One auxiliary boiler of capacity 80 MT/hr to produce steam at 40 bar will be provided for start-up of the sulphuric acid plant. The boiler will be either fire tube or water tube type operated by fuel oil/diesel.

1.13.6 Power generation and distribution

The heat generated during sulphur combustion process and conversion of sulphur dioxide to sulphur trioxide will be used to produce about 225 MT/hr high pressure steam at 40 bar and 400 ˚C in a waste heat boiler that in turn shall be used for generation of about 26 MW electricity in a turbo generator. The power generated will meet the power requirement of the project and any excess power will be exported to the national grid. In the event of a power failure, emergency diesel generator set of about 2.5 MW capacity will be provided to supply power to the essential facilities.

1.13.7 Instrument air

The unit will consist of air compressors, air-drying system and storage of process and instrument air. The ambient air is compressed to 8.0 bar, the heat of compression is removed in inter coolers and after coolers. Two compressors have been provided, one operating and one standby.

1.13.8 Fire fighting system

The sulphuric acid and phosphoric acid plants have been considered as “Ordinary Hazard” category. The basic fire fighting system consists of the following:

a) Hydrant and monitor system

b) Sprinkler system for sulphur storage and conveying areas
c) Portable fire extinguishers: Shall be provided in the storage area, utility facility area and inside the buildings.
d) Fire engine.

Coordination with the local Civil Defense department at the complex shall also be maintained.

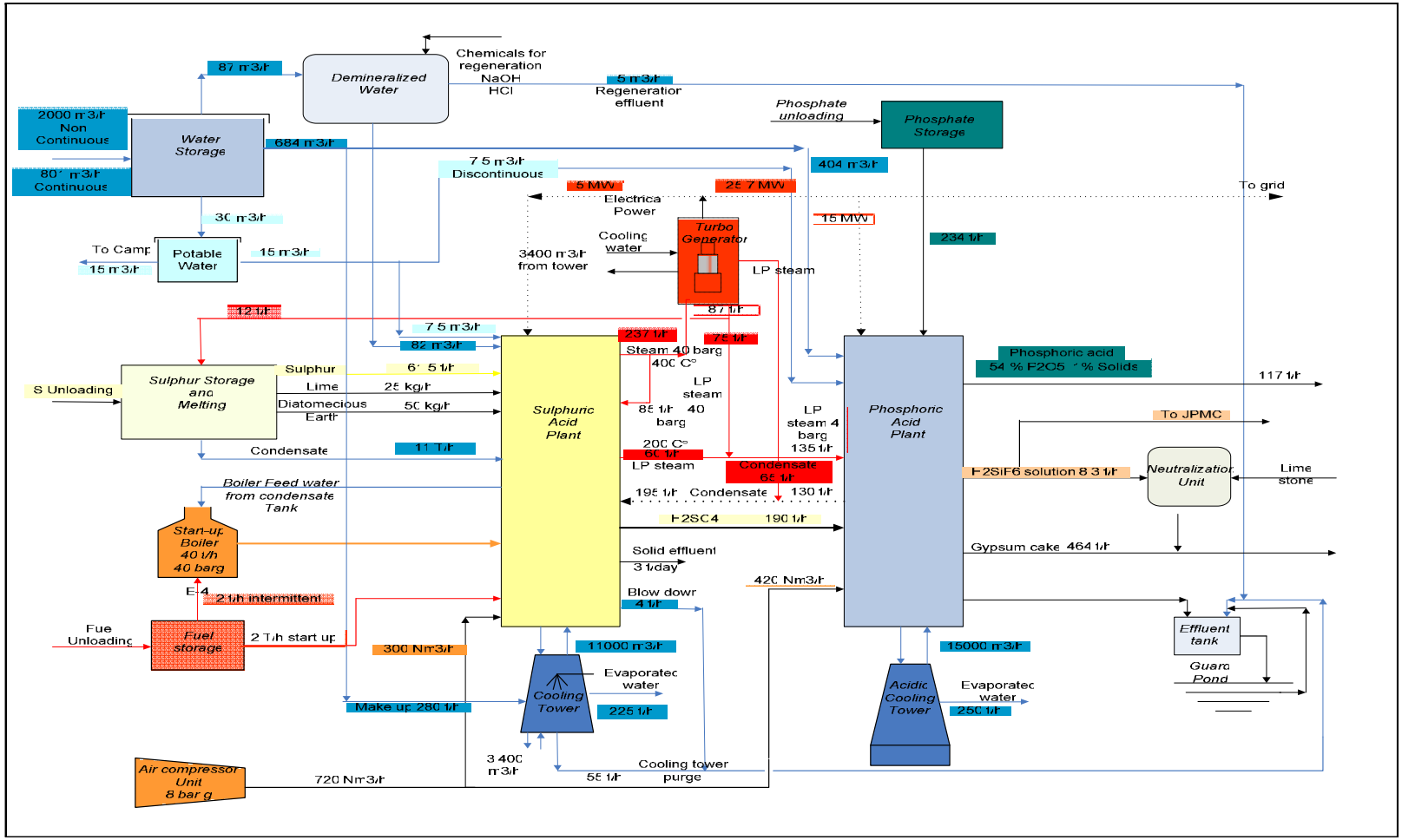
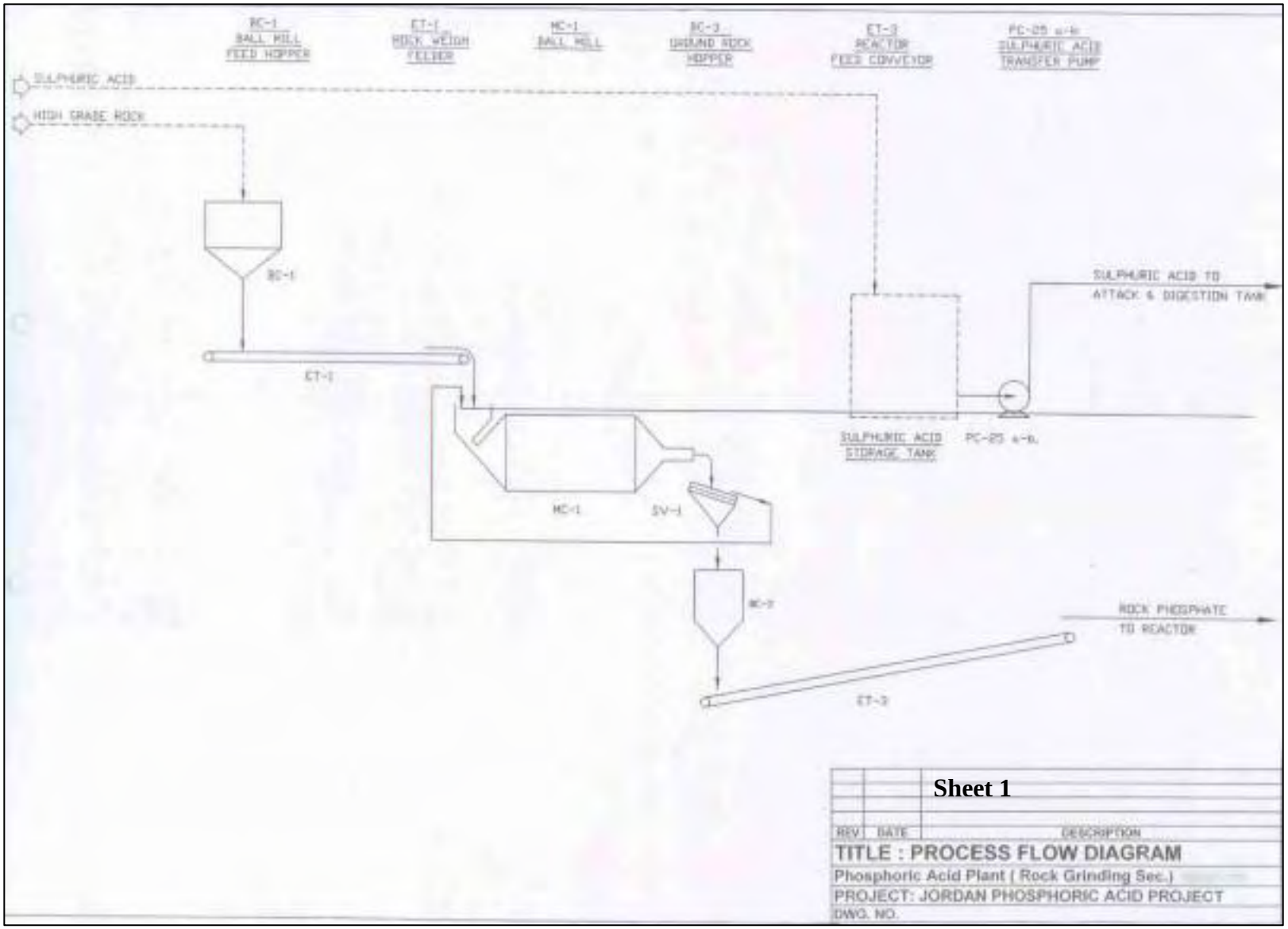


Fig. (1.15): Water and material balance for the project at Eshidyia


BC-1
BALL MILL
FEED HOPPER
ET-1
ROCK WEIGH
FEEDER
MC-1
BALL MILL
BC-2
GROUND ROCK
HOPPER
ET-2
REACTOR
FEED CONVEYOR
PC-25 a-b
SULPHURIC ACID
TRANSFER PUMP
SULPHURIC ACID
HIGH GRADE ROCK
BC-1
ET-1
SULPHURIC ACID TO
ATTACK & DIGESTION TANK
SULPHURIC ACID
STORAGE TANK
PC-25 a-b
MC-1
SV-1
BC-2
ROCK PHOSPHATE
TO REACTOR
ET-2
Sheet 1
REV
DATE
DESCRIPTION
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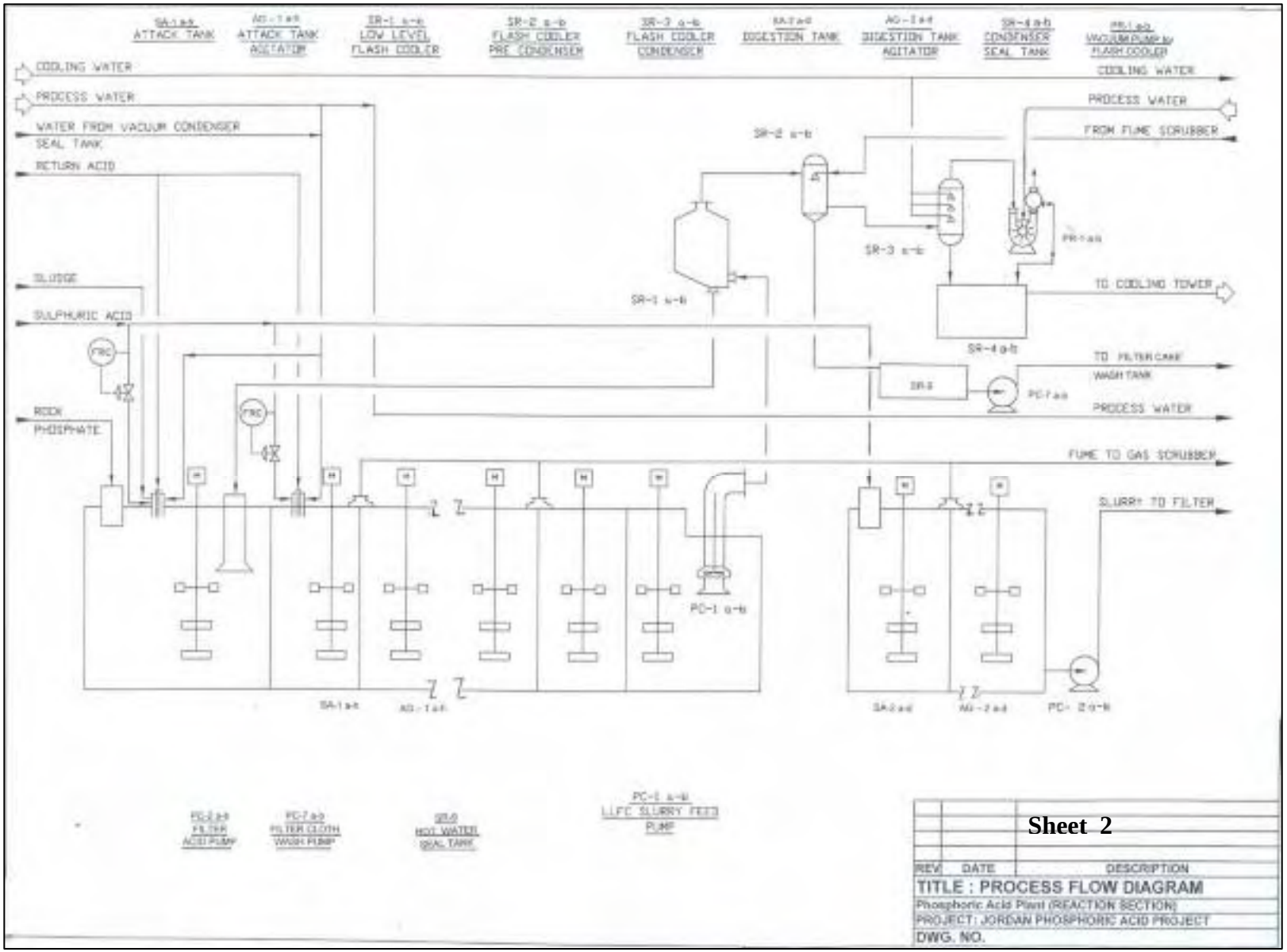
Phosphoric Acid Plant (Rock Grinding Sec.)
PROJECT: JORDAN PHOSPHORIC ACID PROJECT
DWG. NO.


ATTACK TANK
ATTACK TANK AGITATOR
LOW LEVEL FLASH COOLER
FLASH COOLER PRE CONDENSER
FLASH COOLER CONDENSER
DIGESTION TANK
DIGESTION TANK AGITATOR
CONDENSER SEAL TANK
VACUUM PUMP for FLASH COOLER
COOLING WATER
PROCESS WATER
WATER FROM VACUUM CONDENSER SEAL TANK
RETURN ACID
SLUDGE
SULPHURIC ACID
ROCK PHOSPHATE
COOLING WATER
PROCESS WATER
FROM FUME SCRUBBER
TO COOLING TOWER
TO FILTER CAKE WASH TANK
PROCESS WATER
FUME TO GAS SCRUBBER
SLURRY TO FILTER
FILTER ACID PUMP
FILTER CLOTH WASH PUMP
HOT WATER SEAL TANK
LLFC SLURRY FEED PUMP
Sheet 2
REV DATE DESCRIPTION
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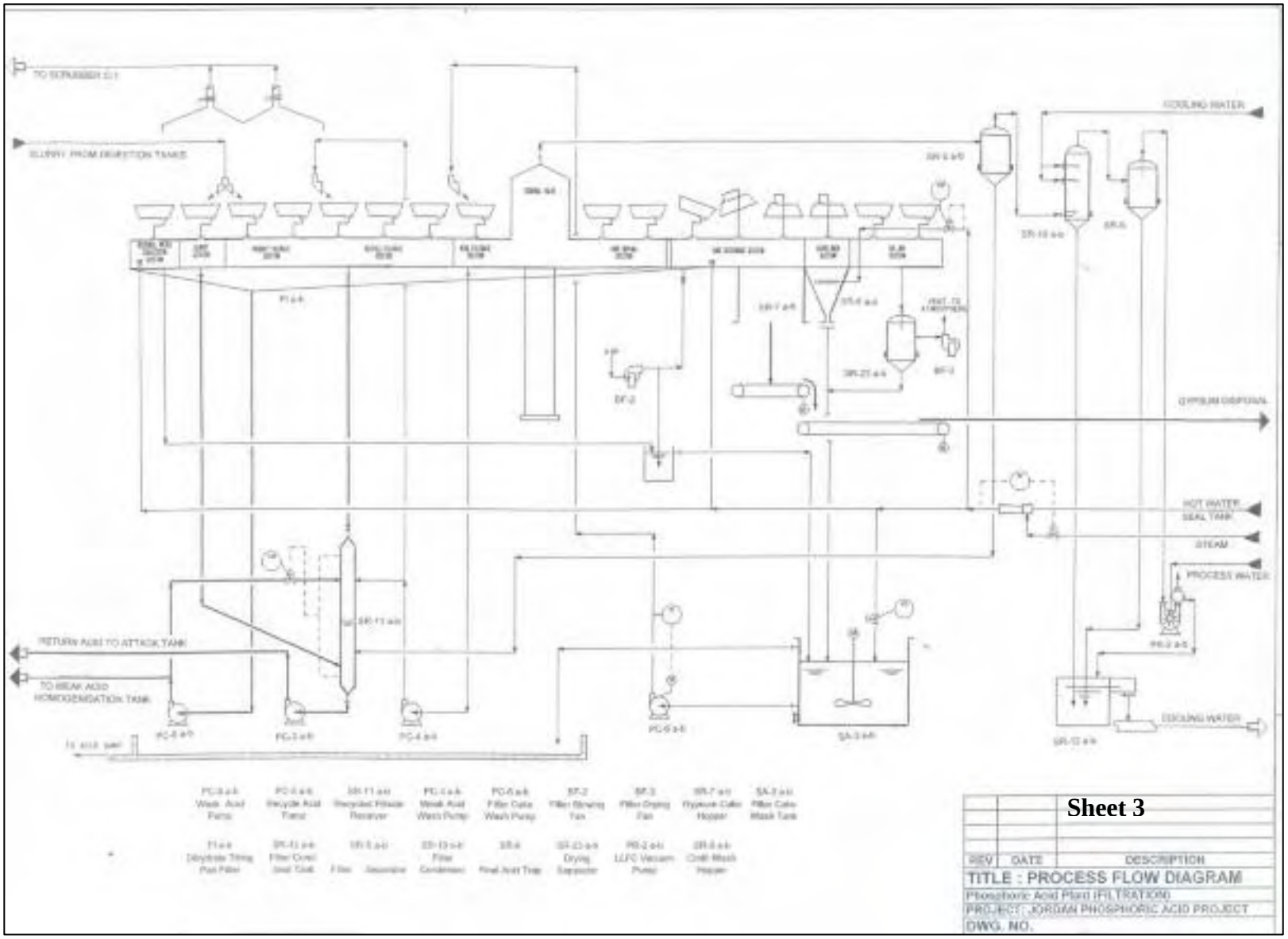
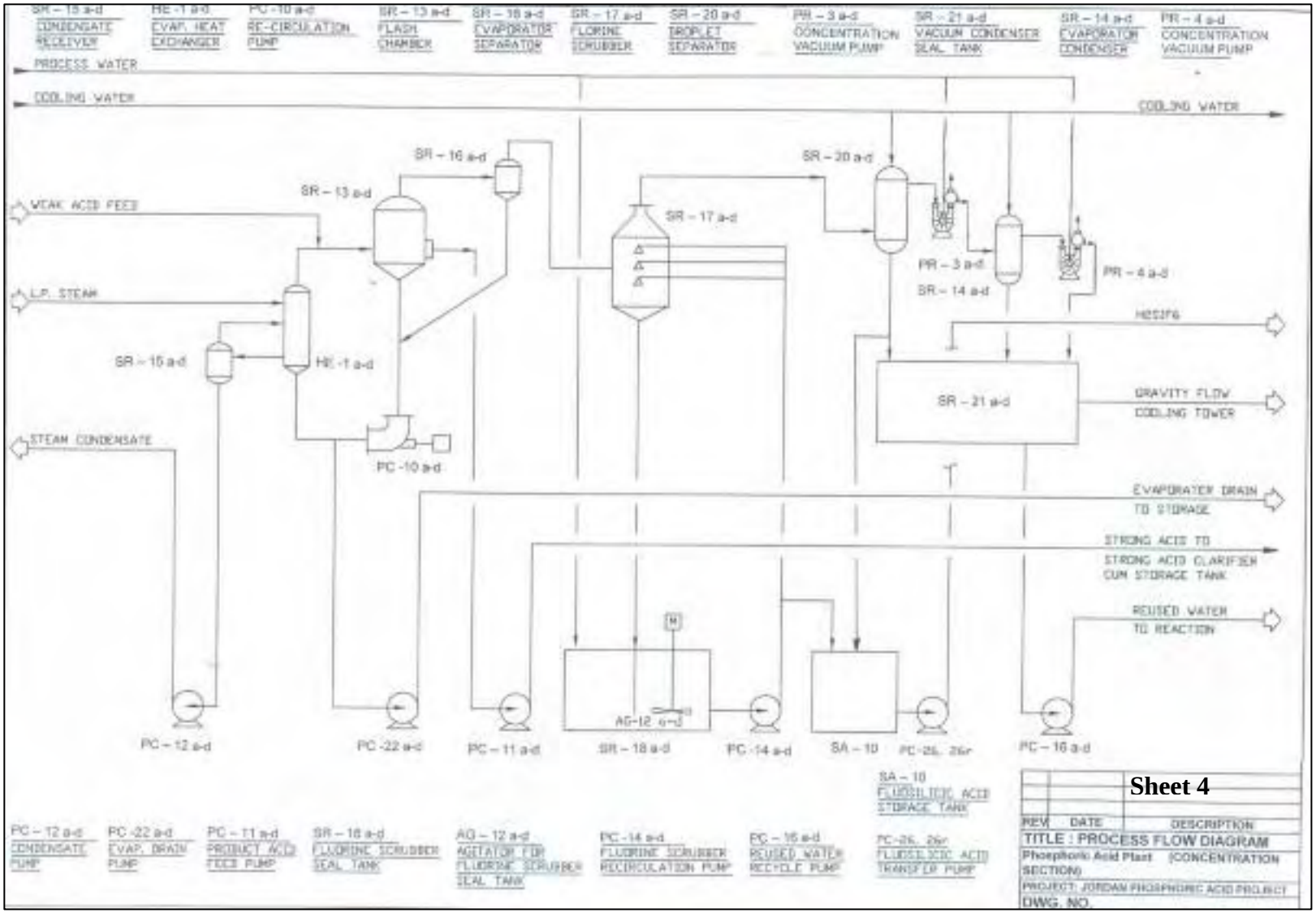
Phosphoric Acid Plant (REACTION SECTION)
PROJECT: JORDAN PHOSPHORIC ACID PROJECT
DWG. NO.


COOLING WATER
GYPSUM DISPOSAL
HOT WATER SEAL TANK
STEAM
PROCESS WATER
RETURN ACID TO ATTACK TANK
TO WEAK ACID HOMOGENIZATION TANK
COOLING WATER
Sheet 3
REV
DATE
DESCRIPTION
TITLE : PROCESS FLOW DIAGRAM
Phosphoric Acid Plant (FILTRATION)
PROJECT : JORDAN PHOSPHORIC ACID PROJECT
DWG. NO.


SR – 15 a-d CONDENSATE RECEIVER
HE -1 a-d EVAP. HEAT EXCHANGER
PC -10 a-d RE-CIRCULATION PUMP
SR – 13 a-d FLASH CHAMBER
SR – 16 a-d EVAPORATOR SEPARATOR
SR – 17 a-d FLORINE SCRUBBER
SR – 20 a-d DROPLET SEPARATOR
PR – 3 a-d CONCENTRATION VACUUM PUMP
SR – 21 a-d VACUUM CONDENSER SEAL TANK
SR – 14 a-d EVAPORATOR CONDENSER
PR – 4 a-d CONCENTRATION VACUUM PUMP
PROCESS WATER
COOLING WATER
COOLING WATER
WEAK ACID FEED
L.P. STEAM
STEAM CONDENSATE
HEZIFG
GRAVITY FLOW COOLING TOWER
EVAPORATER DRAIN TO STORAGE
STRONG ACID TO STRONG ACID CLARIFIER CUM STORAGE TANK
REUSED WATER TO REACTION
PC – 12 a-d
PC -22 a-d
PC – 11 a-d
SR – 18 a-d
PC -14 a-d
SA – 10
PC – 16 a-d
PC – 12 a-d CONDENSATE PUMP
PC -22 a-d EVAP. DRAIN PUMP
PC – 11 a-d PRODUCT ACID FEED PUMP
SR – 18 a-d FLUORINE SCRUBBER SEAL TANK
AG – 12 a-d AGETATOR FOR FLUORINE SCRUBBER SEAL TANK
PC -14 a-d FLUORINE SCRUBBER RECIRCULATION PUMP
PC – 16 a-d REUSED WATER RECYCLE PUMP
SA – 10 FLUOSILICIC ACID STORAGE TANK
PC-26, 26r FLUOSILICIC ACID TRANSFER PUMP
Sheet 4
REV DATE DESCRIPTION
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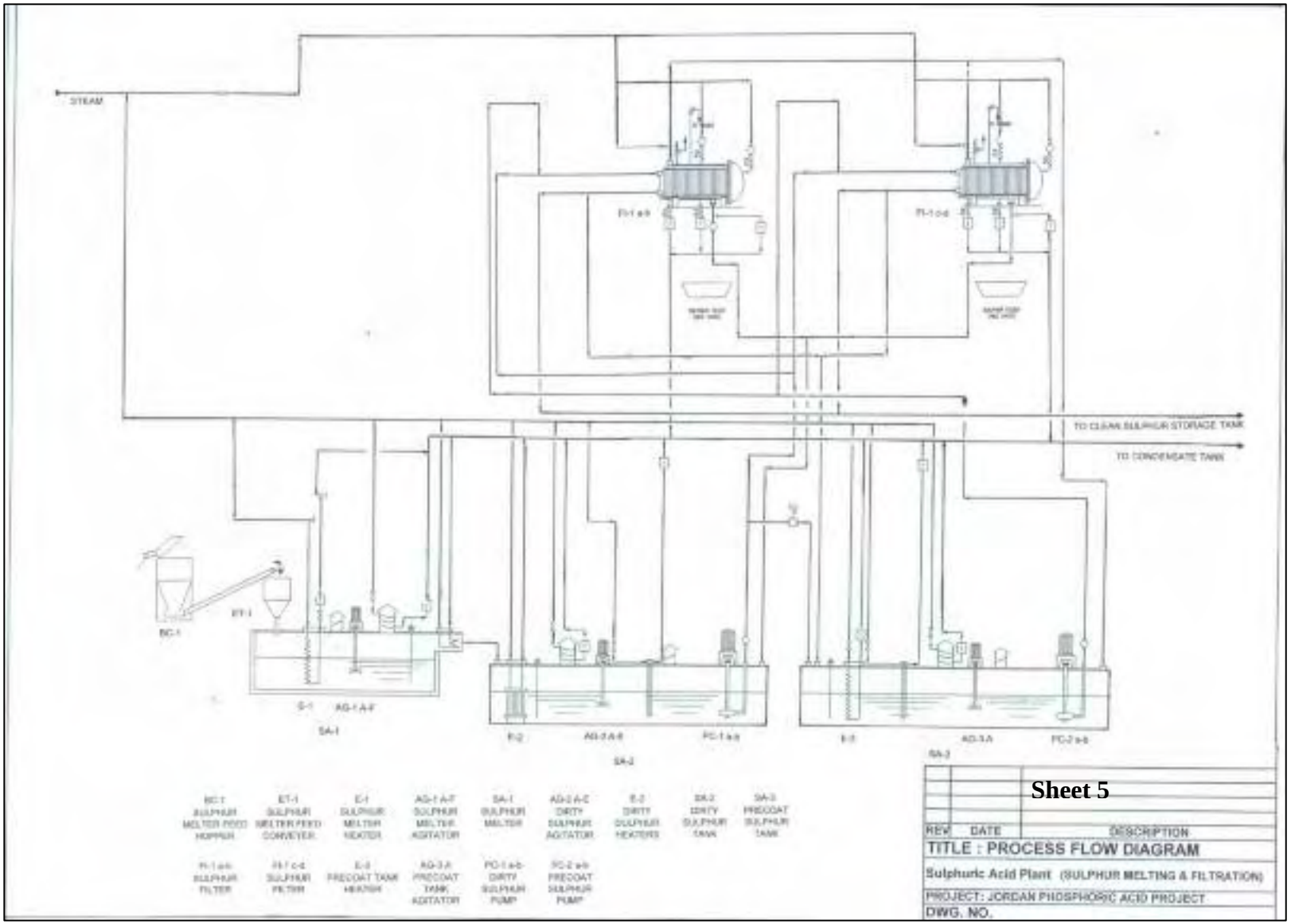
Phosphoric Acid Plant (CONCENTRATION SECTION)
PROJECT: JORDAN PHOSPHORIC ACID PROJECT
DWG. NO.


STEAM
TO CLEAN SULPHUR STORAGE TANK
TO CONDENSATE TANK
Sheet 5
REV DATE DESCRIPTION
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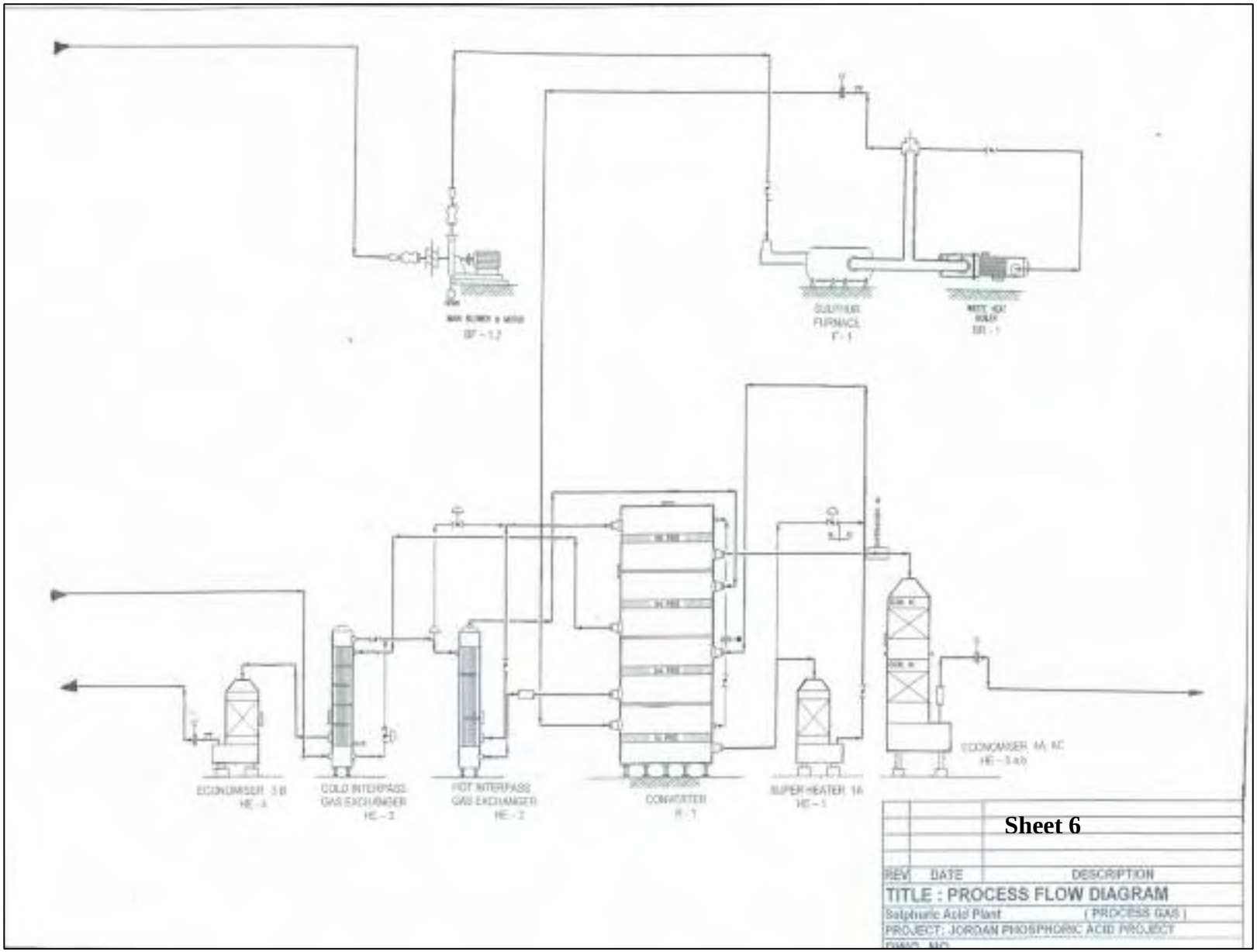
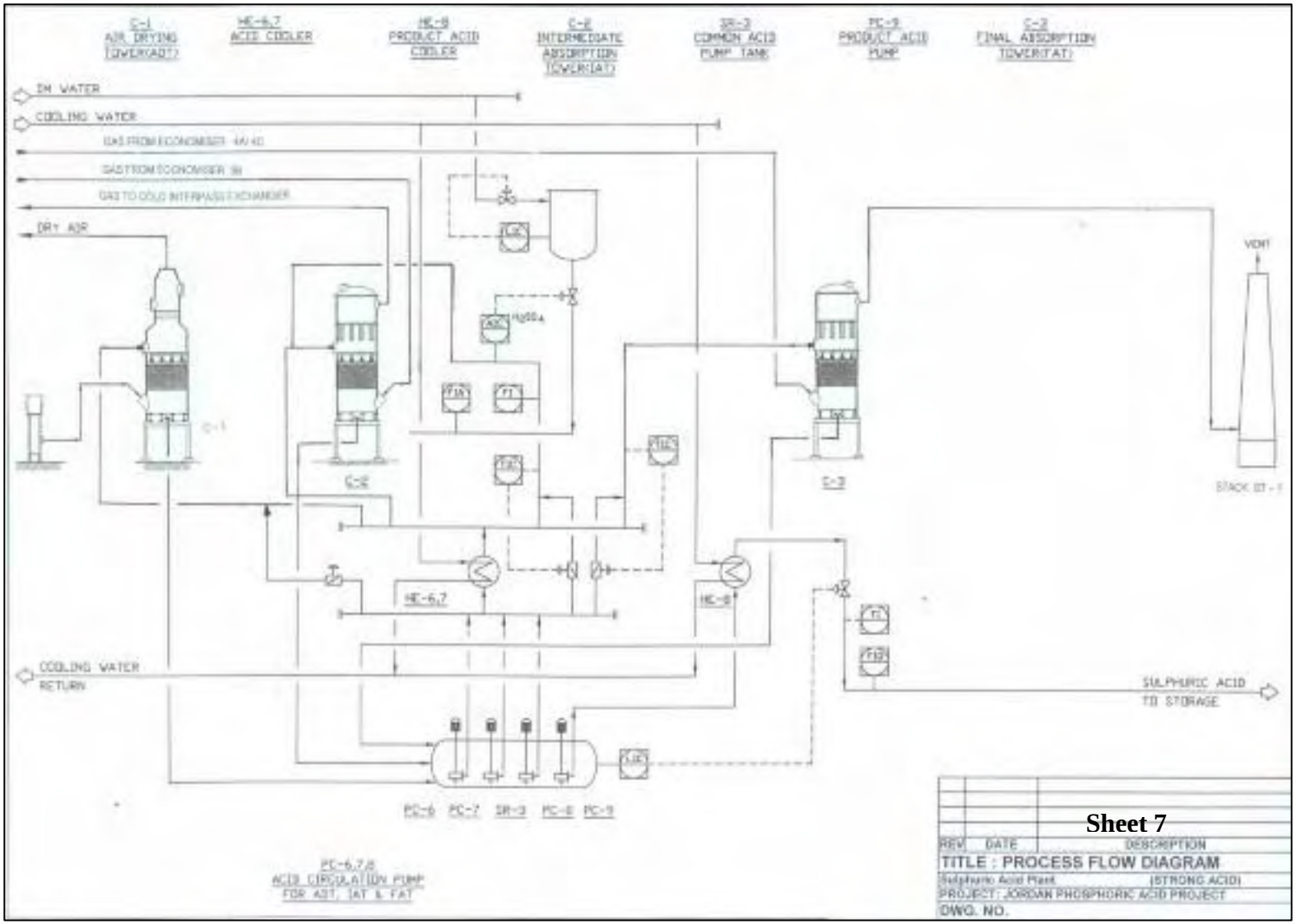
Sulphuric Acid Plant (SULPHUR MELTING & FILTRATION)
PROJECT: JORDAN PHOSPHORIC ACID PROJECT
DWG. NO.


SULPHUR FURNACE
F-1
ECONOMISER 3 B
HE-4
COLD INTERPASS GAS EXCHANGER
HE-3
HOT INTERPASS GAS EXCHANGER
HE-2
CONVERTER
R-1
SUPER HEATER 1A
HE-1
ECONOMISER 4A, 4C
HE-3 A,B
Sheet 6
REV DATE DESCRIPTION
TITLE : PROCESS FLOW DIAGRAM
Sulphuric Acid Plant (PROCESS GAS)
PROJECT: JORDAN PHOSPHORIC ACID PROJECT


C-1
AIR DRYING
TOWER(AIT)
HE-6,7
ACID COOLER
HE-8
PRODUCT ACID
COOLER
C-2
INTERMEDIATE
ABSORPTION
TOWER(IAT)
SR-3
COMMON ACID
PUMP TANK
PC-9
PRODUCT ACID
PUMP
C-3
FINAL ABSORPTION
TOWER(FAT)
DM WATER
COOLING WATER
DRY AIR
VENT
C-1
C-2
C-3
HE-6,7
HE-8
COOLING WATER
RETURN
SULPHURIC ACID
TO STORAGE
PC-6 PC-7 SR-3 PC-8 PC-9
PC-6,7,8
ACID CIRCULATION PUMP
FOR AIT, IAT & FAT
Sheet 7
REV DATE DESCRIPTION
TITLE : PROCESS FLOW DIAGRAM
Sulphuric Acid Plant (STRONG ACID)
PROJECT: JORDAN PHOSPHORIC ACID PROJECT
DWG. NO.

2. POLICY, LEGAL FRAMEWORK AND CONSULTATIONS

2.1 Introduction

This chapter provides an outline of the existing environmental legislations related to the Jordan India Fertilizer Company (JIFCO) project. The emphasis in this chapter is on the Environmental and Social Impact Assessment (ESIA) process, in addition to a description of the legal framework as it applies to the fertilizer industry sector.

Section 2.2 provides the findings of the consultations with the major relevant regulatory authorities during the ESIA study.

Section 2.3 outlines the responsibilities of the Ministry of Environment (MoEnv) and Aqaba Special Economic Zone Authority (ASEZA) as well as other ministries and directorates.

Section 2.4 outlines the guidelines of the World Bank and the International Financing Corporation regarding the projects proposed for financing.

Section 2.5 provides some background on the relevant national environmental legislations and the international agreements and conventions that Jordan has signed and participated in.

2.2 Consultations

The major relevant regulatory and concerned authorities were consulted during the EIA study. These are:

- Ministry of Environment (MoEnv).
- Aqaba Special Economic Zone Authority (ASEZA).
- Ministry of Health.
- Civil Defense Directorate.
- Department of Antiquities.
- Ministry of Labor.

- Ministry of Water and Irrigation
- Water Authority of Jordan.
- Ministry of Public Works and Housing.
- Ministry of Municipal and Rural Affairs.
- Ministry of Agriculture.
- Ministry of Transport.
- Port Corporation.
- Ministry of Industry and Trade.

A summary of responsibilities of governmental authorities is outlined in the following sections and in Table (2.1).

Table (2.1): Summary of responsibilities of relevant regulatory authorities

Authority	Responsibility
Ministry of Environment	• Permitting prior to construction (ESIA report is required). • Inspection during operation.
Aqaba Special Economic Zone Authority	• Permitting prior to construction in Aqaba zone (ESIA report is required). • Inspection during operation.
Ministry of Labor	• Permitting prior to operation (after occupational health and safety measures). • Inspection during operation.
Water Authority of Jordan	• Supplying water needs during project phases. • Water quality monitoring during project life.
Ministry of Health	• Inspection during operation.
Department of Antiquities	• Permitting in case of existence of archaeological remains.
Civil Defense	• Approval for construction plans. • Permitting prior to operation.
Ministry of Housing and Public Works	• Inspection of the heavy trucks loads during operation

2.3 Institutional Framework and Mandate

- Ministry of Environment

  Ministry of Environment (MoEnv) was established in 2003 to replace administratively the General Corporation for Environment Protection. MoEnv has an authority to prepare the environmental by-laws, regulations, directives and guidelines. MoEnv in coordination with other concerned authorities establishes a policy for environmental protection and elucidates the strategy for its implementation.

  MoEnv has issued EIA (No. 37, 2006) which includes the procedures for conducting EIA in Jordan and also gives MoEnv the responsibility to provide/review/approve terms of reference and review EIA study reports. Article 13 of the Environmental Protection Law for 2006, empowers the Ministry of Environment to ask any new establishment that has potential impacts on environment to prepare an EIA study.

  The Licensing and Guidance Directorate in the ministry is responsible for licensing of the projects. The projects are referred to the Licensing and Guidance Directorate, and submitted to a Central Licensing Committee that consists of representatives of the relevant governmental authorities such as ministries of Environment, Health, Water and Irrigation, Municipal and Rural Affairs, Agriculture and Natural Resources Authority. An approval from the committee is required for licensing, which may have conditions attached to it, before the relevant authorities can grant permission. The completed EIA studies are referred to the Licensing and Guidance Directorate, and submitted to a Technical Committee for Reviewing EIA studies that consists in addition to the members of the Central Licensing Committee, representatives from ministries of Tourism and Archeology, Planning and International Corporation, Public Works and Housing, Energy and Mineral Resources Industry and Trade, and representatives from universities of Jordan, Science and Technology, and Balqa. The ministry has also the mandate to inspect and monitor the plants to check the compliance with the set standards and regulations in addition to follow the implementation of the mitigation measures recommended by the EIA studies.

- Aqaba Special Economic Zone Authority (ASEZA)

  The Article "52" of ASEZA Law No. (32) of the year 2000, states that ASEZA Board of Commissioners shall be responsible for protecting and maintaining the environment in the zone and for ensuring sustainable development according to the basis and standards determined in the

Environmental Protection Regulations of ASEZA No. 21 of the year 2001. The article (9) of the Environmental Protection Regulation No. 21 of the year 2001 entitles ASEZA to compel the project owner to conduct EIA processes if it deems it is necessary as to nature, locations or effects resulting from such project. The EIA diroctorate in the authority is responsible for the screening of the project appropriate type of EIA needed, approving the terms of references and inviting the persons and entities to review and analyse the EIA study to ensure its complience with provisions of this regulation. The environmental clearance of the project is issued by the commissioner if the expected adverse environmental impacts are managed in the EIA study including management and monitoring plan.

- Department of Antiquities

  The Law of Antiquities No. 21, 1988 calls for immediate reporting of any found remains. The department then has the right to assess the significance of any discovered remains/antiquities and to put its recommendations accordingly.

- Water Authority of Jordan (WAJ)

  According to the Water Authority Law No. 18, 1988, WAJ is responsible for supplying projects with the required quantity of water needed for industrial and domestic purposes. Additionally, WAJ is responsible for monitoring water quality (surface and ground water and industrial discharges).

- Ministry of Health

  The Ministry is represented by Health Directorates in governorates, which have the responsibility to follow up health matters in industries as well as among the public. The Environmental Health Directorate has also the responsibility to check on the compliance of all industries with the health protection requirements.

- Directorate of Civil Defense

  The Directorate grants approval on safety provisions at industrial premises including indoor fire fighting system, storage and handling of hazardous materials. The directorate issues its final approval after an inspection visit has taken place to the project facilities to ensure conformity with the set requirements. The Jordanian Building Codes and National Fire Protection Association (NFPA) requirements are normally adopted by the directorate.

- Ministry of Housing and Public Works

  The ministry grants approval on the traffic routes that the heavy trucks shall be taken during the operation and make random inspection on the heavy trucks for the compliance of their axial loads to the permissible axial loads on the highway.

2.4 World Bank / International Finance Corporation Environmental Assessment Guidelines

International Finance Corporation (IFC) as one of the World Bank group requires Environmental and Social Impact Assessment (ESIA) for projects proposed financing to ensure that they are environmentally sound and sustainable, and thus to improve decision making. According to Operational Policies (OP 4.01), an environmental screening for each proposed project should be carried out to determine the appropriate type of EA needed, advises the project proponent on environmental and social assessment requirements, reviews findings and recommendations of EA to determine whether they provide an adequate basis for processing the project for financing. IFC bases supervision of the environmental and social aspects of the project and ensures implementation of all findings and recommendations resulting from environmental assessment study.

IFC issued Environmental, Health and Safety (EHS) Guidelines in the year of 2007, as a technical reference documents with examples of good international industrial practice which reflects the relevant standards of countries with recognized regulatory frameworks under normal operation conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques. The guidelines contain the performance levels and measures that are generally considered to be achievable in a new or existing facility by existing technology at reasonable cost. These guidelines cover the environmental issues such as air emissions, noise, wastewater and water quality, wastes and hazardous materials. In addition, these guidelines cover the occupational health and safety aspects and community health and safety aspects throughout the operation phase.

As a complement of the general EHS Guidelines, IFC has also issued EHS Guidelines for phosphate fertilizer manufacturing includes information relevant to facilities that produce phosphoric acid and fertilizers compounds (NPK). These EHS guidelines contain the issues are associated with phosphate fertilizer plants during the operation phase, along with the

recommendations for EHS management. Also, these guidelines include the performance indicators from Good International Industry Practice of the phosphate fertilizer plants. The monitoring programs for this sector are also mentioned in these guidelines which can be implemented to address all activities that have been identified to have potentially significant impacts on the environment during normal operations and upset conditions.

IFC sets out the Performance Standards to manage environmental and social aspects of the projects proposed financing. The project proponent has to meet these standards throughout the life cycle of the project that is invested by IFC as follows:

Performance Standard 1: Social and Environmental Assessment and Management System

The proponent shall establish a social and environmental management system which includes communication between the client, its workers, and the local communities directly affected by the project. The management system incorporates the social and environmental assessment, management program, organizational capacity, training, community engagement, monitoring and reporting.

Performance Standard 2: Labor and Working Conditions

This standard aims to establish worker-management on the principle of equal opportunity and fair treatment. The proponent will not employ children in a manner that is likely to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. The proponent will provide the workers with a safe and healthy work environment away from physical, chemical, biological, and radiological hazards.

Performance Standard 3: Pollution Prevention and Abatement

This performance standard outlines a project life cycle (design, construction, operation and decommissioning) to a pollution prevention and abatement by applying pollution prevention and control technologies and practices to avoid, minimize or reduce adverse impacts on human health and the environment. In addition, the proponent will prepare a respond to process shutdown, accidental, and emergency situations in a manner appropriate to the operational risks and the need to prevent their potential negative consequences.

Performance Standard 4: Community Health, Safety and Security

This performance standard addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety and security that

may be raised from project life cycle. Also, to ensure that the safeguarding of personnel and property is carried out in a legitimate manner that avoids or minimizes risks to the community's safety and security.

Performance Standard 5: Land Acquisition and Involuntary Resettlement
The proponent will consider feasible alternative project designs to avoid or at least minimize physical or economic displacement, while balancing environmental, social, and financial costs and benefits. When displacement can not be avoided, the client will offer displaced persons and communities a fair compensation for loss of assets at full replacement cost and other assistance to help them improve or at least restore their standards of living.

Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management
This performance standard recognizes protecting and conserving ecosystem diversity. In order to avoid or minimize adverse impacts to biodiversity in the project's area of influence, the proponent will assess the significance of project impacts on all levels of biodiversity and on the major threats to biodiversity and habitat destruction.

Performance Standard 7: Indigenous Peoples
This standard is not relevant to this project area, since there is no indigenous people live in the project area.

Performance Standard 8: Cultural Heritage
This performance standard aims to protect irreplaceable cultural heritage and to guide proponent on protecting cultural heritage through life cycle of the project. The proponent will protect and support cultural heritage by undertaking practices for the protection, field-based study, and documentation of cultural heritage.

2.5 Environmental Legislations and Agreements

2.5.1 National legislations

Air Quality Standards
1. Jordan Ambient Air Quality Standards (JS: 1140/2006).
2. Maximum Allowable Limits of Air Pollutants Emitted from the Stationary Sources (JS: 1189/2006).

Water Quality Standards
3. Jordanian Standards for Treated Domestic Wastewater (JS: 893/2006).

4. Jordanian Drinking Water Standards (JS: 286/2001).
5. Jordanian Standards for Industrial Wastewater (JS: 202/2007).

General Environmental Law and Regulations

6. Environmental Protection Law (No. 52, 2006).
7. Environmental Impact Assessment Regulation (No. 37, 2005).
8. Environmental Protection Regulation No. 21 of the year 2001
9. The Antiquities Law (No. 21, 1988).
10. Regulations for Protection of Birds and Wildlife and Rules Governing their Hunting (Regulation No. 113, 1973).
11. Public Health Law (No. 54, 2002).
12. Management of the Medical Wastes Regulation (No.1, 2001)
13. Management and Circulation of the Harmful and Hazardous Materials Regulation (No. 43, 1999).
14. Guidelines for Prevention of Noise, 2003.
15. Water Authority Law (No. 18, 1988).
16. Agricultural Law (No. 44, 2002).
17. Penalty Law (No. 16, 1960).
18. Civil Defense Law (No. 12, 1959).
19. Towns and Villages Law (No. 18, 1988).
20. Traffic Law (No. 47, 2001).
21. Transport Law (No. 89, 2003)
22. Labor Law (No. 8, 1996 as amended).
23. Social Security Law (No. 19, 2001)
24. Investment Law (No. 68, 2003).
25. Municipality Law (No. 55, 1954).
26. Nuclear Energy and Protection of Radiation Law (No. 29, 2001).
27. Regulations No. (1) of year 2006: Instructions for the elimination of unsanitary occurrences related to health harms generated from workers communities residential units.
28. Regulation No. (4) of 2003, Regulation for Management and Handling of Used Oil.
29. Regulation No. (55) of 2004, Regulation for Evaluation of Environmental Impacts.
30. Regulation No. (68) of 2001, Regulation for Management and Handling of Used Oil in Aqaba Special Economic Zone.
31. Guidelines of the Transportation of Hazardous and Explosive Materials, 2003
32. Jordanian Standards for Uses of Treated Sludge and Sludge Disposal (JS: 1145/2006).

A summary of relevant national and international laws, regulations and standards are summarized in Table (2.2).

Table (2.2): Summary of national and international legislations relevant to the project

Laws, Acts, Regulations, Standards		Surface and ground water	Wastewater	Noise	Biodiversity	Archeology	Solid waste	Occupational health	Fire hazard	Socio-economy	Air
Laws & Acts	Law No. 52 of 2006 Environmental Protection Law	A: 11		A: 12	A: 4,16, 18		A: 11				A: 19
	Law No. (18) of 1988 Water Authority Law	A: 2,6,25,30	A: 6, 30								
	Law No. (16) of 1960 Penalty Law	A: 45,455							A: 375		
	Law No. (12) of 1959 Civil Defense Law							A:20	A:4		
	Law No. (44) of 2002 Agriculture Law		A: 15		A:15,27,28,31,32,33,34, 35,39,49,57,61						
	Law No. (54) of 2002 Public Health Law	A: 30,3,7,72,73,74,75 76,77,79	A: 30,3,32,33,59,79	A: 30,31			A:27,28,29,30,31, 49, 50, 59	A: 3,10,13,30,31,36,72,73 74,75,79			A: 30, 31
	Law No. (12) of 1976 Antiquities Law					A: 2,3,5,13,14,16 27, 28					
	Law No.(55) of 1954 Municipality Law		A:41	A:41			A:41		A:41		
	Law No.(18) of 1988 Towns and villages Law		A15,19,43	A:19,44,45	A:15,19,40	A:15,19	A:42,43			A:15,42,50	
	Law No. (29) 2001 Nuclear Energy and Protection from Radiation							A:16			
	Law No. (47) of 2001 Traffic Law	A:49	A: 48	A: 48,49	A: 49			A:4	A:4	A:4	A: 44,68
	Act No.(26) of 1985 Administration of the Ministry of Energy and Mineral Recources							A:3	A:22,23		
Regulations & Standards		- Jordanian Drinking Water Standards (286/2001)	- Jordanain Standards for Treated Domestic Wastewater (893/2006) - Jordanain Standards for Industerial Wastewater (202/2007) - Jordanain Standards for Uses of Treated Sludge and Sludge Disposal (1145/2006) - Regulation No.(4) of 2003, Regulation for Management and Handling of Used Oil - Regulation No.(1) of 1978, Regulation for waste prevention	- Guidelines for Prevention of Noise, (2003). - Guidelines to International Standards on the Measurement of Airborne Acaustical Noise and Evaluation of its Effects on Human Beings. (ISO 2204/1979)	- Regulations No. (13) of 1973; Regulations for Protection of Birds and Wildlife and Rules Govering their Hunting		- Regulation No. (1) of 2001: Management of Medical Wastes - Regulation No. (43) of 1999: Management and Circulation of Harmful and Hazardous Materials	- Environment, Health and Safety. General Guidelines, IFC - National Fire Protection Agency (NFPA) - Occupational Safety and Health Administration (OSHA) - Regulations No. (1) for the year 2006: Instructions for emplyees complex	- National Fire Protection Agency (NFPA)	- Regulation No.(1) of 1978, Regulation for waste prevention	- Jordanian Ambient Air Quality Standards: (JS: 1140/2006) - Jordanian Standard for Stack Emissions (JS: 1189/2006)

2.5.2 International agreements and conventions

Jordan has participated and signed many regional and international environmental agreements and conventions; a list of conventions and agreements relevant to the project is shown in Table (2.3).

Table (2.3): International environmental agreements relevant to the project that Jordan has participated in

Title	Signature
International plant protection convention.	24/4/70
Protocol to amend the convention on wetlands of international importance especially as waterfowl habitat (RAMSAR).	15/3/84
Convention concerning the protection of the world cultural on natural heritage.	5/5/75
Convention on biological diversity.	11/6/96
Convention on the conservation of the migratory species of wild animals.	1979
Convention on international trade in endangered species, of wild fauna and flora.	8/1/81
Basel convention on the Trans-boundary movement of hazardous waste and their disposal.	22/3/89
United Nation framework convention on climate change.	11/6/96

3. PUBLIC AND STAKEHOLDERS CONSULTATIONS

3.1 Introduction

According to the scope of work of the environmental and social impact assessment (ESIA) study for the project that was agreed upon between Jordan Phosphate Mines Co. Ltd. (JPMC) and the Environmental Research Center (ERC) of the Royal Scientific Society (RSS) (Letter No. (17) 227/28/93/2020 signed on January 21, 2008), a scoping study was implemented by RSS study team. The scoping study, which represents an important phase of the ESIA for the project, aims at identifying the stakeholders concerns about the project activities in relation to the major environmental and social aspects. RSS ensured adequate coverage in the consultation process of all stakeholders that may be affected or may interact with the project including regulatory authorities, non-governmental organizations (NGOs) and local communities. Additionally, the arrangements for the scoping study were undertaken in close coordination with the Ministry of Environment (MoEnv) and Aqaba Special Economic Zone Authority (ASEZA), who are responsible for administering the ESIA process, noting that the scope of work for the ESIA study was also shared with the MoEnv and ASEZA so that the ESIA is undertaken according to their requirements.

The planned project has two locations: one for the phosphoric acid production in Eshidiya - Ma'an governorate and the other for the storage of phosphoric acid for export in Aqaba governorate near the industrial port south of Aqaba city. The scoping session was held in Aqaba at the Mövenpick Resort & Residence on February 12, 2008. Invitation letters for the scoping session were sent by MoEnv and ASEZA in coordination with RSS.

The activities undertaken in the scoping sessions are described below.

At the beginning of the session, each participant was provided with information package consisted of a project summary and an overview of the project activities for all phases of the project in Arabic. The names of the participants in the session are shown in Table (3.1).

At the scoping session the following activities took place:

- Opening session: opening speeches were given by government and company representatives as follows:

  - Dr. Bassam Hayek: Director of the Environmental Research Center/RSS.
  - Dr. Bilal Albasheer: Commissioner of Environment, ASEZA.
  - Dr. Mazen Khalil: Head of Environmental Directorate, ASEZA.
  - Izzat Abu-Humra: Environmental Impact Assessment Section Head/ Ministry of Environment.
  - Mr. Chandra Srivastava: Chief Executive Officer (CEO) of Indian Farmers Fertilizer Cooperation Ltd. (IFFCO), India.
  - Mr. Mohammad Baderkhan: Deputy CEO of JPMC.

Fig. (3.1): Opening session, Dr. Bassam Hayek

Fig. (3.2): Opening session, Dr. Bilal Albasheer

Fig. (3.3): Opening session, Dr. Mazen Khalil

Fig. (3.4): Opening session, Mr. Izzat Abu- Humra

Fig. (3.5): Opening session, Mr. Chandra Srivastava

Fig. (3.6): Opening session, Mr. Mohammad Baderkhan

- A presentation about the planned project was given by representatives of the Jordan India Fertilizer Company (Mr. Chandra Srivastava and Mr. Mohammad Baderkhan).

- A presentation about the project sites, activities, facilities, and the expected emissions and wastes was given by Mr. Mohammad Mosa, Head of Environmental Management Studies Division/RSS.

Fig. (3.7): Opening session, Mr. Mohammad Mosa

- A work group session was held and managed by RSS study team to identify environmental and social issues and stakeholders concerns.

  Participants were coached through the work group session by RSS study team to overview all project activities of all phases (construction, operation and decommissioning phases) in order to identify relevant issues and concerns.

  Different work group techniques were followed during the scoping session to ensure effective interaction and participation of all members of the groups.

  During the scoping session, participants were divided into five groups; two of them were requested to identify issues related to construction phase, whereas the other two groups were requested to identify issues related to operation phase and the fifth group for the decommissioning phase. Each participant was asked to write down his/ her issues and concerns on the provided form on individual basis. After that, each group, discussed and then summarized all issues and concerns on transparencies. A representative of each working group presented the summarized issues and concerns of his/ her group to the audience. Some comments and clarifications from other groups' members, RSS study team and the client representatives were made during the presentations of the groups findings.

Fig. (3.8): Aqaba work groups

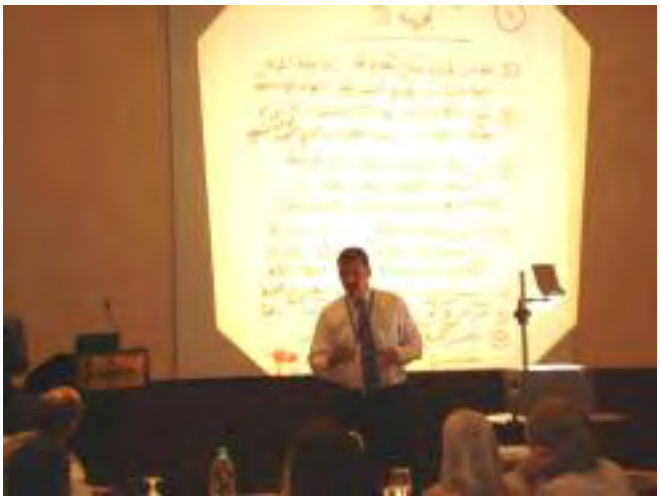


Fig. (3.9): Issues presentation of work groups

3.2 Project Activities According to Phases as Presented in the Scoping Session

3.2.1 Construction Phase

Preparation of Project sites

- Excavation, landscaping and leveling.
- Construction of infrastructure (domestic wastewater treatment system, storm water system).
- Construction of internal and access roads.

Construction of the plants sites

- Transport of construction equipment and materials.
- Construct the foundations of equipments and storage tanks.
- Construction of buildings, services and utilities.
- Construction of process equipment including environmental monitoring and control equipment.
- Installation of piping, conveying system, and connecting piping, electricity and water.
- Construction of the domestic wastewater treatment plant in Eshidiya.
- Construction of storage facilities for raw materials and products.

3.2.2 Operation Phase

- Transport of raw materials (sulphur, phosphate, heavy fuel oil and diesel) to the plant site in Eshidiya and transport of product (phosphoric acid) to the storage area in Aqaba.
- Loading and unloading of raw materials and products on site.
- Storage of raw materials and products on sites.
- Supply of spare parts and consumables.
- Supply of water through wells.
- Production process and wastes handling.
- Routine and emergency maintenance.
- Domestic wastewater treatment system and reuse it in irrigation in Eshidiya.
- Activities related to employment

3.2.3 Decommissioning Phase

- Transport and disposal of used equipment.
- Demolition of buildings and infrastructures and disposal of debris and wastes.
- Reclamation of sites.
- Termination of employees.

3.3 Issues and Concerns Identified through Scoping Session, and Public and Regulatory Consultations

The work group session resulted in identifying a number of issues and concerns for different phases of the project. All forms of issues and concerns filled by the groups during the scoping session were collected by RSS study team and were presented by the groups. During presentation some new issues were raised by the participants, where all of these new issues were written down by RSS study team. Following the scoping session, RSS study team also added some issues that are believed to be relevant and of environmental and social importance.

In addition to the scoping session, public consultations were undertaken in Ma'an and Al-Jafer areas. For that a questionnaire was developed which

includes a brief description of the project in Arabic as introduction. The aim of this public consultations is to investigate and to get the opinion of Ma'an and Al-Jafer residential toward the project and to explore how differences in livelihood, cultural and socio-economic conditions influences the attitude and perceptions of people in the community.

A representative sample of 78 persons (from both genders) was chosen through visiting several homes as well as some local organizations such as: Al-Jafer Municipality, Women Community Gathering the Hashemite Fund for Human Developments, Ma'an Governorate, Community Development Organization at Al-Jafer sub-district, Ma'an Industrial Chamber, Al-Jafer Court and Al-Jafer Civil Defense. In addition to that the study team interviewed those organizations managers and gets their feedbacks.

During the survey, it was found that the people are familiar with the important of the project and they are with the project idea, although several issues and concerns were raised up:

- Not giving priority of employment to the local community.
- Over pumping of water from Al-Jafer aquifer, which is already has been depleted in last 30 years (see water resources chapter).
- Pollution and dust emission which will negatively affect their health (see public health chapter).
- Traffic accidents and traffic jam.
- Not considering safety issues in the company.
- Existing of foreign employees in the area and affecting the culture tradition.

After that, all issues identified during the scoping session and the public consultations were analyzed and studied by RSS study team. Potential interactions of these issues were specified and evaluated with respect to the following valued environmental components (VECs):

- Biodiversity.
- Water resources.
- Socio-economic conditions.
- Public health.
- Occupational health and safety.
- Marine environment.
- Archeology.

The level of significance for each issue was evaluated taking into consideration the relevant VEC and the following criteria:

- The level of impact was ranked as: 1 (low), 2 (moderate) and 3 (high).
- The likelihood of occurrence was ranked as: a (low), b (moderate) and c (high).
- All interaction ranked 2b, 2c, 3a, 3b and 3c may have environmental impacts and will be assessed in the ESIA study.

List of all issues and concerns identified for construction, operation and decommissioning phases and their evaluation are shown in Tables (3.2), (3.3) and (3.4) respectively. General concerns for construction and operation phases listed in Tables (3.5) and (3.6) respectively will also be taken into consideration in the assessment and monitoring plans. Table (3.7) presents the potential interactions between project activities and valued environmental components during accidental incidents.

3.4 Conclusion

The above findings will comprise the main focus of the EISA study, and shall be attached to the TOR set for the study. The RSS study team will proceed in the study and shall take any comment the authorities may have on this report into account.

Table (1): List of participants in scoping session held in Aqaba on 12/2/2008

No.	Name	Organization
1.	Bilal Albasheer	ASEZA[1]
2.	Mazen Khalil	ASEZA
3.	Izzat Abu-Humra	Ministry of Environment
4.	Jihad Aljaban	ASEZA
5.	Jihad Almajali	ASEZA
6.	Hayat Alathameen	ASEZA
7.	Salim Almoghrabi	ASEZA
8.	Bassam Alsaleem	ASEZA
9.	Aiman Suleiman	ASEZA
10.	Muaid Alkhateb	ASEZA
11.	Mahmoud Almubaied	ASEZA
12.	Eman Alkous	ASEZA
13.	Haitham Adaileh	Ministry of Environment - Amman
14.	Fawaz Karasneh	Ministry of Environment - Amman
15.	Mahmoud Alees	Ministry of Energy and Natural Resources - Amman
16.	Nisreen Nasir	Ministry of Municipal Affairs - Amman
17.	Asmaa Al-Ghzawi	Ministry of Municipal Affairs - Amman
18.	Ahmad Amarat	Ministry of Public Works and Housing - Amman
19.	Dima Haddadin	Ministry of Public Works and Housing - Amman
20.	Yanal Awajan	Ministry of Labor - Amman
21.	Zuhair Asharman	Ministry of Agriculture - Amman
22.	Abdullah Heyasat	Ministry of Health - Amman
23.	Randa Rabadi	Ministry of Transport - Amman
24.	Hani Hijazi	Ministry of Water and Irrigation - Amman
25.	Saleh Almalkawi	Water Authority of Jordan - Amman
26.	Mohammad Qtieshat	Water Authority of Jordan - Amman
27.	Mohammad Amarat	Central Electricity Generating Company - Amman
28.	Yasin Al-Zu'bi	Al-Balqa Applied University - Amman
29.	Mahmoud Helalat	Ministry of Tourism - Aqaba
30.	Mustafa Abu-Aisheh	Port Corporation - Aqaba
31.	Ziad El-Taani	Aqaba Water Company (AWC)
32.	Mohammad Alzibdah	Marine Science Station - Aqaba
33.	Mohammad Rasheed	Marine Science Station - Aqaba
34.	Khaled Taleb	Department of Lands and Survey - Quwairah – Aqaba
35.	Bilal Khalafat	Jordan Maritime Authority - Aqaba
36.	Faisal Abu-Sondos	Royal Marine Conservation Society of Jordan – Aqaba
37.	Omar Bdour	National Trading and Investment Group - Aqaba

No.	Name	Organization
38.	Ali Ababneh	Nippon Jordan Fertilizer Company - Aqaba
39.	Bilal Alnsour	KEMAPCO[2] - Aqaba
40.	Khaled Essamin	Arab Potash Company - Aqaba
41.	Amna Byayda	Arab Potash Company - Aqaba
42.	Mousa Ali	Jordan Petroleum Refinery Company - Aqaba
43.	Khaldoun Almoumen	Aqaba Governorate
44.	Khaled Addaja	Royal Naval Force - Aqaba
45.	Hussein Khawaldah	Police Directorate - Aqaba
46.	Mohammad Asshawa'rah	Environment Police - Aqaba
47.	Ali Adamat	General Intelligence Department
48.	Rakan Alajarmeh	Military Security
49.	Abdullah Shbilat	Maan Governorate
50.	Tahani Almahamed	Ministry of Municipal Affairs - Ma’an
51.	Najla Almahamed	Ministry of Municipal Affairs - Ma’an
52.	Suhayla Abu Dewish	Ministry of Agriculture - Ma’an
53.	Aiman Dwene’	Ministry of Agriculture - Ma’an
54.	Aiman Alejami	Ministry of Municipal Affairs - Ayl - Ma’an
55.	Sameer Almaaytah	Ma’an Water Company
56.	Mohammad Al-Houiti	Al-Hussein bin Talal University - Ma’an
57.	Mohammad Baderkhan[5]	JPMC[3] - Amman
58.	Chandra Srivanlaia[5]	IFFCO[4] - India
59.	Faysal Doudin[5]	JPMC - Aqaba
60.	Mohammad Hjouj[5]	JPMC - Aqaba
61.	Baker Obaidat[5]	JPMC - Aqaba
62.	Santosh C[5]	IFFCO - India
63.	Alok Jain[5]	IFFCO - India

1: ASEZA: Aqaba Special Economic Zone Authority
2: KEMAPCO: Kimera Arab Potash Company
3: JPMC: Jordan Phosphate Mines Company
4: IFFCO: Indian Farmers Fertilizer Cooperation Ltd, India
5: Client representatives.

Table (3.2): Evaluation of issues and concerns identified for construction phase

Impact of	Significance	Potential Impact	VEC (*)
Destruction of archeological sites and items at both Eshidiya and Aqaba project sites.	3b	Yes	Archeology
Dust and gaseous emissions generated from construction activities on public health.	2b	Yes	Public Health
Dust generated from construction activities on marine environment.	1a	No	Marine Environment
Dust and gaseous emissions generated from construction activities on workers.	2b	Yes	Occupational Health & Safety
Noise from construction activities on close residential areas.	2b	Yes	Public Health
Noise from construction activities on workers.	2c	Yes	Occupational Health & Safety
Domestic solid waste generated from workers during construction on public health.	2a	No	Public Health
Domestic solid waste generated from workers during construction on workers.	2b	Yes	Occupational Health & Safety
Disposal of spent oil and used batteries from construction vehicles/equipment and machinery on water resources.	2b	Yes	Water Resources
Disposal of spent oil and used batteries from construction vehicles/equipment and machinery on marine environment.	2a	No	Marine Environment
Domestic wastewater generated from workers during construction on public health.	1b	No	Public Health
Domestic wastewater generated from workers during construction on water resources.	2b	Yes	Water Resources
Domestic wastewater generated from workers during construction on workers.	2b	Yes	Occupational Health & Safety
Domestic wastewater generated from workers during construction on workers.	2b	Yes	Marine Environment
Disposal of debris on fauna and flora	2b	Yes	Biodiversity
Excavation works on existing neighboring buildings	1b	No	Public Health
Not considering wind speed and direction during design and construction phases	3c	Yes	Public Health
Direct damage of flora and fauna at both sites of the project.	2b	Yes	Biodiversity
Not having a green belt around the plant site in Eshidiya	2b	Yes	Public Health

Impact of	Significance	Potential Impact	VEC (*)
Not having a green belt around the plant site in Eshidiya	2a	No	Biodiversity
Noise from construction activities and machines on fauna.	2b	Yes	Biodiversity
Improper design of storage facilities to withstand earthquake risk (earthquake rating in Aqaba is high).	3c	Yes	Socio-economic
Not studying of the current condition of surface and ground water in the area.	2b	Yes	Water Resources
Not studying of alternative water resources management.	3b	Yes	Water Resources
Not determining the existing wadies and drainage of the surface run off.	3b	Yes	Water Resources
Not studying the possibilities of reusing treated wastewater	2b	Yes	Water Resources
Not having or not following occupational health and safety measures during construction.	2b	Yes	Occupational Health & Safety
Stress on roads and highways, due to transporting raw materials, equipments and heavy machinery.	2b	Yes	Socio-economic
Not supporting the neighboring local communities	2b	Yes	Socio-economic
Not considering the surrounding inhabitants	2b	Yes	Socio-economic
Diseases between workers (foreigners and locals)	2b	Yes	Occupational Health & Safety
Not abiding the standards of civil defense regulations in constructing the storage tanks in Aqaba and Eshidiya.	3a	Yes	Public Health
Not having a containment area around the storage tanks.	3b	Yes	Occupational Health & Safety
Not having coordination with Ministry of Water and Irrigation regarding the location of the water wells and the wastewater treatment plant.	3b	Yes	Water Resources
Not having coordination with the Ma'an governorate regarding the development plan of Eshydia-Moudawwara.	1a	No	Socio-economic
Not having a geophysical and geotechnical study at Aqaba site.	3a	Yes	Marine Environment

Impact of	Significance	Potential Impact	VEC (*)
Not considering the safety of workers due to the vehicles movement.	3a	Yes	Occupational Health & Safety
Construction of storage tanks in Aqaba on sight seeing (visual impact).	2b	Yes	Socio-economic
Not giving priority, for local contractors and employees during construction works.	2b	Yes	Socio-economic
Provision of food, beverages and supplies from local stores (Ma'an).	2b	Yes	Socio-economic

(*) VEC: Valued Environmental Component

Table (3.3): Evaluation of issues and concerns identified for operation phase

Impact of	Significance	Potential Impact	VEC
Reuse of treated domestic or industrial wastewater on water resources.	2b	Yes	Water Resources
Transporting sulphur by railway from Aqaba port to Eshidya site.	3b	Yes	Socio-economic
Not having granulated sulphur	1a	No	Occupational Health & Safety
Gypsum disposal on groundwater resources	3a	Yes	Water Resources
Investigation of traffic situation in the area from Ma'an to Aqaba and the axial load.	3c	Yes	Socio-economic
Spillage of chemicals and oils during transportation.	3c	Yes	Public Health
Spillage of chemicals and oils during transportation.	2b	Yes	Marine Environment
Spillage of phosphoric acid from the storage tanks and pipelines at Aqaba.	3c	Yes	Marine Environment
Domestic wastewater during operation phase	3b	Yes	Marine Environment
Not installing the necessary control devices (e.g. interlocks, vents, alarm systems) on the storage tanks.	3a	Yes	Public Health
Not installing the necessary control devices (e.g. interlocks, vents, alarm systems) on the storage tanks.	3b	Yes	Occupational Health & Safety
Not complying with the technical standards for sulphur and phosphate storage in Eshidya (closed storage facilities).	3c	Yes	Occupational Health & Safety
Not monitoring air quality in the site.	3c	Yes	Occupational Health & Safety
Not monitoring air quality in the site.	2b	Yes	Public Health
Considering an alternative road for transporting of raw materials and products (Eshidyia - Rum – Rashediyah - Aqaba).	2a	No	Socio-economic
Not having a healthy residence for workers.	2b	Yes	Occupational Health & Safety
Not having or not following occupational health and safety measures during operation.	2b	Yes	Occupational Health & Safety
Guard pond on natural ecosystems (specially migrant birds)	2c	Yes	Biodiversity
Dust and gaseous emissions generated from operation activities on public health.	2b	Yes	Public Health
Dust and gaseous emissions generated from operation activities on workers.	3c	Yes	Occupational Health & Safety
Disposal and/or reuse of solid waste (domestic and sludge).	2b	Yes	Public Health

Impact of	Significance	Potential Impact	VEC
Disposal and/or reuse of solid waste (domestic and sludge).	3c	Yes	Occupational Health & Safety
Not covering the conveyor belts of raw materials outside buildings.	3c	Yes	Public Health
Not covering the conveyor belts of raw materials outside buildings.	2b	Yes	Occupational Health & Safety
Noise from operation activities on close residential areas.	2b	Yes	Public Health
Noise from operation activities on workers.	3c	Yes	Occupational Health & Safety
Not having appropriate training and awareness for the workers.	2c	Yes	Occupational Health & Safety
Not having coordination with civil defense and traffic directorate in case of transporting hazardous chemicals.	2b	Yes	Public Health
Not having wind breaker to prevent dust dispersion.	2b	Yes	Public Health
Not complying with the rules of the Ministry of Water and Irrigation regarding water resources protection zones.	3c	Yes	Water Resources
Project on the non-renewable water aquifer.	3c	Yes	Water Resources
Project activities on the existing wadies and drainage of the surface run off.	2b	Yes	Water Resources
Not studying of alternative water resources.	3c	Yes	Water Resources
Disposal of gypsum and the possibilities of reuse.	3c	Yes	Public Health
Disposal of gypsum and the possibilities of reuse.	2c	Yes	Biodiversity
Disposal of hazardous waste (e.g. vanadium pentoxide).	3c	Yes	Occupational Health & Safety
Disposal of hazardous waste (e.g. vanadium pentoxide).	2b	Yes	Public Health
Quantity of byproducts such as flousilisic acid.	3b	Yes	Water Resources
Quantity of byproducts such as flousilisic acid.	2a	No	Biodiversity
Quantity of byproducts such as flousilisic acid.	1a	No	Public Health
Not having an emergency plan.	2c	Yes	Marine Environment
Destruction of archeological sites and items.	2a	No	Archeology
Disposal of used oils.	2c	Yes	Public Health
Soil contamination due to disposal of used oils.	2c	Yes	Biodiversity

Impact of	Significance	Potential Impact	VEC
Quantity of water used for fire fighting.	1a	No	Water Resources
Not giving the priority to employment from local community.	3b	Yes	Socio-economic
Earthquakes on the equipment and instruments.	3C	Yes	Public Health
Leak of phosphoric acid from the storage site in Aqaba or from the pipeline due to earthquakes and other natural disasters.	3c	Yes	Public Health
Availability of benefits package for the employees including medical insurance, social security, etc.	2b	Yes	Socio-economic
Not providing adequate protection of the phosphoric acid pipeline from storage tanks to jetty as well as enough sectionalizing valves.	3c	Yes	Public Health
Contributing to social development of local communities (especially remote ones) close to the project site.	2b	Yes	Socio-economic
Leaks and fire as a result of not following up-to-date international standards in constructing and operating the plant.	2b	Yes	Public Health

Table (3.4): Evaluation of issues and concerns identified for decommissioning phase

Impact of	Significance	Impact	VEC
Disassemble ability of the machinery and equipment.	1a	No	Occupational Health & Safety
Not having specialized workers for disassembling of the plant.	1a	No	Occupational Health & Safety
Random disassembling.	2b	Yes	Biodiversity
Reuse or recycle of the disassembled machines.	2b	Yes	Socio-economic
Inform the neighboring localities of decommissioning.	2b	Yes	Public Health
Possibility of the utilization of the area of the project.	2c	Yes	Socio-economic
Disposal of contaminated machinery and equipment.	2b	Yes	Public Health
Disposal solid waste which can not be recycled.	2b	Yes	Public Health
Not having a fair compensation to local communities.	1a	No	Socio-economic
Dust and debris generated from building demolition.	2b	Yes	Public Health
Dust and debris generated from building demolition on workers.	2b	Yes	Occupational Health & Safety
Rehabilitation of the site (visual impact).	2b	Yes	Socio-economic
Employee's termination.	2c	Yes	Socio-economic

Table (5): General issues and concerns identified for construction phase

General Concerns
Study the effects of the project on the groundwater aquifer in both sites (Ma'an and Aqaba).
Study the area in regard of rainfall, runoff and soil erosion.
Study of the capacity of the port and the pipelines to import and export the raw materials and products.
Have baseline data of the air pollutants before starting project activities.
The effect of excavation works on the land of the project.
Not having medical support (including first aid clinic and ambulance).
Getting permits from relevant governmental ministries and organizations prior to start up of field works.
Consider conducting public awareness campaigns (lectures, seminars, TV, Radio, etc) regarding the project, taking into consideration the variation in education level from one area to another.
Nominate a liaison officer from the construction company to facilitate coordination with all relevant stakeholders.

Table (3.6): General issues and concerns identified for operation phase

General Concerns
Informing and involving the public in implementing emergency plans in close residential areas.
Getting full information of transport and storage of flousilisic acid.
Developing a proper security system for the protection of people and properties.
Have a detailed emergency plan describing all the responsibilities.
Prepare HAZOP study for the project.

Table (3.7): Potential interactions between project activities and valued environmental components during accidental incidents

Valued Environmental Components	Incidents				
	Road accidents	Malfunction of units	Occupational accidents	Fire	Natural hazards
Public health	/			/	/
Occupational health and safety		/	/	/	/
Socio-economic conditions	/	/	/	/	/
Water resources	/			/	/

4. WATER RESOURCES

4.1 Introduction

Jordan is facing a future of very limited water resources among the lowest in the world on a per capita basis. It lies among the dry and semi dry climatic zones which are characterized by their minimal rainfall and high percentage of evaporation. The temperature varies from a few degrees below zero in the winter to around 42 degrees centigrade in the summer season. Annual precipitation ranges from 50 mm in the desert to 600 mm in the northwest highlands, and only nine percent of Jordan's area receives more than 200 mm of the rainfall annually. Approximately, 92.2% of the rainfall evaporates, 5.4% recharges the groundwater and the rest 2.4% goes to the surface water (Halasah, N, and Ammari, B, 2005).

Recently, the problem of water shortage in Jordan has been raised as a result of high natural population growth, influxes of refugees and returnees to the country in response to political situation in the Middle East area, rural to urban migration and increased modernization and higher standards of living. Consequently, available water resources per capita are decreasing as a result of population growth, they are projected to decline from more than 160 m^3 per capita per year for all uses in 2005 to only 91 m^3 per capita per year by 2025, thus putting Jordan in the category of having an absolute water shortage (Ministry of Water and Irrigation report, 2002).

In the year 2005, the amount of water supplied was about 1000 million cubic meters (MCM). Out of these 481 MCM came from groundwater, 450 MCM from surface water sources, and the rest from treated wastewater (Ministry of Water and Irrigation report, 2002). Municipal uses represented around 29%, irrigation uses represented around 66%, and industrial uses represented around 5% of the total consumption (Ministry of Water and Irrigation report, 2000). Based on projections of available water amounts, the gap between supply and demand from all sources is increasing annually. Despite the huge investment in the water sector for the coming years, water deficit for all uses is projected to be 437 MCM by the year 2020 compared with 320 MCM in 2005. These figures show the necessity for adopting a long term water plan and future scenarios of water management that consider both demand management and non-conventional water resources, in order to decrease the gap between supply and demand.

This chapter provides baseline data regarding the water resources and geology of the Jordan India Fertilizer Company (JIFCO) project that will consist of sulphuric and phosphoric acid plants, employee's residential complex in Eshidiya area. The project also includes of phosphoric storage tanks area that will be located in the southern part of Aqaba area, southeast of industrial port.

In addition, the chapter provides an assessment of potential impacts of the project activities on the water resources during the project phases and the necessary mitigation measures to reduce /minimize the negative impacts.

4.2 Existing Environment for the Project Areas

The study areas of the project consist of Eshidiya area where the plants and employee's residential complex will be located, and the southern part of Aqaba area where the phosphoric acid storage tanks are located. The plants in Eshidiya will use an area of 1.7 km^2, the location is at a distance of approximately 250 km south of Amman and at 75 km east of Ma'an city. The storage tanks area will be built in Aqaba at the Industrial zone near the southern seaport, about 1.5 kilometers west of the shore and to the northeast of the current existing tanks that belong to the Indo-Jordan Chemicals Company.

4.2.1 Geology of the project site in Eshidiya area

The study area in Eshidiya area is a part of Jordan plateau. Most of the study area is relatively flat and covered with recent sediments of sand, phosphatic sand, ash and clayey silt. The layers consist of the following formations:

1. <u>Superfacial Sediments</u>

The superfacial cover of the site consists of Pleistocene sediments composed of rozy sand, clayey silt, phosphatic sand with some cobbles and gravels of chert (Al-Doha Engineering Center, 2008).

2. <u>The Muwaqqar Formation (B3)</u>

The Muwaqqar Chalk Marl formation (B3) belongs to Paleocene Maastrichian period that consists of tan and gray marl, partly chalky, with some intercalations of chalk and limestone. Thin beds of gypsum and chert lenses occur occasionally. The outcrop of Muwaqqar formation that is classified in Balqa group occurs in the wellfield area dipping southwest to northeast, with a total thickness ranges from 114-289 m as shown in Fig. (4.1). Although the layer is saturated with water, the aquifer potentiality is poor in horizontal and vertical directions due to low porosity. Therefore, the possibility of infiltration

is very low through this formation (Royal Scientific Society/ Environmental Impact Study of Hydro-Agri Jordan, 1999).

3. The Amman-Wadi Sir Formation (B2/A7)

The upper unit of the Ajlun group (Wadi Sir Limestone formation (A7)) has been grouped with the lower part of the Balqa group (Wadi Ghudran - Amman Formations (B1-B2)). (A7) formation that belongs to Turonian period consists of light grey to buff limestones, partly dolomitic, with some nodules and bands of chert and sandy limestone. The lower Balqa group (B1-B2) consists dominantly of chalk, limestone, chert and cherty limestone with some marly intercalations and phosphate.

The outcrop of Amman-Wadi Sir formation (B2/A7) occurs in Eshidiya mine area with a slope from southwest to northeast, and the thickness ranges between 39-114 m, while in wellfield area it occurs with a thickness of around 75 m. The aquifer potentiality would be good if it is located in the saturated zone. Therefore, infiltration through this formation is expected.

4. The Lower Ajlun Group (A1-A6)

Ajlun group that belongs to Cenomanian - Lower Turonian period (A1-A6) consists dominantly of carbonate sediments in the northern and central parts of Jordan. Ajlun group changes gradually southward and southeastward direction. The group consists of the following formations beginning with the oldest:

- Naur formation (A1-A2) and the overlying Fuheis formation (A3) comprise mainly green-grey marl and marly limestone with some massive limestone layers in the upper part of the Naur formation.

- The overlying formation Hummer (A4) is characterized by uniform unconsolidated medium to coarse grained sandstones with a total thickness of around 20 m.

- The overlying Shueib Formation (A5-A6) consists of marl and thinly bedded limestones with some layers of calcareous siltstones and limestone.

The thickness of the lower Ajlun group ranges from 225 m to 300 m in the wellfield area, and around 100 m in the Eshidiya mine area as shown in Fig. (4.1) and (4.2).

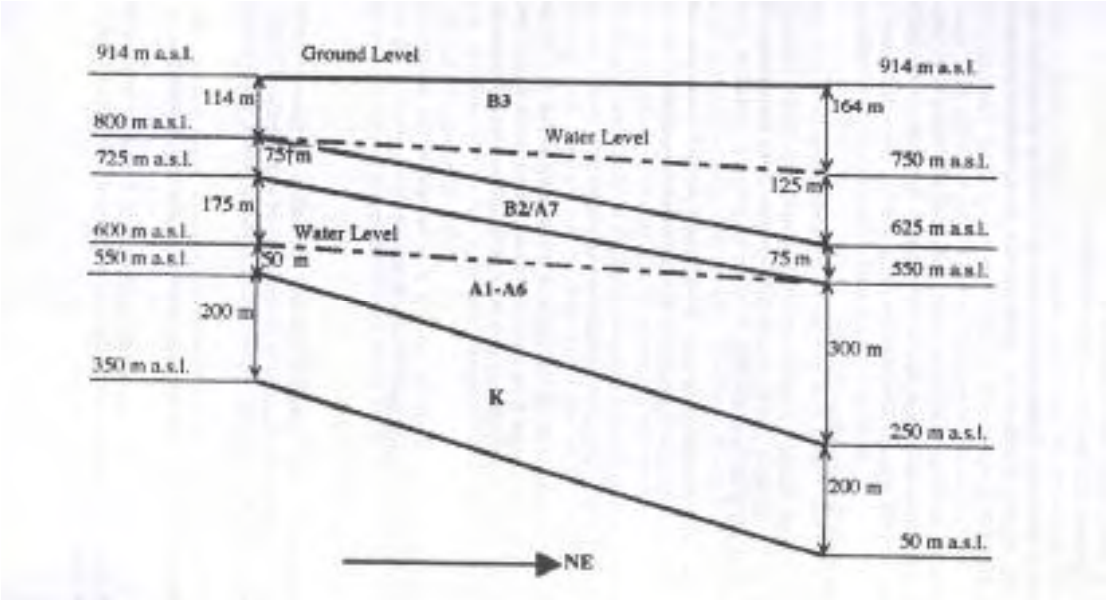


Fig. (4.1): Geological formations sequence in well field zone

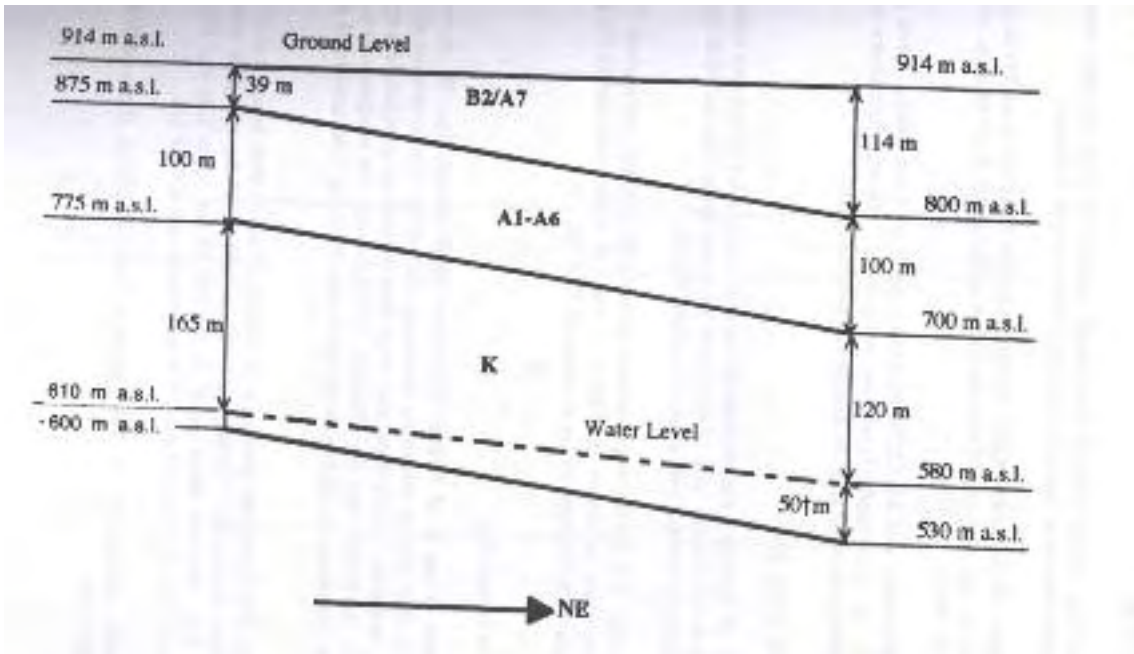


Fig. (4.2): Geological formations sequence in Eshidiya phosphate mine zone

The A4 (Hummer) and A1-A2 (Naur) aquifers have good potentiality. Since they are overlain by impermeable layers, they are confined. The other formations are of poor potentiality although they are located in a saturated zone.

5. The Kurnub Group (K)

It consists of light grey and varicolored fine to coarse grained sandstones with thin intercalations of siltstone and of some sand clays and shale. Thin to thick bedded Kurnub sandstone extends over most of southern Jordan. The thickness of Kurnub Group is around 200 m in the wellfield and around 170 m in Eshidiya mine area, while it outcrops in the slime disposal area with a thickness of 247 m.

6. The Khreim Group (Kh)

The Khreim Group belongs to Middle Ordovician-Upper Silurian age. It consists of dominantly fine grained micaceous sandstones alternating with micaceous siltstone and some mudstone. Colors of outcrop range from reddish and greenish to gray. The Khreim is subdivided upward direction into the Hiswash, the Dubaydib, the Mudawwara and the Khushsha sandstone formations. However, it is considered as one unit. In the end of the slime disposal line, the thickness of Khreim group is around 900 m. The aquifer potentiality of this group is poor. Therefore, the possibility of infiltration is low.

4.2.2 Geology of the storage tanks site in Aqaba area

The geology of the southern part of Aqaba area consists entirely of granular sedimentary deposits which are derived from the Precambrian granite mountain north and east of the area. The sedimentary deposits vary from coarse silts to granitic gravels, cobbles and boulders. They were formed by erosion of the granite (and possibly Paleozoic sandstone which previously overloaded the granite) and were laid by rivers, and in lakes, during the Pleistocene period.

Subsequent and continuous surface water erosion of these deposits had produced the present topography of the study area. The study area consists of ridges of cemented sedimentary deposits, separated by wadis which have eroded into these deposits. The product of this recent erosion forms the wadis bed soil. In general, sediments have high permeability and this may cause groundwater pollution (Royal Scientific Society/ Environmental Impact Study of Hydro-Agri Jordan, 1999).

4.2.3 Faulting structure in the project site in Eshidiya area

According to the seismic zones map of Jordan that was prepared by the Natural Resources Authority as shown in Fig. (4.3), the project site is located within zone 1, which is characterized by the properties shown in Table (4.1) (Al-Doha Engineering Center report, 2008).

Table (4.1): Seismic properties of the study area in Eshidiya area

Seismic zone	Type of material	Soil profile factor	Zone factor (Z)	Seismic factor	
				Acceleration (Ca)	Velocity (Cv)
1	Marly limestone, phosphate, chert and coquina	S_B	0.075	0.08	0.08

4.2.4 Faulting structure in the storage tanks site in Aqaba area

Aqaba area is characterized seismically as a high risk area, because it is located within the seismically active 1000 km along Dead Sea rift zone, a left-lateral strike-slip fault system. Although very large earthquakes occurred in the past 2000 years, no extensively large events have occurred in the 20th Century. The Dead Sea rift zone is a sinisterly slip plate boundary that extends from the Gulf of Aqaba northeast along the Dead Sea Jordan valley into central Lebanon terminating in northwest Turkey. A few active faults appear on the aerial photograph of the northern sandy-silty zone, “plain area” (Royal Scientific Society/ Earthquake Hazard Study in Jordan, 2004). The dominant fault is the fault, which extends for few kilometers within the plain area in NW-SE direction parallel to the northern coast of the Gulf of Aqaba as shown in Fig. (4.4).

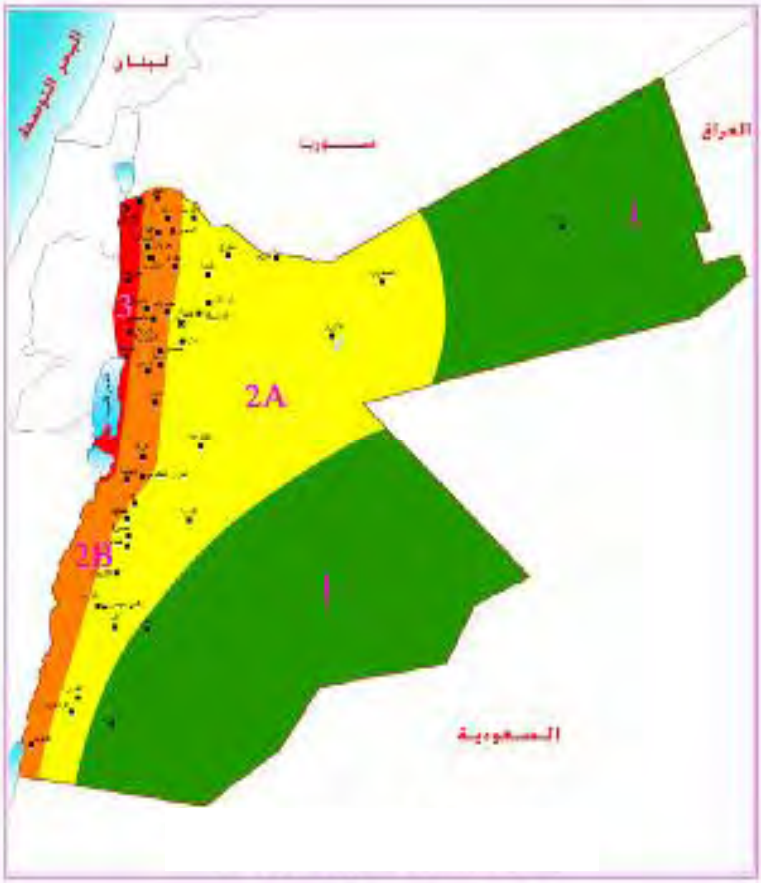


Fig. (4.3): Seismic classification map in Jordan

Fig. (4.4): The dominant fault extends for few kilometers within the plain area in NW-SE direction parallel to the northern coast of the Gulf of Aqaba

These faults together with the other parallel faults having NW-SE direction are transversal faults. They have nowhere been manifested crossing the alluvial fill of the south Araba plain. These faults are limited in extent and they cease to exist before reaching the eastern border fault or the western strike-slip fault.

4.2.5 Surface water resources of the project site in Eshidiya area

Al-Jafer catchment area is considered as depression area in southern part of Jordan, with a total area of 12.2 km². It is a flat area bordering the highlands in the west. The annual rainfall is around 30.4 mm of which around 30 mm evaporates. There is no perennial stream flow. Runoff takes place for a few days during rainstorms. Most of the runoff originates in the western highlands where the rainfall is high. There is one gauging station in the whole basin. The total discharge of the catchment is around 15 MCM / year, of which 10 MCM / year flow as floods into the Al-Jafer depression, where they either evaporate or infiltrate into the ground down there. The base flow, in the form of spring discharge, is totally used in irrigation, whereas 0.75 MCM / year is used by local villages and farms (Salameh, 1996).

The sub-catchment area of the project site is located in the middle of Al-Jafer catchment area at downstream of Qa'a Al Shbeiki; which is the lowest depression area in Al-Jafer catchment area. The project sub-catchment area is estimated at about 5.5 km^2 and sloping at about 1.2% toward northeast direction, as shown in Fig. (4.5). The sub-catchment area is characterized by a gentle hypsometric gradient, therefore the gradient of watercourses of streams is gentle and regionally flows toward north-east direction and discharges into Qa'a Al Shbeiki. The precipitation amount is poor during winter season, while the major part of the rainfall in the area is either absorbed by the soil, or directly lost by depression storage and then evaporated. During winter and especially in the heavy rainy days, surface water presents as small ephemeral wadis, while in the rest of the year they are dry. The thunderstorms form a great part of the rainfall precipitated over the catchment area and is characterized by irregular intensity and duration.

Regarding to the gauging records of Al-Jafer catchment area, the runoff is estimated by using the United States Soil Conservation Services (SCS) Curve Number Approach to study the impact of the surface runoff on the project site. This method relates storm runoff to rainfall by relationship depends primarily on the potential abstraction of water

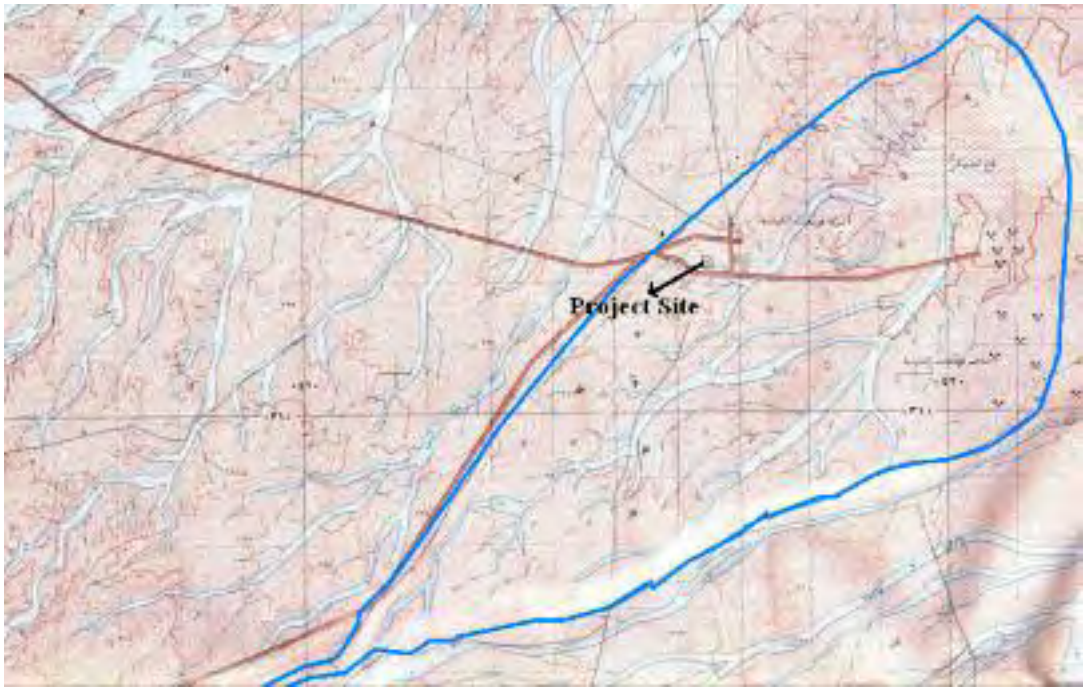


Fig. (4.5): Sub-catchment area of the project site in Eshidiya area

by soil storage. High potential abstraction means less runoff for a given rainfall represented by lower curve number. The curve number (CN) is estimated from the topographic maps, geologic map and land use (Chow et al., 1988). The equation relating the runoff to accumulated rainfall is

$$Q = (P-0.2\,S)^2 / (P+0.8\,S) \text{ ---------- } (4.1)$$

Where;
Q: Runoff depth (inches)
P: Rainfall depth (inches)
S: Depth of the potential abstraction (inches)

The relation between the curve number (CN) and S (inches) was found as:

$$S= (1000/ CN)-10 \qquad \text{---------- } (4.2)$$

According to the rainfall data taken from Water Authority of Jordan (WAJ) data bank, the annual average rainfall during the period years from 1980 to 2006 over the project site catchment area is around 14.3 mm which is equivalent to 0.08 MCM. The runoff is estimated by using SCS Curve Number method. The area of the project site catchment area is estimated to be 5.5 km². Due to the project site is characterized as poor vegetation cover and the surface soil is silty clay, the curve number (CN) is estimated as 80 for the project site catchment area (. By applying the equation (4.2), the potential abstraction was found 63.5 mm. By applying the equation (4.1), the annual runoff at the outlet

of the project site catchment area relating to the annual rainfall volume is calculated as shown in Table (4.2). The long term average runoff at the outlet of the project catchment area is 0.002 MCM.

Table (4.2): The average runoff volume at the outlet of the project sub-catchment area

Year	Avg. Rainfall Depth (mm)	Rainfall Volume (MCM)	Runoff Volume (MCM)
1980/1981	6.27	0.03	0.004
1981/1982	7.35	0.04	0.003
1982/1983	5.17	0.03	0.006
1983/1984	7.63	0.04	0.002
1984/1985	8.72	0.05	0.001
1985/1986	17.75	0.10	0.002
1986/1987	17.66	0.10	0.002
1987/1988	11.73	0.06	0.0001
1988/1989	23.19	0.13	0.008
1989/1990	15.41	0.08	0.001
1990/1991	10.79	0.06	0.0003
1991/1992	22.07	0.12	0.007
1992/1993	11.94	0.07	0.0001
1993/1994	13.02	0.07	0.00001
1994/1995	18.62	0.10	0.003
1995/1996	16.52	0.09	0.001
1996/1997	13.67	0.08	0.0001
1997/1998	19.26	0.11	0.003
1998/1999	20.44	0.11	0.005
1999/2000	16.52	0.09	0.001
2000/2001	7.71	0.04	0.002
2001/2002	17.73	0.10	0.002
2002/2003	14.34	0.08	0.0002
2003/2004	11.82	0.07	0.0001
2004/2005	14.22	0.08	0.0002
2005/2006	19.56	0.11	0.004
2006/2007	16.32	0.09	0.001

4.2.6 Surface water resources of the storage tanks site in Aqaba area

The study area belongs to Wadi Yutum catchment area, which drains and from an extensive area in southwest Jordan, east of Aqaba into the Red Sea. The extent of the catchment area is 4.4 km². Precipitation over the area falls in the form of rainfall and ranges from 150 mm/year in the highlands to less than 50 mm/year in the central and eastern parts of the catchment area. The potential evaporation is very high and ranges from 3400 mm/year in the western parts up

to 3800 mm/year in the eastern and southern parts. Since the area is flat, precipitation water infiltrates into the barren rocks, mostly consisting of sandstones and weathered rocks. There are no groundwater discharges in the area, and the surface water forms as floods resulting from intense precipitation.

The rainfall occurs accidentally with short durations, normally lasting less than three hours. The surface runoff consists of flash floods along the short side wadis coming from the eastern highlands. Most of the surface water is lost due to evaporation and percolation in wadis floor. The remaining water in the wadis could transport some of the sediments into the sea. The total water discharge from the eastern wadis into the area is estimated at 1 MCM/year, indicating the very low potentialities of the area. The drainage of whole catchment area into the Red Sea is around 10 MCM/year (Salameh, 1996).

4.2.7 Groundwater resources of the project site in Eshidiya area

The main groundwater aquifer in the area is B4 formation of the Balqa group, consisting of thin beds of chert, limestone, clay and marl with a total thickness of 20 - 25 meters. The B2/A7 and the Kurnub and Disi sandstones form the deeper aquifers, which are separated from each other by thick aquitards. The different aquifers are weakly interconnected. The groundwater flow in the B4 aquifer is generally directed from west to east. In the lower aquifers, the groundwater flows in a general northerly direction with components towards the northeast and northwest. The groundwater in the deeper aquifers represents a support and backbone of other groundwater bodies found northwest and south of Al-Jafer Basin. Hence, extracting the water of the deeper aquifers would undermine other resources (Royal Scientific Society/ Environmental Impact Study of Hydro-Agri Jordan, 1999).

Recharge to the B4 aquifer takes place in the mountainous highlands of Shoubak lying to the west of the Al-Jafer Basin. Direct recharge by precipitation is negligible, because the surface area of the depression plain, where floodwater collects, is covered by very fine sediments. This does not allow for the rapid infiltration of recharge water. The total recharge to the B4 aquifer is around 7 MCM/year (Parker, 1979). Because of over-exploitation, the groundwater resources started to deteriorate in the late sixties after only a few years of extraction. The salinity increased rapidly from 600 to 700 mg/l in the early sixties in the different wells to values between 700 and 2800 mg/l in the early seventies.

Since that time, no major changes have taken place in the water quality. Although some water salinities increased beyond their values of the early seventies.

The study area is located in the southern part of Jafer basin. Three aquifer systems exist in the study area; these are Amman-Wadi Sir, lower Ajlun, and Kurnub aquifers.

1. The Amman-Wadi Sir (B2/A7)Aquifer

This is the major aquifer in the area and considered as a good aquifer in the northern part of the study area. It outcrops in the southern part of the basin at Eshidiya mine where it is phreatic and unsaturated. While in the wellfield zone, it becomes confined by Muwaqqar aquiclude and fully saturated. Groundwater flows eastwards from the western. The total recharge of the aquifer is estimated at 3.5 MCM/year; where a 2.1 MCM/year from the Shoubak Mountain and 1.4 MCM/year by infiltration of runoff through the wadi beds in the outcropping area. In the confined portions of the aquifer, a downward vertical leakage from the overlying Muwaqqar aquiclude seems to provide little additional replenishment to the aquifer. However, a subsurface recharge from the southern and eastern part to the project site area is negligible because B2/A7 formation is almost dry. In addition, the aquifer in project site area is slightly elevated, which means that subsurface flows coming from the west will not reach the project site area due to groundwater flow conversion northwards following the regional direction of the formations towards Al-Jafer basin. The estimated depth of water level of B2/A7 formation is about 114 m.

2. The Lower Ajlun (A1-A6) Aquifer

In Al-Jafer basin, the predominant sandstone facies of the lower Ajlun can be considered as an aquitard with no good potential for water storage, with a mean thickness of 200 m. It has been encountered of depths more than 300 m in the wellfield zone and around 100 m in the Eshidiya mine.

The general direction of groundwater flow is from the northeast to southeast. In the southeast, the lower Ajlun is of locally hydraulic continuity with B2/A7. Since the B2/A7 aquifer is dry in this area, it is quite evident that the A1-A6 is also dry due to the lack of downward leakage from the B2/A7. The volume of groundwater stored in Ma'an - Al-Jafer Eshidiya area is estimated at about 40,000 MCM, of which 1% can be extracted under economic conditions. In most of Al-Jafer basin, this aquifer is stored under confined conditions except in the southern escarpment where it is under phreatic conditions.

3. The Kurnub Aquifer

This multilayered aquifer outcrops extensively in the southeast edge of the Jafer basin, where it forms the single largest outcrop of Kurnub in Jordan. It has an average thickness of 200 m. Depths to aquifer are greater in the west and the north than in the east and south. The depth to the water level is around 334 m in the project site area and around 300 m in the wellfield zone. The groundwater direction is from southwest to northeast. Due to the aridity of the climate in the southern areas, the entire outcrop remains unsaturated and the stored groundwater is old (10,000 - 30,000 years, nonrenewable water). The estimated total aquifer storage is approximately 30,000 MCM. In addition, the hydraulic characteristics of the aquifer are expected to be unfavorable for exploitation as it is characterized as a low porosity and has a low well yield.

The Water Authority of Jordan (WAJ) has drilled many wells in the basin for irrigation and domestic uses, and permitted JPMC to drill wells in Eshidiya area to utilize the groundwater for industrial uses. The amounts of the groundwater abstracted from the aquifer for the irrigation, industrial and domestic uses is shown in Table (4.3), the data are according to WAJ data bank. In addition, WAJ has drilled observation wells for monitoring the water level in the basin area, as shown in Table (4.4) (WAJ Data Bank Report, 2007).

Table (4.3): The average amounts of groundwater abstraction from Al-Jafer basin

Production (MCM)	Year						
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Industrial	6.63	5.97	6.98	7.02	6.49	6.24	6.65
Irrigation	10.35	8.03	9.51	6.82	7.61	8.89	7.89
Domestic	7.56	7.68	7.71	10.53	6.91	6.72	6.77
Total	24.54	21.68	24.2	24.37	21.01	21.85	21.31

Table (4.4): The characteristics of the drilled wells by WAJ (2007)

Station ID	Station Name	Depth to Water (m)	Static Water Level (m)
G 1210	Udruh 4 (S 118)	59.67	1242.38
G 1341	J.O.3/Jafer observation well	125.95	788.65
G 1342	J.T.3/Jafer test well	40.9	873.25
G 1346	Abu Makhtub/observation well (No.4)	105.12	1225.03

Station ID	Station Name	Depth to Water (m)	Static Water Level (m)
G 1405	Ibn Jazi observation well	194.4	1115.92
G 3081	Jafer observation well 1	19.91	850.34
G 3082	Jafer observation well 2	25	844.25
G 3145	Jitheh/Wheida observation well 1	18.22	1231.98
G 3146	Jitheh/Wheida observation well 2	84.45	1145.7
G 3147	Jitheh/Wheida observation well 3	38.07	1164.1
G 3149	Jafer monitoring well 3	18.47	871.96
G 3163	Jafer monitoring well 4	34.22	881

4.2.8 Groundwater resources of the storage tanks site in Aqaba area

The storage tanks site area is located in southern Wadi Araba aquifer, where the wadi floor is composed of quaternary alluvial sediments brought from the surrounding mountains in the east and west. The thickness of the sediment fill is measured in kilometers, but the fresh and brackish groundwater is found in the uppermost portions of the aquifer. The groundwater flow is directed from the north to the Red Sea in the south. The recharge comes from precipitation falling on the surrounding mountains in the east and infiltrates there in the barren rocks and flows laterally into the wadi courses of the side wadis and Wadi Araba itself. The total potential annual yield is about 10 MCM which is mostly composed of brackish water, where the salinity increases in the direction of groundwater flow; from north to south.

4.2.9 Potential risk of groundwater contamination from project site in Eshidiya area

The sequence of geological units in the project site in Eshidiya area from the surface to a depth of 350-400 m can be described as soil and alluvial deposits then Amman-Wadi Sir formation (B2/A7) followed by the Lower Ajlun Group (A1-A6) and Kurnub Group (K).

To estimate the risk of groundwater pollution, a mathematical equation that is based on Darcy's law is applied on the formations and soils from the shallow

wells and deep wells drilled earlier in the studied area. The results indicate that the rock can be considered as a homogenous up to the top of the Kurnub sandstones i.e up to the depth 334 m. The site area is very arid with maximum annual precipitation of about 50 mm and has very high evaporation rates.

The following assumptions are used to define the risk of groundwater contamination at the site for the worst conditions.

- Maximum rainfall of 50 mm representing constant head (y). The 50 mm value has been taken from the long-term rainfall map (50 years) of Jordan done by the Ministry of Water and Irrigation.

- The rock material beneath the alluvial deposits has a maximum permeability of 1×10^{-8} m/s (Salamah and Udluft, 1985).

- The energy for water seepage is gravitational

- Maximum porosity (n) is 30%.

- Maximum moisture content of 5%.

In order to calculate the velocity of the seepage at the site, the Darcy's law was considered. The diffusivity (D) is defined as:

$D = K \times dH/dØ$ ---------- (4.3)

Where:
H is matrix suction
Ø is the volumetric water content which is equal 1-n.
dH/dØ is the moisture content of formation.
K is the maximum permeability of the formation (m/sec).

The diffusivity is calculated to be equal to 5×10^{-10} m/sec. This value of diffusitivity is relatively very low.

The velocity of water flow through the rock mass in the direction of gravity force can be calculated as follows:

$V_f = -(K + D \times dØ/dy)$ ---------- (4.4)

Where:
V_f is the velocity of water flow through the formation (m/sec).

y is the constant head representing a maximum annual rainfall, it is assumed as 50 mm (worst condition).

By solving Eq. (4.4), the velocity of seepage water is calculated to be equal to 1.07×10^{-8} m/s. Using the seepage velocity, the time needed for the passage of water of constant head of 50 mm to reach a 334 meter depth is about 990 year. This means that the risk of groundwater contamination is very low.

For sensitivity analysis and by assuming that such geological formations could have easily joints and fractures that will enhance the vertical permeability, the permeability of the rock formation above the groundwater table has been increased by one order to be 1×10^{-7} m/s. As a result of such increase the velocity of seepage water will be increased to be equal 1.07×10^{-7} m/s. The time needed for water passage will be about 99 years.

4.2.10 Potential risk of groundwater contamination from storage tanks site in Aqaba area

The storage tanks area consists of ridges of cemented sedimentary deposits, separated by wadis which have eroded into these deposits. The product of this recent erosion forms the wadis bed soil. In general, sediments have high permeability and this may cause groundwater pollution. The hydraulic conductivity of such deposits (according to the Bureau of Reclamation, groundwater manual, US Dept, Interior, 480 pp, 1977) is in the range of 100 m/day or 1×10^{-3} m/s.

The geotechnical characteristics indicate that the sediment deposit can be considered as a homogenous up to the top of the sea water interface, i.e. up to 10 meters depth below sea level. The following assumptions are used to define the risk of sea water contamination at the site in worst conditions.

- Maximum rainfall of 50 mm representing constant head (y).
- The soil material has a maximum permeability of 1×10^{-3} m/s. This value is from Bureau of Reclamation (1977) and soil samples.
- The energy for water seepage is gravitational.
- Maximum porosity is 35%.
- Maximum moisture content of 10%.

– Distance from sea coast to the project site is about 1.5 km.

– The fresh water/ salt water table at a distance of 1.5 km is 50 m.

The diffusivity (D) was calculated to be $1x10^{-4}$ m/ s. This value of diffusitivity is relatively very high. The velocity of water flow through the sediment mass in the direction of gravity force was calculated using Eq. (4.4) to be 2.3×10^{-3} m/s. By using the seepage velocity, the travel time for one drop of pollutant to travel from the ground surface to the water table the time needed for the passage of water of constant head of 50 mm to reach a 50 meter depth is about 3 hours. This means that the risk of sea water contamination is very high.

4.2.11 Water supply for the project in Eshideya area

Groundwater of Al-Jafer aquifer is the main source for water supply in the project site in Eshidiya area for industrial and domestic uses. For industrial uses, Jordan Phosphate Mines Company (JPMC) drilled 21 wells, 19 wells have a total yield of 1900 m^3/hr, while 3 wells are stand by. The total water used by the industries in Eshidiya area till 2006 amounted to 117 MCM (58 MCM for JPMC, 39 MCM for Indo-Jordan Chemical Company, and 20 MCM for domestic uses).

The proposed water demand of JIFCO project is estimated at 19,000 m^3/day for industrial and domestic purposes. The water supply of the project will be provided through Ministry of Water and Irrigation by permitting JIFCO to drill water well to fulfill their demands.

The laboratories of Royal Scientific Society analyzed the water sample that was taken by JPMC from the well in Eshidiya area. The average values of the chemical characteristics of the well are shown in Table (4.5).

Table (4.5): Average values of the chemical characteristics of Eshidiya well

Parameter	Units	Results
Color	PCU	10
Turbidity	NTU	40
Electrical Conductivity	µs/cm	653
pH	mg/L	6.95
Total Dissolved Solids	mg/L	386
Total Suspended Solids	mg/L	8
Ca	mg/L	51
Mg	mg/L	27
Bicarbonate (HCO_3)	mg/L	261
Sulfite (SO_4)	mg/L	36

Parameter	Units	Results
Cl	mg/L	58
F	mg/L	0.3
Na	mg/L	46
K	mg/L	9
Fe	mg/L	1.55
Mn	mg/L	<0.017
SiO_2	mg/L	25.5
Cu	mg/L	<0.02
Pb	mg/L	<0.09
Phenol	mg/L	<0.002

4.2.12 Water supply for the project in Aqaba area

The main source of water supply for the project site is Disi-Mudawwara aquifer, which is the same as in Aqaba region. The aquifer consists of deep sandstone fossil water, which appears to be the only extensive and substantial source for fresh water. The only economically viable location for development of this aquifer is the sandstone closer to the surface located in the far south of the country. The outcrop area of Disi-Mudawwara in Jordan is approximately 300 square kilometers, and the nearest static depth to water is generally less than 100 meters.

Water demand for the storage tanks area in Aqaba is estimated at 0.4 MCM/year (assuming six employees will be existed in the project site).

4.3 Impact Evaluation

4.3.1 Boundaries

The temporal boundaries for the evaluation of impacts on water resources are determined by the project life (construction, operation, and decommissioning phases). The spatial boundary comprises the surface water catchment area and the groundwater aquifer for Eshidiya and Aqaba areas where the project plants and storage tanks located within.

4.3.2 Issues and concerns

The major issues and concerns identified during the scoping session about water resources were as follows:

<u>Construction Phase</u>

- Disposal of spent oil and car batteries from construction vehicles and machinery.

- Domestic wastewater generated from workers.
- Not studying the current condition of surface and ground water in the area.
- Not studying alternative water resources use and management.
- Not determining the existing wadies and drainage of the surface runoff.
- Not studying the possibilities of reusing treated wastewater.
- Not having coordination with Ministry of Water and Irrigation regarding the location of the water wells and the wastewater treatment plant.

Operation Phase

- Reuse of treated domestic or industrial wastewater on water resources.
- Gypsum disposal on groundwater resources.
- Not complying with the rules of the Ministry of Water and Irrigation regarding water resources protection zones.
- Utilizing the non-renewable water aquifer as resources for the process.
- Project activities on the existing wadis and drainage of the surface runoff.
- Not studying of using alternative water resources for the cooling process.

4.3.3 Assessment

Disposal of industrial wastewater

All of the generated industrial wastewater during operation phase (spills, leaks) will be drained to sumps then it will be reuse into the process. For emergency case or during shutdown, a guard pond which capacity is around of 25,000 m^3 will be used.

The off-grade fluosilicic acid is generated from the process will be recycled into the phosphoric acid plant. In case of possibility of neutralization of small quantities of off-grade fluosilicic acid with limestone, the solid waste will be disposed with gypsum, while the liquid waste will be recycled into the phosphoric acid plant.

Groundwater contamination in the project site in Eshidiya area would pose low-moderate risk if lining were not considered. According to the analysis in section (4.2.9) and (4.2.10) the time for underground passage of liquid waste to reach 334 m depth is estimated at about 99 years. However, the risk of seawater contamination at the storage tanks area in Aqaba (that might be resulting from handling and storage of phosphoric acid) is high. Estimation indicates travel time of pollutants would be three hours. On the other hand, the laws and regulations in Aqaba zone prohibit any chemicals to reach the sea water.

Handling and disposal of domestic wastewater

The domestic wastewater generated from workers during the construction and operation phases in Eshidiya and Aqaba areas may pollute the soil and cause vector diseases, if it is not managed in an environmental safe manner. However, the wastewater resulting from the workers and employees in Eshidiya will be treated in a domestic treatment plant and the treated wastewater will be used for irrigation purposes.

Disposal of spent oil and leakage of oil storage tank

The waste oil and car batteries will result from the machines, equipment and vehicles used in excavation during the construction phase. The leaked oil may be generated from the fuel oil storage tank that is used as standby fuel and from any spent lubricating oil from equipment and vehicles during the operation phase. Due to the high risk of the waste oil infiltration to the sea water table in Aqaba storage tanks, the impact of pollution on soil and sea water will be high if the disposal method is not managed well. However, the risk of pollution of the groundwater inside the project site in Eshidiya area is low but the impact of pollution to the soil is considered high, if a remediation procedure is not conducted.

Impact of the industrial solid wastes

The industrial solid wastes will be generated from different units such as gypsum (as by product from phosphoric acid production), spent vanadium pentoxide catalyst and sulphur wastes from filtration process in the sulphur storage and melting unit.

The gypsum is produced at a regular amount of 2.8 million metric ton per year and is disposed into the land near the plants site and next to the current existing gypsum disposal site that belongs to IJCC. The new disposal site will occupy an area of around 1.7 km2. The gypsum that is generated from JPMC in Eshidiya and Aqaba site contains a concentration of radionuclides (^{226}Ra, ^{210}Po and ^{210}Pb) and trace metals including heavy metals and some impurities (Al Hwaiti, M and et al; "*Distribution and mode of occurrence of radionuclides in phospho-gypsum from Aqaba and Eshidiya Fertilizer Plants/ Jordan, 2007*". As radionuclides are considered most radiotoxic and the heavy metals could have a problem to the surrounding environment, it is implied that these substances may have a negative impact on the groundwater through infiltration into the water table. Al Hwaiti studied the mobility pathways of the radionuclides and heavy metals of the phospho-gypsum in both Eshidiya and Aqaba stacking areas sites and their potential effect on the groundwater table in these sites. The results of the study indicated that the ^{226}Ra, ^{210}Pb and heavy

metals are strong bound to phospho-gypsum size particles and are hardly transferred to the environment in a soluble form. This suggests that these substances could not transfer to the environment by simple dissolution. In addition, ^{226}Ra and ^{210}Pb are enriched in phospho-gypsum particles not associated with $CaSO_4$ itself. This implies that they may be contained in different minerals phases, and therefore do not form a threat to the surrounding environment. However, the potential of pollution to the soil is still valid if the disposal is not managed properly.

The sulphur waste will be generated from the sulphur filtration process which is the filter cake. This waste will be mixed with the gypsum and then disposed into the staking area.

Impact of the surface runoff

The average annual volume of the runoff of the project sub-catchment area in Eshidiya area is very low; it is calculated as 0.002 MCM. There are no water courses in the project site in Eshidiya area; therefore any change of the water flow pattern in the site resulting from excavation is not significant. The company will construct overland trenches, lined drains, and underground pipe system to divert the storm water runoff away from the plant structure and without disturbing the far end wadis.

The existence of the wadi close to the location of the storage tanks in Aqaba area may cause an impact during a heavy storm runoff and may cause damage to the structure of the tanks

Considering an alternative water resources

Considering future water demand by all industries in the Eshidiya area, it seems that future water needs from the B2/A7 aquifer will not be sustained. Alternative water supply options in that area can be either the Disi-Amman Water Supply Conveyance System or the deep drilling into the Rum group (Disi aquifer) within the Eshidiya area.

A) The Disi Amman –Water Conveyance System: The project involves supplying an average of 100 MCM/yr water from the Disi Aquifer to Amman over a distance of more than 300 km. This is required to meet urgent municipal and industrial requirements of Greater Amman area and the southern governorates. The project construction period is about five years. It seems that the Disi pipeline will be one of the most attractive options to meet the water demand of the phosphate mines in the near future.

b) The Rum Group (Disi Aquifer) within the vicinity of the Al-Jafer Area: The Rum aquifer covers about 3,000 km^2 and it occur under the Jafer/Eshiydiya area at large depth. Recent estimates by the Phosphate Company and the Water Authority of Jordan indicate the depth to the top of the Rum group to be about 1500 m. The estimated water level under artesian conditions is estimated at about 200 m. The pumping lift will be economically acceptable under such head. Expected salinity will be less than 1000 ppm. The water temperature will be high and is expected to be around 45 degrees centigrade. The yield of such a borehole will be between 100 – 150 m^3/hr. Such a drilling and exploitation program will not affect the resource availability of Rum aquifer (Disi) within the vicinity of Disi and Mudawwara area due to the relatively large horizontal distance, which is estimated at about 70 km. Furthermore, the aquifer thickness increases to reach 1500 meters in that area and the potential storage amount is very high in comparison to the abstracted amount.

Table (4.6) summarizes the residual impacts of significant issues on water resources.

4.3.4 Mitigation Measures

Disposal of the industrial wastewater

- The guard pond shall be designed and lined by using high density polyethylene material in a proper method to prevent any possible occurrence of the infiltration of the industrial wastewater into the groundwater table. The lining material shall be inspected regularly.
- The phosphoric acid storage tanks in Aqaba area shall be designed according to the local and international codes against the seismic hazard. In addition, the tank should be provided with a properly lined containment area capable of holding the largest tank volume and 10% of its volume. During the operation phase, emergency handling and cleaning program in case of accidents shall be included in the design of the site facility. The storage tanks should be inspected on a regular basis.
- It is recommended to establish a monitoring program to monitor infiltration through soil sampling through shallow boreholes located downstream of the guard pond and the gypsum staking area.

Disposal of waste oil and leakage of oil storage tanks

- Fuel oil/diesel storage tank should be designed according to international standard codes. In addition, the tank should be provided with a properly lined containment area capable of holding the tank volume.

- The waste oil generated from the spillage, leakage of oil storage tanks, and the spent lubricating oil of equipment and vehicles should be collected in special containers and transported in a safe manner to Jordan Petroleum Refinery Company or sold to the licensed collector of used oil.

Handling and disposal of domestic wastewater

- During the construction phase, the domestic wastewater should be collected in an impermeable reinforced (sealed) tank and should be disposed to the nearest municipal wastewater treatment plant using licensed vacuum tanks and following the appropriate environmental regulations.
- During the operation phase, the treated domestic wastewater resulting from the treatment unit shall be complying with the Jordan and IFC regulations before it can be used for irrigation.
- The dismantling of the domestic wastewater treatment unit during the decommissioning phase should be done in an environmentally safe manner. The wastewater should be emptied before by using vacuum vehicles. The wastewater should be disposed to the nearest domestic treatment unit.

Impact of the industrial solid wastes

- The spent vanadium pentoxide catalyst (V_2O_5) should be sealed in steel or plastic drums and stocked in designated area and then it shall be returned to the supplier.
- The floor of the gypsum stacking area shall be constructed and compacted in a proper way using proper material to obtain the soil permeability not larger than $1x10^{-6}$ m/sec. The stacking area shall be contained by dike in all sides to prevent seepage of the wastes out the containment area.

Impact of the surface runoff

During the construction phase, the company shall consider constructing gabions along the side of the wadi near to the storage tanks in Aqaba to minimize the flood impact on the tanks. The company shall also work on protecting the drainage pattern of this wadi from the construction activities.

Considering an alternative water resources

Further studies shall be commenced by all industries in Eshidiya area to find alternative resources to compensate for the deficit between the available and required quantities. The company should use the excess amount of the treated domestic wastewater from the project as well as to study in future the possibility to reuse the treated domestic wastewater from Ma'an municipal

treatment unit and the planned treatment unit of Ma'an industrial zone. The company shall comply with the rules of the Ministry of Water and Irrigation regarding water resources protection zones.

Table (4.6): Evaluation of potential impacts of water resources

Impact of	Geographic Extent	Level	Frequency	Duration	Direct (D) Indirect (ID)	Reversible (R) Irreversible (IR)	Likelihood	Significant	Positive/ Negative	Remarks
Groundwater pollution in Aqaba	H	H	M	H	D	R	M	Yes	Negative	Mitigation measures are required
Groundwater pollution in Eshidiya	L	L	L	L	D	R	M	Yes	Negative	Mitigation measures are required
Impact of surface runoff in Aqaba	L	M	M	L	D	IR	M	Yes	Negative	Mitigation measures are required
High demand on water consumption	M	M-H	H	H	D	R	H	Yes	Negative	Mitigation measures are required

<u>Significance criteria:</u>

Geographical Extent:	L:	Limited to project site.	M:	May reach outside the project site.	H:	Will reach outside the project site.
Level:	L:	Will not change existing level.	M:	Will change existing level slightly.	H:	Will change existing level severely.
Frequency:	L:	Occurs only once/ rarely.	M:	Occurs during abnormal conditions.	H:	Occurs continuously.
Duration:	L:	During specific activity.	M:	During construction phase.	H:	During operational phase continuously.
Likelihood:	L:	Impact is not likely to occur.	M:	May occur.	H:	Will occur.

5. BIODIVERSITY

5.1 Introduction

This chapter aims at assessing the direct and indirect impacts of the project sites at Eshidiya and Aqaba on various aspects of terrestrial biological environment along the project life. According to the Performance Standard 6 IFC, the following parts of the biological environment were the study targets:

- Ecosystems
- Habitats: Natural habitats modified habitats, critical habitats and legally protected areas
- Species
- Communities

The study correlated these target biological environment aspects with their physical environment units. The effects of the predicted impacts that would occur for these physical environment units on the biological environment aspects in the project sites were examined.

The following parts of the biodiversity were the study targets: bio-geographical zones that the project area (corridor) passes through, flora and fauna of the project area, and sensitive habitats.

The study adopted the following methodologies:

1. Literature survey: The survey team collected and reviewed the available data about the biological environment in the project sites. Data collection was achieved through library search for the available reference on the biodiversity or any related biological aspects and references from institutions and specialists that work in this field.
2. Field work survey: This survey was completed and updated the literately collected data. Different techniques were used in the field work and as the following:
   - Line Transects: This technique was used to study most of the biological aspects of environment as the following:

     Flora: Line transects was commonly used to study changes in vegetation along a physical environmental gradient. Also, it was used to estimate overall density of cover values of species in a single type of vegetation, which also can be correlated to various physical environmental factors such as salinity, humidity, soil composition, topography.

Fauna: In this technique, researchers walked the selected grid in a systematic way that enabled them to cover the whole sampling unit. This technique was applied for different target groups of fauna as follows:

Birds: Line transects were effective method to study birds of extensive open habitats in both terrestrial and wetland habitats. This method was used to identify counting density along various environmental gradients.

Mammals: Line transects technique was applied for both large and small mammals as well as for large reptiles. It was the easiest and direct method for counting mammals and or recording them through a gradient of various environmental factors. It depends mainly on recording their singes like footprints, spoors and body remnants.

- Interviewing Technique: This technique was used to study the historical record for the flora and fauna of the project sites. It was used to correlate the environmental changes with the change on the biological environment and to build up the prediction for the future trend in biological environment with the presence of the expected impacts of the project.

5.2 Evaluation of Physical Environment

5.2.1 Location

The first project site which is proposed for sulphuric and phosphoric acids plants is located in the Eshidiya area, 75 km to the east of Ma'an and 180 km northeast of Aqaba. The other site of the project, which is proposed for the storage tanks, is located at the southern shore of Aqaba, around 25 km south of the city and around 1.5 km from the shoreline, see Fig. (5.1).

5.2.2 Topography

The proposed site for the phosphoric and sulphuric acids plants belongs to the Eastern Desert Topographic region, which is also called Badia. Badia in general comprises the eastern plateau of Jordan. It is considered as a flattened area subjected to flash floods. Badia contains two major depressions: Al-Jafer and Al Azraq where a permanent Oasis was formed. The proposed site is a flat terrain penetrated with very shallow runoff depressions, see Fig. (5.2).The proposed site for the storage tanks is an

old dumping wadi side, where piles of waste excavation debris exist all around this side, see Fig. (5.3).

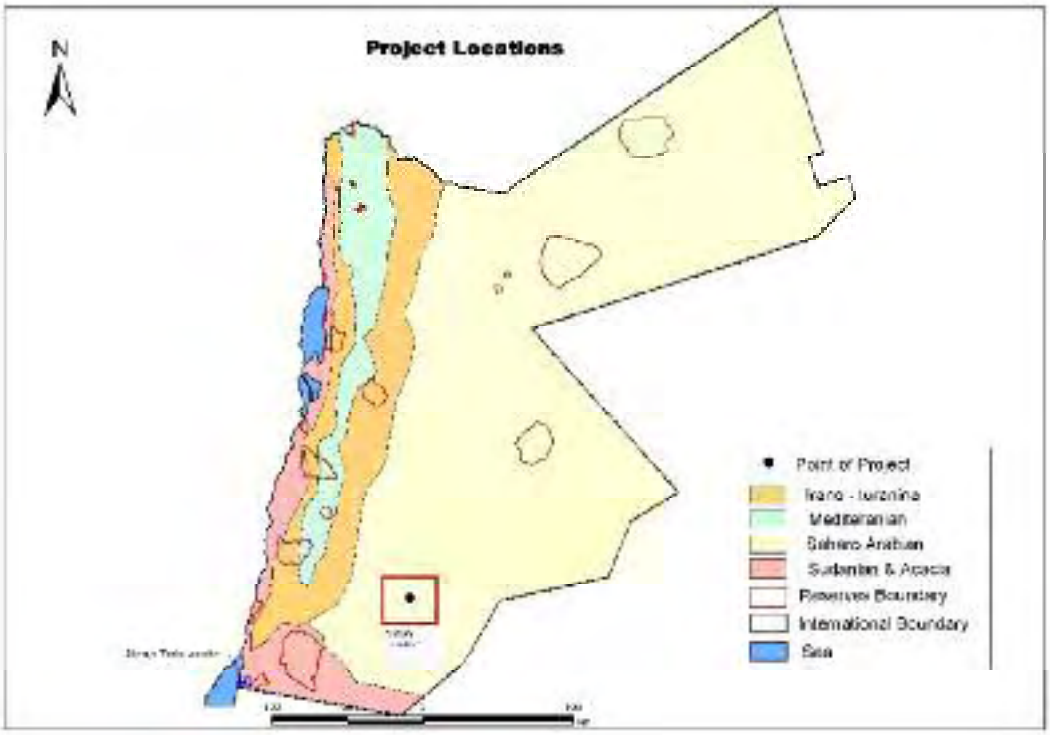


Fig. (5.1): Location of the proposed project

Fig. (5.2): Proposed location for the sulphuric and phosphoric acids plants

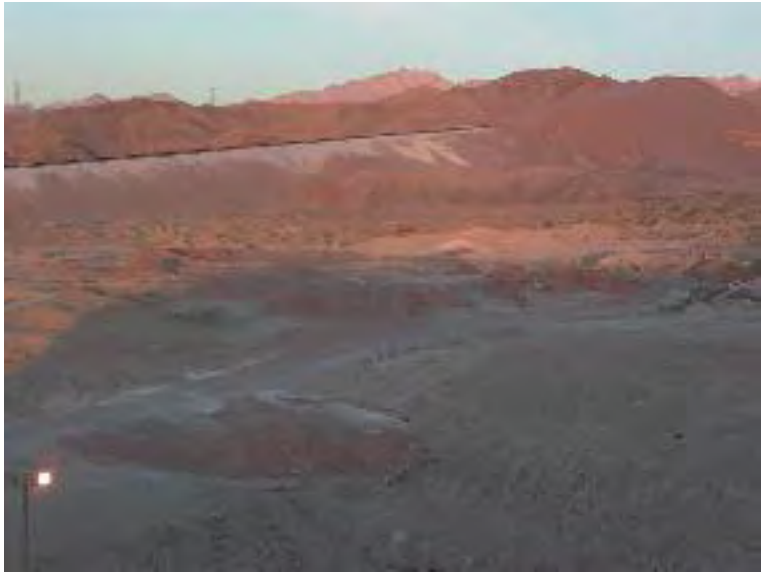


Fig. (5.3): Proposed location for the storage tanks

5.2.3 Soil type

The proposed location of the project site at Eshidiya has the same soil types. These are loess and calcareous soil. They are composing the dominant soil types in this site. These soil types are found in the Irano-turranian zone too. The soil of the proposed site for the storage tank is a mix of sand and alluvial fans fine gravel.

5.2.4 Climate

Both sites of the project are characterized by Saharan Mediterranean bioclimatic. The average minimum temperature for this bioclimatic zone at the coldest month (January) ranges between -1 ˚C and +3 ˚C for the cool variety, +3 ˚C and +7 ˚C for the warm variety and +8 ˚C and +12 ˚C for the very warm variety. The maximum temperature of the hottest month (August) ranges between 35 ˚C and 40 ˚C.

5.3 Evaluation of the Biological Environment

- **Biogeographic Zone**
  The proposed locations for the phosphoric and sulphuric acids plants, and the storage tanks at Aqaba are belonging to two biogeographic zones, see Fig. (5.4).

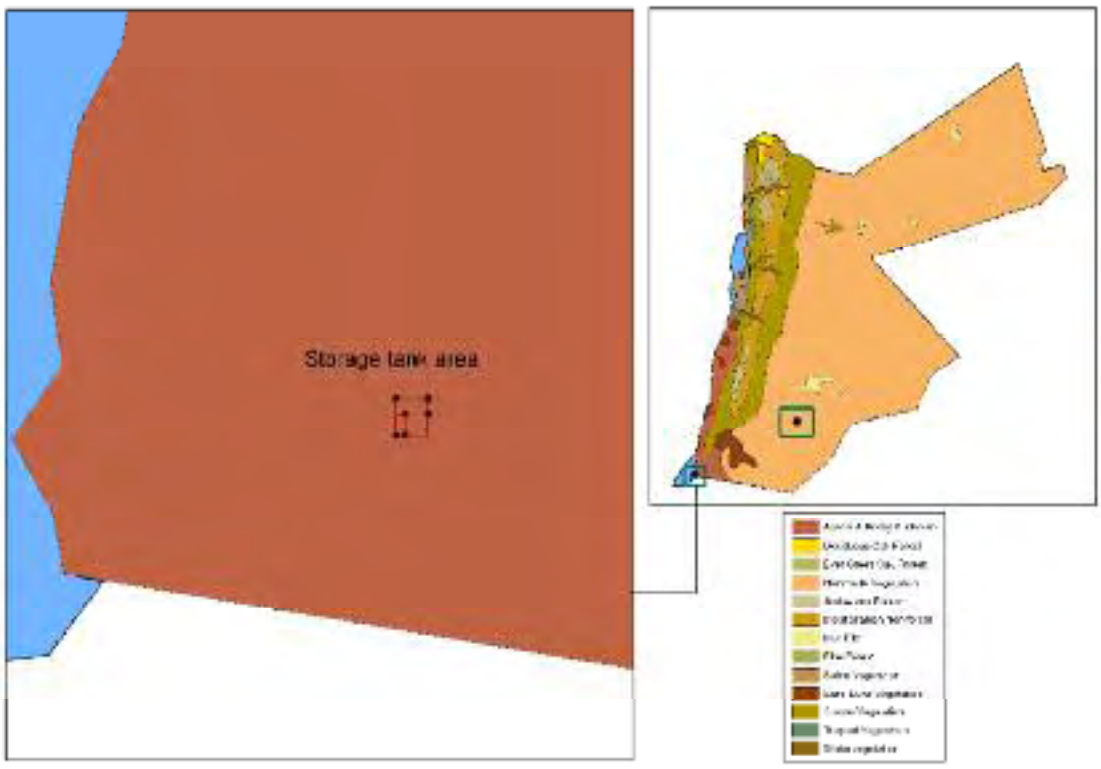


Fig. (5.4): Biogeographic zones and vegetation types at project sites

Saharo-Arabian Bio-geographical Zone

The proposed location for the phosphoric and sulphuric acids plants is part of the Saharo-Arabian Desert Region. In Jordan, this region is usually called the Badia which comprises more than 80% of the total area of Jordan. The Badia differs from the typical desert. In typical desert, there are a lot of sand dunes, while in Jordan the desert is clayey and covered by gravel or pebble. Jordan Desert (Badia) is divided into two parts; Harra, which is covered by black basaltic pebbles and Hammad which is covered by gravel, where the plants located.

Sudanian (Sub-tropical) Biogeographic Zone

This zone is represented in the proposed location of the storage tanks at Aqaba. This zone starts at Al-Karamah in the north and continues to the south through the Dead Sea depression and Wadi Araba, which end at the tip of Gulf of Aqaba. Moreover, this ecozone includes the southern Jordan and southern Edom mountains. The vegetation is related to tropical varieties such as: Acacia sp. (Al-Eisawi, 1985). The ecological pyramids and climatic conditions in the northern Jordan Valley, "Ghor", are different from those of southern Ghor and Wadi

Araba. So, northern Ghor is considered part of the Mediterranean ecozone.

The most important characteristic of this region is its altitude, considered the lowest point on earth (- 400 m below sea level), providing a unique environment and thus a unique ecosystem.

Rainfall ranges from 50-100 mm/year, the mean annual minimal temperature ranges from 10-20 °C, and mean annual maximal temperature ranges from 20-35 °C. Soil is mostly alluvial transported by water, saline soil, sandy and granite. The only inland sand dunes in Jordan are restricted to this region. Vegetation is characterized by having tropical tree element such as *Ziziphus spina-christi* in addition to some shrubs and annual herbs.

- **Ecosystem**

  The proposed locations for this project represent parts of two ecosystems in the country. The first one found at Eshidiya which is called Desert Ecosystem. This ecosystem is gently undulating plateau with an elevation of 500 m to 900 m above sea level. Four broad habitats- types can be distinguished in this ecosystem:

  1. Hammada; smooth and gravel/chert plains which stretches from Ras Al Naqab to the Iraqi border in the northeast.
  2. Harrat; black boulder-fields of basalt rocks, which extends from south Syria through northeast Jordan, and onwards into Saudi Arabia.
  3. Extensive sand dunes desert that occur in the southernmost part of the country such as Wadi Rum and Wadi Araba areas.
  4. Clay pans lying at the bottom of close drainage basins in the desert and can become flooded after heavy rains with the water persisting for several months rather than draining away.

  This largely treeless ecosystem is dominated on its fringe, adjoining the highlands ecosystem by Irano Turanian species of small shrubs and bushes such as *Artemisia, Retama, Anabasis and Ziziphus*. The majority of the ecosystem to the east of this highland fringe has even poorer plant cover dominated by *Artemisia, Phlomis, Stipa, Astragalus and Trigonella*.

  The Badia (desert) is the main rangeland of Jordan, where the range quality is deteriorating due to very heavy grazing and widespread of ploughing for cultivation of rain fed barley, which has led to loss of

natural plant cover and accelerated soil erosion and degradation through wind and water erosion.

The second ecosystem is called Sub- tropical Ecosystem, where the proposed storage tank lactated. This ecosystem extends in the Rift Valley from Dier Alla area and down until Aqaba areas. Also, it is called sub-tropical due to the Sudanian penetration in this zone. The Dead Sea rift follows the line of a gigantic fault, which extends 370 km from the north of Jordan River in the north to the Gulf of Aqaba, and its part of the African Rift Valley. The northern part of the valley, defined by the drainage basin of the Dead Sea, is called Ghor. The southern part of the valley, draining into the Gulf of Aqaba, is named Wadi Araba.

The natural vegetation of the valley plain and lower scrap slopes has been greatly modified by cultivation and grazing, but is more intact in Wadi Araba: Tropical Sudanian species of tree and dwarf-shrub are prominent in the spare and very open vegetation, including *Acacia, Blanites, Tamarix, Calotropis, Maerua, Salvadora, Ochradenus and Panicum*.

- **Flora of the proposed sites of the project**

  The vegetation of the proposed sites for the phosphoric and sulphuric acids plants and the storage tanks site are mostly composed of two vegetation types that can resist the hot conditions, see Fig. (5.4). Vegetation cover is restricted to the watersheds in the shallow wadi systems where enough soil moisture exists. The most common species are: *Artemisia herba-alba, Achillea fragrantissima, Phlomis, Astragalus, Stipa, Trigonella, Acacia tortillas and Acacia radiana*.

  <u>Vegetation Types</u>

  The proposed site for phosphoric and sulphuric acids plants has one vegetation type which is Pebble Hammada or Harrah Vegetation type. This vegetation type is found in areas covered by black pebbles that vary in sizes between small and large bolds that makes vehicles or individuals movement quite hard. The leading species of this vegetation type are:

Salsola vermiculata	*Halogeton alopecuroides*
Anabasis articulate	*Diplotaxis harra*
Linum album	*Achillea fragrantissima*
Thymus bovei	*Euphorbia retusa*

Paracaryum rugulaosum
Hammada eigii
Zilla spinosa
Alcea chrysantha
Atriplex leucoclada
Lepidium aucheri

The vegetation type at the proposed site for the storage tanks is Acacia and Rocky Sudanian Vegetation type. This vegetation is found in Aqaba area which is confined to the granite bases and the rocky part of Wadi Araba, Aqaba, Wadi Al Yutum and Wadi Rum in the Sudanian biogeographic zone. Acacia trees are scattered through Wadi Araba but they get denser toward the hard rocks of the mountain bases until they form a pure stand of Acacia woodland to the North of Aqaba. In the side wadies toward Wadi Al Yutum, Acacia trees are found at the wadi beds with various densities according to the slope and soil cover percentage. The leading plant species of this vegetation type (Eisawi, 1996) are:

Acacia radiana
Hammada scopira
Caralluma spp.
Gymnocarpos decandrum
Helianthemum lippii
Anastatica hierechuntica.
Anabasis articulate
Sclerocephalus arabicus
Acacia tortilis
Cassia italica
Traganum nudatum
Reaumuria hirtella
Asteriscus graveolens
Fagonia spp.
Zygophylum domosum

Table (5.1): Conservation important species

Family	Species	Importance
Leguminosae	*Acacia raddianna*	Decreasing/ palatable for livestock/ source of fire wood
	Acacia tortilis	Palatable for livestock/ source of fire wood
Capparaceae	*Capparis cartiligina*	Used in traditional medicine for the treatment of joints and back pains
Solanaceae	*Lycium shawii*	Decreasing/ palatable for livestock/ source of fire wood
Compositae	*Artemisia judaica*	Used in traditional medicine for the treatment of cough.
Chenopodiaceae	*Hammada salicornica*	Palatable for livestock/ source of fire wood
Resedaceae	*Ochradinus baccatus*	Palatable for livestock
Leguminosae	*Trigonella stellata*	Palatable for livestock/ used in traditional spices.

- **Fauna of the project sites**

Amphibians and Reptiles

The majority of the Herpeto-Fauna of Jordan is found in the eastern and southern dry lands of the country, where a wide range of microhabitats exists due to its large area and unpredictable harsh climatic conditions.

Table (5.2): Important amphibians and reptiles of the eastern desert area

Family	Scientific Name	Arabic Name
Bufonidae	*Bufo viridis*	العلجوم الأخضر
Ranidae	*Rana ridibunda*	ضفدع البحيرة
Chamaeleonidae	*Chamaeleo chamaeleon*	الحرباء
Agamidae	*Trapelus pallda haasi*	
	Trapelus blanfordi fieldi	
	Uromastyx aegyptius microlepis	الضب
Lacertidae	*Acanthodactylus boskianus*	
	Acanthodactylus schmidti	
	Mesalina guttulata	
	Ophisops elegans	
Sincidae	*Chalcides ocellatus*	
	Mabuya vittata	السحلية الخضراء
Varanidae	*Varanus griseus*	الورل
Colubridae	*Coluber elegantissimus*	
	Natrix tessellata	أفعى الماء
	Spalerosophis diadema	النشاب
	Psammophis schokari	حية الرمل
Elapidae	*Walterinnesia aegyptia*	الكوبرا المصرية
Viperidae	*Pseudocerastes persicus*	الأفعى المقرنة الكاذبة

Mammals

The mammals of the two sites are belonging to two different zoogeographic zones in Jordan. These zoogeographic zones are:

Saharo-Sindian Zone (also referred to as the Saharo-Arabian and Irano-Turanian phytogeographic region by Zohary 1973)

The mammals of the proposed site for the phosphoric and sulphuric acids plants is belonging to this zone. This zone is located to the east of the mountain ranges that extending from south of Jordan to northeast in Mafraq area. It is another sub region within the Palearctic and includes the Sahara Desert and the Arabian Desert. The majority of the project's mammals are belonging to this zone.

Ethiopian or Afrotropical Zone

The mammals of the proposed location for the storage tanks are belonging to this zone. Mammal species in the most southern tip of Jordan are of African origin, especially those in the Rift Valley at Aqaba area. Most of the mammals that exist in the Aqaba area and its mountain range are also belong to this zone.

Table (5.3): Important mammals of the saharo-sindian zone

Family	Scientific Name	Common Name	Status
Erinaceidae	*Paraechinus aethiopicus*	Desert Hedgehog	Insufficient data
	Hemiechinus auritus	Long-eared Hedgehog	Insufficient data
Soricidae	*Corcidura suaveolens*	Lesser white-toothed shrew	Vulnerable
Canidae	*Canis aureus*	Golden jackal	Vulnerable
	Canis lupus	Grey Wolf	Nationally Threatened
	Vulpes cana	Blanford's fox	Nationally Endangered
	Vulpes rueppelli	Sand Fox	Nationally Endangered
Felidae	*Felis caracal*	Caracal	Nationally Endangered
	Felis silvestris	Wild Cat	Vulnerable
	Felis margarita	Sand Cat	On the verge of Extinction
Hyaenidae	*Hyaena hyaena*	Striped hyena	Nationally Threatened
Mustelidae	*Vormela peregusna*	Marbled Polecat	Vulnerable
	Mellivora capensis	Honey Badger	Nationally Threatened
Procaviidae	*Procavia capensis*	Hyrax	Nationally Threatened
Bovidae	*Capra ibex*	Nubian Ibex	Nationally Endangered
Hystricidae	*Hystrix indica*	Indian crested porcupine	Vulnerable

Table (5.4): Important mammals of the ethiopian zone

Family	Scientific Name	Common Name	Status
Erinaceidae	*Paraechinus aethiopicus*	Desert Hedgehog	Insufficient data
Canidae	*Canis lupus*	Grey Wolf	Nationally Threatened
	Vulpes cana	Blanford's fox	Nationally Endangered
	Vulpes rueppelli	Sand Fox	Nationally Endangered
Felidae	*Felis caracal*	Caracal	Nationally Endangered
	Felis silvestris	Wild Cat	Vulnerable
Herpestidae	Hepestes ichneumen	Egyptian mongoose	Vulnerable
Hyaenidae	*Hyaena hyaena*	Striped hyena	Nationally Threatened
Mustelidae	*Mellivora capensis*	Honey Badger	Nationally Threatened
Procaviidae	*Procavia capensis*	Hyrax	Nationally Threatened
Bovidae	*Capra ibex*	Nubian Ibex	Nationally Endangered
Hystricidae	*Hystrix indica*	Indian crested porcupine	Vulnerable

Birds

Jordan has a wide diversity of bird habitat types due to its varied topography and climate as well as due its biogeographical location. More than 420 bird species have been recorded in Jordan, of which more than 141 species are breeding birds and this number might increase with the continuous research. Jordan lies on the main route of bird's migration between Africa, Asia and Europe. Millions of birds are migrating over Jordan each year, among which the majority of the Jordanian avifauna is belonging. The huge number of migrant birds that visit Jordan twice a year has made the country of a great importance for the global avifauna. The proposed locations for this project are not occurring within important bird areas; however it hosts different resident desert birds.

Table (5.5): Important migrant species

Family	Scientific Name	Common Name	Status
Ardidae	*Botaurus stellaris* 1	Great Bittern	Globally Threatened
Accipitridae	*Aquila heliaca*	Imperial Eagle	Globally Threatened
Rallidae	*Crex crex*	Corn Crake	Globally Threatened
Accipitridae	*Buteo buteo*	Buzzard	Significant Proportion of the World Population
Accipitridae	*Pernis apivorus*	Honey Buzzard	Significant Proportion of the World Population
Accipitridae	*Aquila nipalensis*	Steppe Eagle	Significant Proportion of the World Population
Accipitridae	*Accipiter brevipes*	Levant Sparrowhawk	Significant Proportion of the World Population

Table (5.6): Important breeding birds

Family	Scientific Name	Common Name	Status
Anatidae	*Marmaronetta angustirostris*	Marbled Duck	Globally Threatened
Falconidae	*Falco naumanni*	Lesser Kestrel	Globally Threatened
Otididae	*Chamydotis undulata*	Houbara Bustard	Globally Threatened
Accipitridae	*Aegypius monachus*	Black Vulture	Globally Threatened
Strigidae	*Ketupa zeylonensis*	Brown Fish Owl	Globally Threatened
Phasianidae	*Francolinus francolinus*	Black Francolin	Regionally Threatened
Accipitridae	*Gypaetus barbatus*	Lammergeier	Regionally Threatened
Accipitridae	*Torgos tracheliotus*	Lappet-faced Vulture	Regionally Threatened
Passeridae	*Passer moabiticus*	Dead Sea Sparrow	Restricted to Middle East
Fringillidae	*Serinus syriacus*	Syrian Serin	Restricted to Middle East
Fringillidae	*Corpodacus synoicus*	Sinai Rosefinch	Nationally Threatened
Paridae	*Parus caeruleus*	Blue Tit	Nationally Threatened

5.4 Baseline Results

During the field work conducted for the project sites, the following results were obtained:

Phosphoric and Sulphuric Acids Plants Site

- **Biogeographic Zone**
  The proposed location is characterized by the Saharo – Arabian biogeographic zone. It is part of the Badia with basalt (harra) characterizations. The area is basalt desert with low vegetation cover with clay soil and exposed limestone deposits

- **Ecosystem**
  The proposed location for this project represents the Desert Ecosystem. It is characterized with the dry climate with wide daily and seasonal temperature ranges. The site is penetrated with shallow wadi systems that form seasonal wetlands in the flooding seasons.

- **Flora**
  During the baseline survey only six plant species were recorded in the proposed site. All recorded plant species are not of conservation

importance or conservation priority on the national or international levels except one species, *Acacia gerrardii*. The proposed site is highly deteriorated due to the existing mining and processing activities surrounding this site, see Fig. (5.5). Also, the proposed site has a minor activity of camels grazing observed in the site at some locations of the sites close to the water pipeline where leaked water has supported the growth of some forage plants, see Fig. (5.6). The introduction of the phosphoric and sulphuric acids plants to the area will add minor pressure on the vegetation cover that also must be mitigated during the project life to make any negative impact minimal or negligible.

Table (5.7): Recorded plant species at the proposed Eshidiya site

Family	Scientific Name	Status
Mimosaceae	*Acacia gerrardii*	vulnerable
Chenopodiaceae	*Anabasis articulata*	Common
	Anabasis syriaca	Common
Compositae	*Artemisia herba-alba*	Common
Leguminsae	*Astragalus spinosus*	Common
	Trigonella stellata	Common

Fig. (5.5): Proposed site for phosphoric and sulphuric acids plants

Fig. (5.6): Camels grazing in the proposed site for the phosphoric and sulphuric acids plants

- **Fauna**

  The proposed site is large enough to hold significant faunal diversity, but due to the high levels of disturbance and habitats destruction in the site, the number of fauna species among the target groups was low. Following are the recorded fauna species of the target groups in this study:

  Reptiles

  Desert ecosystems are known of being rich with reptiles diversity, but due to the disturbance and habitat destructions in the proposed location, the recorded number of reptiles in the proposed site were only 2 species. Among these species only one species is of conservation importance which under the pressure of habitats destruction and hunting.

Table (5.8): Recorded reptiles species at Eshidyia site

Family	Scientific Name	Status
Agamidae	*Uromastyx aegyptius*	Nationally Threatened
Lacertidae	*Acanthodactylus boskianus*	Common

  Birds

  A total of 5 species of birds where recorded at the proposed site. Two of the recorded species were migrants while the others were resident birds that breed in the desert ecosystems.

Table (5.9): Recorded birds species at Eshidiya site

Family	Scientific Name	Status
Ardeidae	*Ardea purpurea*	Migrant
Ciconiidae	*Ciconia ciconia*	Migrant
Falconidae	*Falco tinnunculus*	Resident
Columbidae	*Streptopelia decaocto*	Resident
	Streptopelia senegalensis	Resident

Mammals

The proposed location one supports low diversity of mammals due to the habitats destruction and high levels of disturbance. 3 species of mammals were recorded in this site and surrounding, two of them were recorded in the area around the proposed site and of conservation importance.

Table (5.10): Recorded mammals species at Eshidiya site

Family	Scientific Name	Status
Leporidae	*Lepus cpensis*	Nationally Threatened
Hyaenidae	*Hyaena hyaena*	Nationally Threatened
Canidae	*Vulpes vulpes*	Common

Storage Tanks Site

- **Biogeographic Zone**
  The proposed location for the storage tanks belongs to Sudanian (Sub-tropical) Biogeographic Zone.

- **Ecosystem**
  The proposed site represents the Sub- tropical Ecosystem. It is characterized with the dry climate with wide daily and seasonal temperature ranges. The site is penetrated a wadi system that may form seasonal wetlands in the flooding seasons, but due to the past use of the site as dumping site for excavations debris it has lost its natural appeal.

- **Flora**
  During the survey, only four plant species were recorded in the site. All recorded plant species are not of conservation importance or priority on the national or international levels except one species that found in the borders of this site which is *Acacia radianna*, which is under wood collection pressure, see Fig. (5.7).

Table (5.11): Recorded plants species at Aqaba site

Family	Scientific Name	Status
Chenopodiaceae	*Anabasis articulata*	Common
Amaranthaceae	*Aerva javanica*	Common
Cruciferae	*Zilla spinosa*	Common
Leguminosae	*Acacia raddianna*	Decreasing

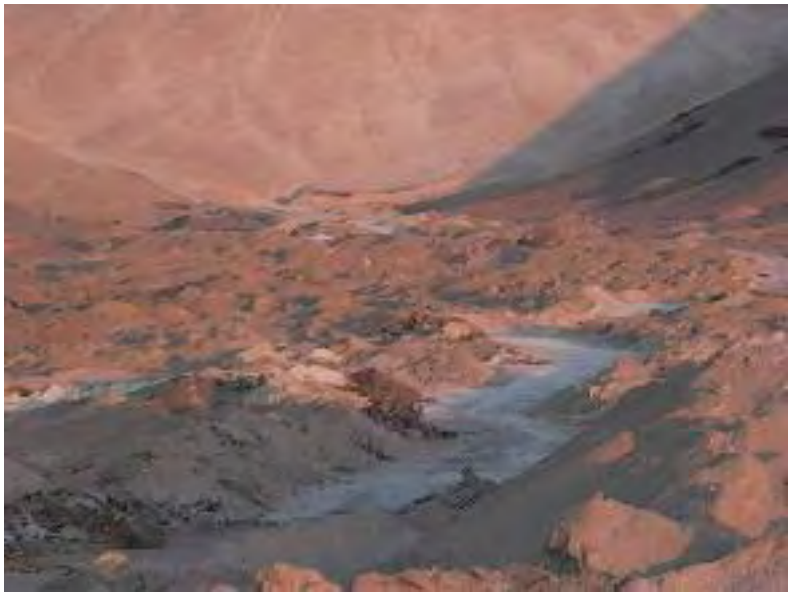


Fig. (5.7): Deteriorated habitats at Aqaba site

- **Fauna**

  The proposed site is not large enough to hold significant faunal diversity, and due to the high levels of disturbance and habitats destruction in the site, the number of fauna species among the target groups was low. Following are the recorded fauna species of the target groups in this site:

  Reptiles

  Only one species of reptiles was recorded during the survey which reflects the high levels of destruction in the natural habitats at the micro level.

Table (5.12): Recorded reptiles species at Aqaba site

Family	Scientific Name	Status
Lacertidae	*Acanthodactylus boskianus*	Common

Birds

A total of 5 species of birds where recorded at the proposed site. All recoded species were resident birds and those that tolerate high human disturbance activities.

Table (5.13): Recorded birds species at Aqaba site

Family	Scientific Name	Status
Falconidae	*Falco tinnanculus*	Resident
Columbidae	*Columba livia*	Resident
Alaudidae	*Ammomanes deserti*	Resident
	Galeridae cristata	Resident
Corviidae	*Corvus splendens*	Resident

Mammals

The proposed site has low diversity of mammals due to the habitats destruction and high levels of disturbance. 3 species of mammals were recorded in this site and surrounding, one of them was recorded in the area around the proposed site and of conservation importance which is Cape Hare (Lepus cpensis).

Table (5.14): Recorded mammals species at Aqaba site

Family	Scientific Name	Status
Leporidae	Lepus cpensis	Nationally Threatened
Dipodidae	*Jaculus jaculus*	Common
Canidae	*Vulpes vulpes*	Common

5.5 Impacts Assessment and Mitigation Measures

Construction Phase

- **Flora**
  - Disposal of debris on flora: The proposed sites for the plants and the storage tanks are suffering from very high levels of deterioration and the expected accumulative impact of the debris disposal is minimal and reversible.

    Mitigation Measure

    Disposal of debris should avoid the shallow depressions in the area that have some vegetation cover

  - Direct damage of the flora at both sites of the project: As observed and studied during the baseline; both proposed sites of the project

have very low species flora diversity as well as the absence of any critical or conservation important plant species. Therefore, the expected impact is considered insignificant and dose not threatens the absence of similar species in the surrounding area.

Mitigation Measure
At the proposed site for the plants, construction should avoid shallow depressions that have vegetation as much as possible.

- Collecting wood by workers: This impact on the vegetation is of low magnitude level due to the lack of woods in both sites, but some shrubs might be used by workers in the construction.

Mitigation Measure
To prohibit workers from collecting wood.

- Habitats destruction: Due to random access dirt road to the construction site, it is expected to have a low magnitude impact on the vegetation that found in the site.

Mitigation Measure
To limit construction activities within the plants site.

- Solid and liquid wastes: This impact might be significant of medium level especially on the surrounding area to the proposed sites of the project like the wadi systems. Hazard liquid wastes from machineries used in the construction might affect the seasonal wetlands formed in the flood seasons.

Mitigation Measure
To collect all wastes in sealed containers and to be disposed properly according to the regulations of the Ministry of Environment.

- **Fauna**
  - Disposal of debris on fauna: This impact is very limited to insignificant level due to the high disturbance levels in the project sites that made the fauna diversity restrict mainly to the micro levels of small reptiles and rodents that are not considered critical or conservation important species.

Mitigation Measure
Disposal should avoid the shallow depressions in the area that have some vegetation cover that might have rodents or reptiles borrows.

- Direct damage of the fauna at both sites of the project: The kind of expected damage is restricted to the disturbance during the construction phase. The proposed sites have low fauna diversity. However, this impact may be of more significance at night time and during the migration seasons of birds during spring and autumn.

  Mitigation Measure
  Any killed mammal or rodent species should be reported to the Ministry of Environment for recording its status.

- Noise from construction activities and machines on fauna: This impact is reversible and of minimal impact due to the low diversity in fauna species in the area.

- Animals and birds hunting by workers: This impact is of low magnitude level due to the low abundance of game species in the proposed sites of the project.

  Mitigation Measure
  To prohibit workers from hunting.

- Accidental killing of animals and birds: Accidents of animal killing due to the movements of the vehicle and machineries is expected especially during the night time. This impact is of low magnitude level.

  Mitigation Measure
  To report any accident and inform the Ministry of Environment.

- Solid and liquid wastes: Domestic wastes might attract some animals species to the site which might initially threat the workers in the site and also threat the animals if it contaminated with hazard wastes produced by the construction activities. This impact is of medium magnitude level.

  Mitigation Measure
  To collect all wastes in sealed containers and to be disposed properly according to the regulations of the Ministry of Environment.

Operational Phase

- **Flora**
  - Disposal of gypsum and possibilities of reuse: The proposed area for the gypsum disposal has very low vegetation coverage of shrubs that are on no conservation importance in away make this impact negligible. In addition to that, the gypsum disposed will have moisture that will harden the residues when its dry in a way minimize the weathering impact on the vegetation cover surrounding the project site.

    Mitigation Measure
    Restrict gypsum disposal in the proposed site only.

  - Soil contamination due to disposal of used oil: This impact has significant levels on the soil although the vegetation cover is very poor in the project area and the surroundings. The extent of this impact can last beyond the project life where the soil will not be able to support regeneration of plant species after the project in the area.

    Mitigation Measure
    All disposed oil shall be collected and management according to the regulations of the Ministry of Environment.

- **Fauna**
  - Guard pond impact on the migratory birds: The project area is on the fly way of the migratory birds especially the raptors which can be attracted to the pond that will have harmful liquid (acid). The impact of this pond on the migratory birds is very significant.

    Mitigation Measure
    Guard pond should not be in direct interaction (contact) with migratory birds. Therefore, strict mitigation measures should be placed such as covering the pond with pale color mesh (sand color) in order to avoid having birds attracted to the pond. The pond should also be fenced to protect the wild animals from falling in it.

  - Disposal of gypsum and the possibility of reuse: This impact is very limited to the micro level habitats of reptiles and rodents, as the disposal of gypsum might cover the borrow areas that are mainly restricted to the areas of vegetation cover. This impact is of low significance since there is no conservation important reptile or

rodent species found in the area, and the proposed area for gypsum disposal is almost empty of vegetation cover.

Mitigation Measure
Avoid disposal in depression areas with vegetation cover as much as possible.

- Hunting by workers: This impact is expected to be of low magnitude level due to the mild interaction of workers during the operational phase with the surrounding environment during night time.

Mitigation Measure
To prohibit workers from hunting.

- Accidental killing: Due to the heavy transportation activities, road killing for animals is expected especially during the night time due to the nocturnal activities for the animals in the area. This impact is of low magnitude level.

Mitigation Measure
To report any accident and inform the Ministry of Environment.

Decommissioning Phase

- **Flora**
  - Random disassembling: This impact is limited to destruction of habitats at the surrounding area during the decommissioning activities by using it as temporary storage or parking sites for machineries.

Mitigation Measure
Disassembling should be restricted within the project boundaries.

- **Fauna**
  - Random disassembling: This impact limited to the disturbance that may occur in the area during this phase which may affect fauna species, especially if these activities take place during the night time or during the migration seasons of birds.

Mitigation Measure
Disassembling should be restricted within the project boundaries and during day time as much as possible.

6. PUBLIC HEALTH

6.1 Introduction

This public health chapter provides an assessment of the project potential impacts related to air quality, noise pollution, solid waste and wastewater in order to set mitigation measures to avoid or reduce negative impacts and enhance the positive ones. The assessment is based on information provided by the company and the collected data from other related institutes in addition to the air quality and noise monitoring programs that were undertaken during the study.

6.2 Issues and Interactions Between Project Activities and Public Health

Public health was identified as a valued environmental component in the Terms of References (TORs) and during the scoping session. During the scoping session that was held by RSS, the following interactions between the project activities and public health were identified for the different phases of the project.

6.2.1 Construction phase

During the construction phase of the project, the following interactions were identified between project activities and public health:

- Dust and gaseous emissions generated from construction activities.
- Domestic wastewater generated from workers.
- Domestic solid waste generated from workers.
- Not considering wind speed and direction during design and construction phases.
- Not having a green belt around the plant site in Eshidiya.
- Not abiding the standards of civil defense regulations in constructing the storage tanks in Aqaba and Eshidiya.

6.2.2 Operation phase

During the operation phase of the project, the following interactions were identified between project activities and public health:

- Spillage of chemicals and oils during transportation.

- Not monitoring air quality in the site.
- Dust and gaseous emissions generated from operation activities.
- Disposal and / or reuse of domestic solid waste and domestic sludge generated from wastewater treatment unit.
- Dust generated from conveying belts
- Spills of the materials out the conveying belts
- Noise from operation activities on close residential areas (labor camp).
- Not having coordination with civil defense and traffic directorate in case of transporting hazardous chemicals.
- Not having wind breakers to prevent dust dispersion.
- Disposal of gypsum and the possibilities of reuse.
- Disposal of hazardous waste (e.g. vanadium pentoxide).
- Quantity of byproducts such as fluosilicic acid.
- Disposal of used oils.
- Earthquakes and their effects on equipment and instruments.
- Leak of phosphoric acid from the storage site in Aqaba or from the pipeline due to earthquakes and other natural disasters.
- Not providing adequate protection of the phosphoric acid pipeline from storage tanks to jetty as well as enough sectionalizing valves.
- Leaks and fire as a result of not following up-to-date international standards in constructing and operating the plant.

6.2.3 Decommissioning phase

During the decommissioning phase of the project, the following interactions were identified between project activities and public health:

- Inform the neighboring localities of decommissioning.
- Disposal of contaminated machinery and equipment.
- Disposal of solid waste which can not be recycled.
- Dust and debris generated from building demolition.

6.3 Existing Conditions

6.3.1 Air quality monitoring at the North West border of the proposed JIFCO project site

A monitoring program for a period of one month (3/1-3/2/2008) was conducted at the northwest border of the proposed JIFCO project site in Eshidiya; downwind the existing industrial activities since the prevailing winds in this area are north and west winds. The coordinates of the

monitoring site are N924760 and E259300. The monitored database of the major air pollutants will be compared with the monitored ones during the construction phase of JIFCO project as well as during the operational phase, where the future monitoring site will be chosen to lie downwind of the new proposed JIFCO project different activities.

The monitoring program included continuous monitoring of air pollutants (SO_2, NO_x, NO, NO_2, CO and PM10) that represent the main air pollutant emissions from the JIFCO different activities, in addition to monitoring of weather parameters; wind speed and wind direction. A mobile laboratory, equipped with different analyzers and samplers, was placed and operated at this monitoring site to carry out the monitoring program. In addition, five-spot measurements of HF were conducted in the ambient air of the monitoring site.

The obtained baseline ambient air quality monitoring results were compared with the maximum allowable limits specified in the Jordanian air quality standards (JS: 1140/2006) and WHO ambient air quality guidelines (IFC regulations). A summary of these standards for main pollutants is shown in Table (6.1) and a summary of the obtained baseline ambient air quality monitoring results is shown in Tables (6.2) and (6.3).

Table (6.1): Jordanian (JS: 1140/2006) and WHO ambient air quality maximum allowable limits of some pollutants

Duration	Pollution	JS: 1140/2006	WHO (IFC)	Number of allowable exceedances
1-hour	SO_2	0.300 ppm* (786 µg/m^3**)	------	3 times/ any consecutive 12 months
24-hours	SO_2	0.140 ppm	125 µg/m^3 (0.044 ppm)	1 time / any consecutive 12 months
Annual	SO_2	0.040 ppm	50 µg/m^3	-------
24-hours	TSP	260 µg/m^3	------	3 times/ any consecutive 12 months
Annual	TSP	75 µg/m^3 (Geometric mean)	------	-------
24-hours	PM10	120 µg/m^3	150 µg/m^3	3 times/ any consecutive 12 months
Annual	PM10	70 µg/m^3	70 µg/m^3	------
24-hours	PM2.5	65 µg/m^3	75 µg/m^3	3 times/ any consecutive 12 months
Annual	PM2.5	15 µg/m^3	35 µg/m^3	------
1-hour	NO_2	0.210 ppm (400 µg/m^3)	200 µg/m^3 (0.097 ppm)	3 times/ any consecutive 12 months
24-hours	NO_2	0.080 ppm	-------	3 times/ any consecutive 12 months
Annual	NO_2	0.050 ppm	40 µg/m^3	------
1-hour	CO	26 ppm	30 mg/m^3 (24 ppm)	3 times/ any consecutive 12 months
8-hours	CO	9 ppm	10 mg/m^3 (8 ppm)	3 times/ any consecutive 12 months
24-hour	P_2O_5	100 µg/m^3	------	3 times/ any consecutive 12 months
Annual	P_2O_5	40 µg/m^3	------	------
24-hours	HF	------	1 µg/m^3 (1.1 ppb)	------

* ppm: Parts per million. ** µg/m^3: Microgram per cubic meters.

Table (6.2): A summary of the measured ambient air quality background levels at the monitoring site of Eshidiya (3/1–3/2/2008)

Pollutant	Max. Daily Average	No. of Daily Average Exceedances to JS:1140/2006 and IFC	Daily Exceedances Percentage (%) to JS:1140/2006 and IFC	Max. Hourly Average (ppm)	No. of Hourly Exceedances to JS:1140/2006 and IFC	Hourly Exceedances Percentage (%) to JS:1140/2006 and IFC	Max. 8-hour Average for CO	No. of 8-hour Exceedances for CO to JS:1140/2006 and IFC	8-hour Exceed. for CO Percentage (%) to JS:1140/2006 and IFC
SO_2	0.006 ppm	0	0.0	0.084 ppm	0	0.0			
NO_x	0.016 ppm	NS	NS	0.168 ppm	NS	NS			
NO	0.004 ppm	NS	NS	0.082 ppm	NS	NS			
NO_2	0.012 ppm	0	0.0	0.086 ppm	0	0.0			
CO	---	NS	NS	0.800 ppm	0	0.0	0.738 ppm	0	0.0
PM10	224 $\mu g/Nm^3$	8 (JS)	25.8 (JS)	1000	NS	NS			
		4 (IFC)	12.9 (IFC)						

NS: No standard available.
---: Not considered as no standard is available.

Table (6.3): A summary of the spot measurements of HF as background levels at the monitoring site at Eshidiya

Date	Measurements period	HF (ppm)
3/1/2008	18:00-18:30	0.0 (*Less than the detection limit of the monitoring instrument of 0.05*)
4/1/2008	9:30-10:00	
7/1/2008	15:30-16:00	
16/1/2008	9:00-9:30	
21/1/2008	16:00-16:30	

Monitoring results of sulfur dioxide (SO_2) in the ambient air at the monitoring site in Eshidiya showed that the maximum SO_2 hourly average was 0.084 ppm. The SO_2 hourly averages did not exceed the 0.300 ppm hourly limit specified in Jordanian Standards (JS: 1140/2006) during the monitoring time. In addition, the SO_2 daily averages did not exceed the 0.140 ppm daily limit specified in JS: 1140/2006 and the 125 µg/m^3 (0.044 ppm) IFC daily limit during the monitoring time, see Fig. (6.1).

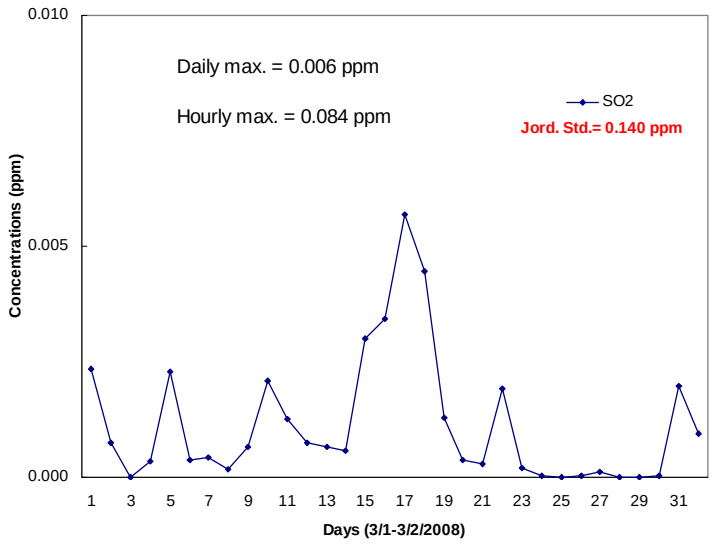


Fig. (6.1): Daily average concentrations of SO_2 at the monitoring site at Eshidiya during the period (3/1-3/2/2008)

Monitoring of PM10 was done so as to get background values of ambient dust before construction of the new JIFCO project in a desert area that suffers mainly from the natural dust. Results of PM10 continuous monitoring program showed that PM10 daily concentrations ranged between 15 µg/Nm^3 and 224 µg/Nm^3. Eight PM10 exceedances with a percentage of 25.8% were recorded to the daily limit of 120 µg/Nm^3 specified in ambient air Jordanian Standards (JS: 1140/2006). While four PM10 exceedances with a percentage of 12.9% were recorded to the daily limit of 150 µg/Nm^3 specified in WHO ambient air guidelines (IFC regulations), see Fig. (6.2).

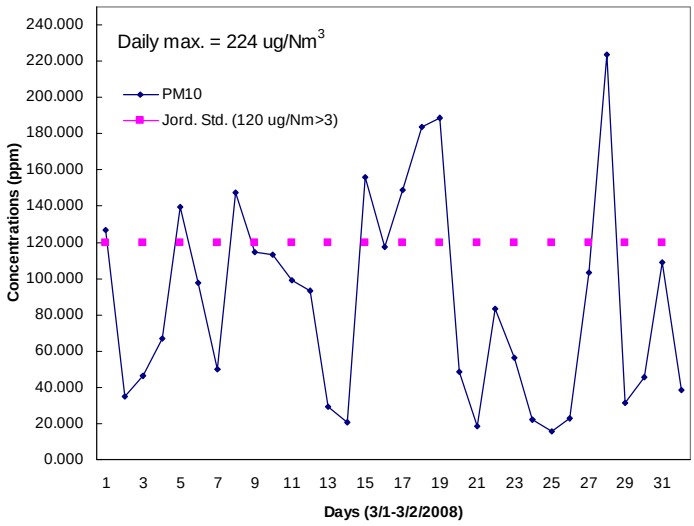


Fig. (6.2): Daily average concentrations of PM_{10} at the monitoring site at Eshidiya during the period (3/1-3/2/2008)

Monitoring results of carbon monoxide (CO) in the ambient air at the monitoring site at Eshidiya showed that the maximum 8-hours average was 0.738 ppm and the maximum CO hourly average was 0.800 ppm. The CO hourly average did not exceed the 26.0 ppm hourly limit specified in Jordanian Standards (JS: 1140/2006) nor the 24.0 ppm hourly limit specified in WHO ambient air guidelines (IFC regulations) during the monitoring time. The CO 8-hours averages did not exceed the 9 ppm 8-hours average limit specified in (JS: 1140/2006) nor 8 ppm 8-hours average limit specified in WHO ambient air guidelines (IFC regulations) in the monitoring time, see Fig. (6.3).

Regarding the other monitored pollutants (NO_x, NO and NO_2), maximum hourly NO_X, NO and NO_2 average concentrations were 0.168 ppm, 0.082 ppm and 0.086 ppm respectively. Thus, no exceedances were recorded to NO_2 hourly limit of 0.210 ppm specified in the ambient Jordanian Standards JS:1140/2006 nor to IFC NO_2 hourly limit of 200 µg/m^3 (0.097 ppm). The maximum daily NO_X, NO and NO_2 average concentrations were 0.016 ppm, 0.004 ppm and 0.012 ppm respectively. Also, no exceedances were recorded to the 0.080 ppm NO_2 daily limit specified in the ambient Jordanian Standards, see Fig. (6.4).

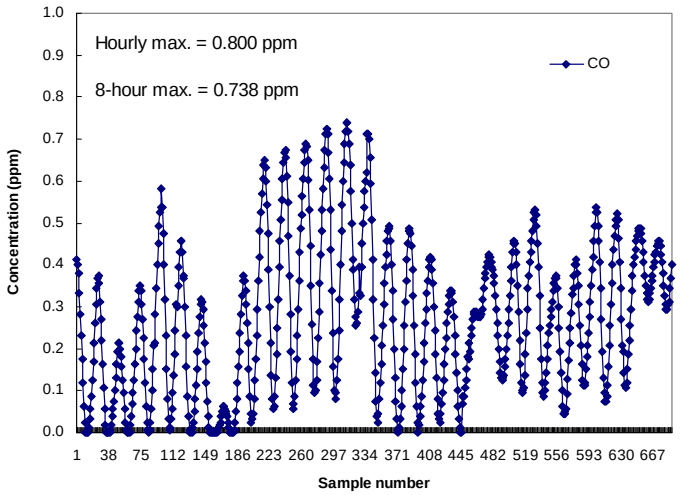


Fig. (6.3): Maximum 8-hour averages of CO recorded daily at the monitoring site during the period (3/1-3/2/2008)

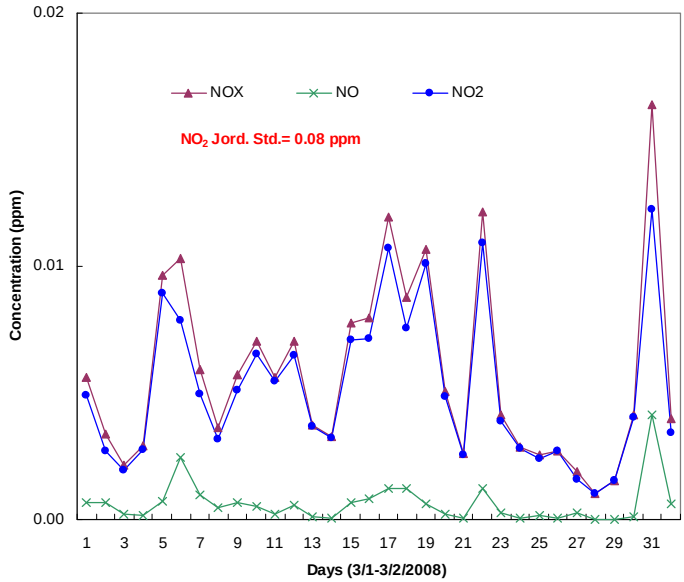


Fig. (6.4): Daily average concentrations of NO_X, NO and NO_2 at the monitoring site at Eshidiya during the period (3/1-3/2/2008)

The results of HF spot measurements conducted at the monitoring site in Eshidiya were all below the detection limit of the portable monitor of 0.05 ppm taking into consideration that each sample period was 30 minutes and there is no Jordanian standard of HF in the ambient air. The WHO ambient air limit of HF is set for 24-hour and equals 1 µg/m^3 (0.011 ppm).

The ambient air monitoring results at the proposed site of JIFCO project show very low concentrations of main air pollutants (SO_2, NO_x, NO, NO_2, CO and HF) in spite that the monitoring site was downwind the existing industries (IJCC and JPMC). However, PM10 continuous monitoring shows high level of PM10 in Eshidiya area and this can be mainly due to the desert nature of the area that is more effective than the probable dust emissions from IJCC and JPMC different activities, taking into consideration the existence of high wind speed (more than 20 knots) during 6% of the monitoring period.

Results of wind speed and wind direction monitoring during the period (3/1-3/2/2008) in Eshidiya showed that the prevailing wind direction was west (W) with a frequency of 24.1%, followed by northwest (NW) and north with frequencies of 19.2% and 18.5%, respectively. The prevailing wind speeds were those speeds of 0-2 knots with a frequency of 33.6% during the monitoring period, which represent the calm conditions at the project area, see Fig. (6.5) and (6.6).

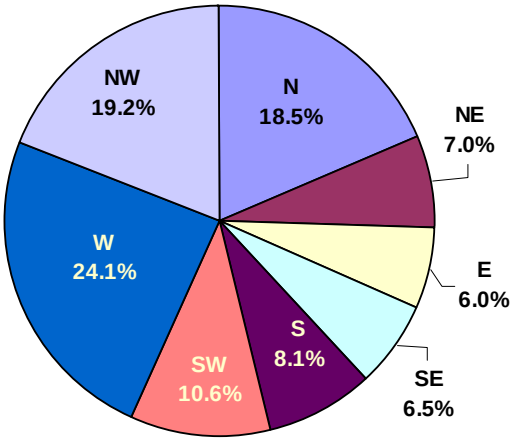


Fig. (6.5): Wind direction distribution (3/1-3/2/2008)

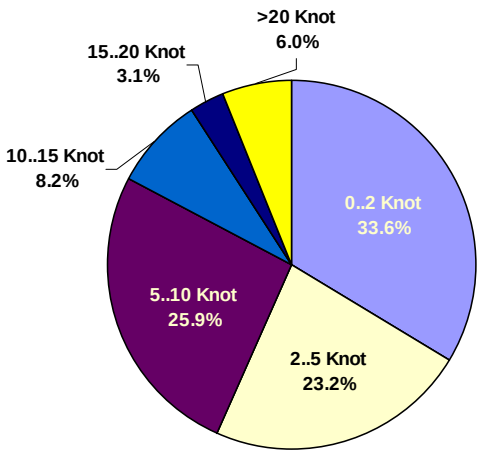


Fig. (6.6): Wind speed distribution (3/1-3/2/2008)

Eshidiya is a desert area that is very hot and dry in summer, and cold with very little rainfall in winter. The closest meteorological record center to Eshidiya industrial site that belongs to the Meteorological Department of Jordan is Al-Jafer. Fig. (6.7) and (6.8) show the wind direction distributions at Al-Jafer area for 36 years during the period (1965-2000) and for 8 years (2000-2007) respectively.

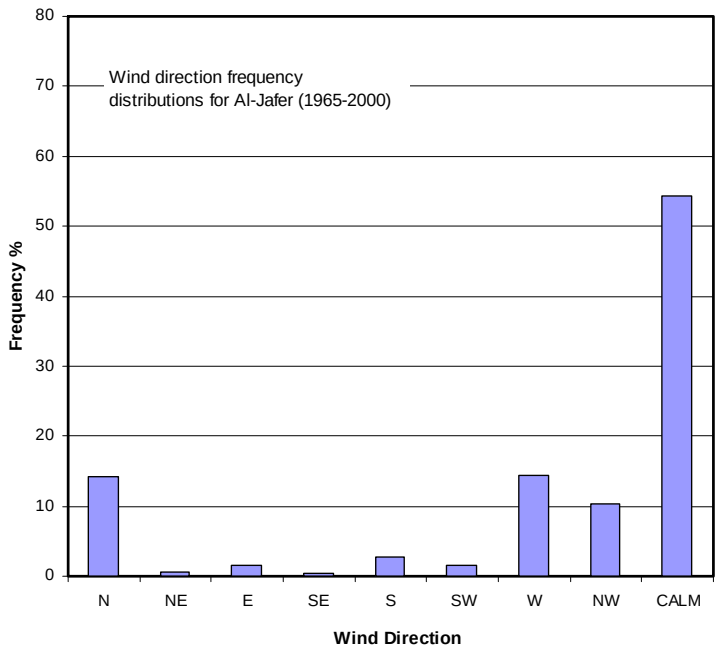


Fig. (6.7): Wind direction frequency distributions at Al-Jafer area in the period (1965-2000)

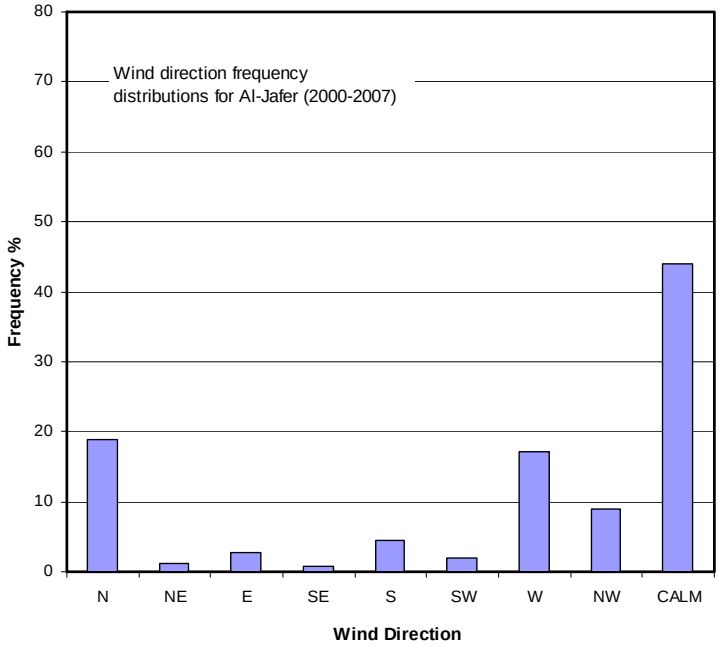


Fig. (6.8): Wind direction frequency distributions at Al-Jafer area in the period (2000-2007)

Tables (6.4) and (6.5) present the average daily temperatures and the average maximum and minimum temperatures for 36 years during the period (1965-2000) and for 8 years (2000-2007) respectively.

Table (6.4): Average daily temperatures and the average maximum and minimum temperatures for the period 36 years (1965-2000) at Al-Jafer area

Month	Average temperature (ºC)	Minimum average temperature (ºC)	Maximum average temperature (ºC)
January	7.7	0.7	14.6
February	9.2	2.0	16.5
March	12.7	5.2	20.2
April	17.8	9.5	26.1
May	22.0	13.5	30.6
June	25.0	16.1	34.0
July	26.6	17.6	35.6
August	26.8	17.9	35.6
September	24.8	16.0	33.6
October	20.3	12.1	28.5
November	14.1	6.6	21.6
December	9.1	2.0	16.3
Yearly	18.0	9.9	26.1

Table (6.5): Average daily temperatures and the average maximum and minimum temperatures for the period 8 years (2000-2007) at Al-Jafer area

Month	Average temperature (ºC)	Minimum average temperature (ºC)	Maximum average temperature (ºC)
January	7.9	1.1	15.1
February	10.1	2.8	17.1
March	13.9	6.0	21.8
April	18.4	10.3	26.6
May	22.7	14.0	31.4
June	25.9	17.0	34.9
July	28.0	19.2	36.9
August	28.0	19.2	36.8
September	25.3	16.5	34.0
October	21.4	13.3	29.4
November	14.3	6.8	21.8
December	9.4	2.0	16.8
Yearly	18.8	10.7	26.9

Tables (6.6) and (6.7) present the total rainfall amount, total evaporation and mean pressure for 36 years during the period (1965-2000) and for 8 years (2000-2007) respectively.

Table (6.6): Total rainfall, total evaporation and mean pressure at the station level for the period 36 years (1965-2000) at Al-Jafer area

Month	Total rainfall (mm)	Total evaporation Class "A" Pan (mm)	Mean pressure at station level (hPa)
January	5.9	112.3	917.5
February	4.3	151.8	916.1
March	5.2	235.2	914.7
April	3.3	326.7	914.1
May	1.0	398.1	913.6
June	0.0	463.4	912.3
July	0.0	483.3	910.3
August	0.0	447.6	911.1
September	0.1	350.9	913.7
October	3.1	264.2	916.3
November	4.3	152.5	917.4
December	5.3	112.2	918.0
Yearly	32.5	291.5	914.6

Table (6.7): Total rainfall, total evaporation and mean pressure at the station level for the period 8 years (2000-2007) at Al-Jafer area.

Month	Total rainfall (mm)	Total evaporation Class "A" Pan (mm)	Mean pressure at station level (hPa)
January	3.0	94.3	917.3
February	2.8	126.1	916.8
March	0.4	212.8	915.8
April	7.1	284.6	914.1
May	0.1	391.8	913.7
June	0.0	413.3	912.4
July	0.0	456.5	910.7
August	0.0	417.5	911.4
September	0.0	306.0	914.4
October	3.4	212.7	916.5
November	1.3	114.9	918.0
December	3.3	81.0	918.3
Yearly	21.5	259.3	915.0

The wind roses for the period 1982-2001 and 2000-2007 at Al-Jafer according to Jordan Meteorological Department are shown respectively in the Fig. (6.9) and (6.10).

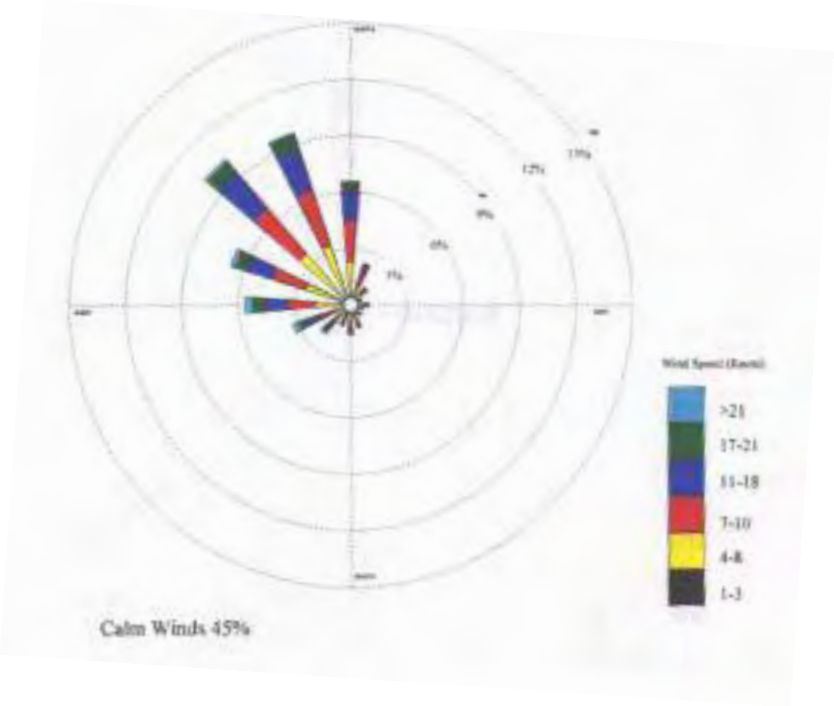


Fig. (6.9): Wind rose at Al-Jafer area in the period (1982-2001)

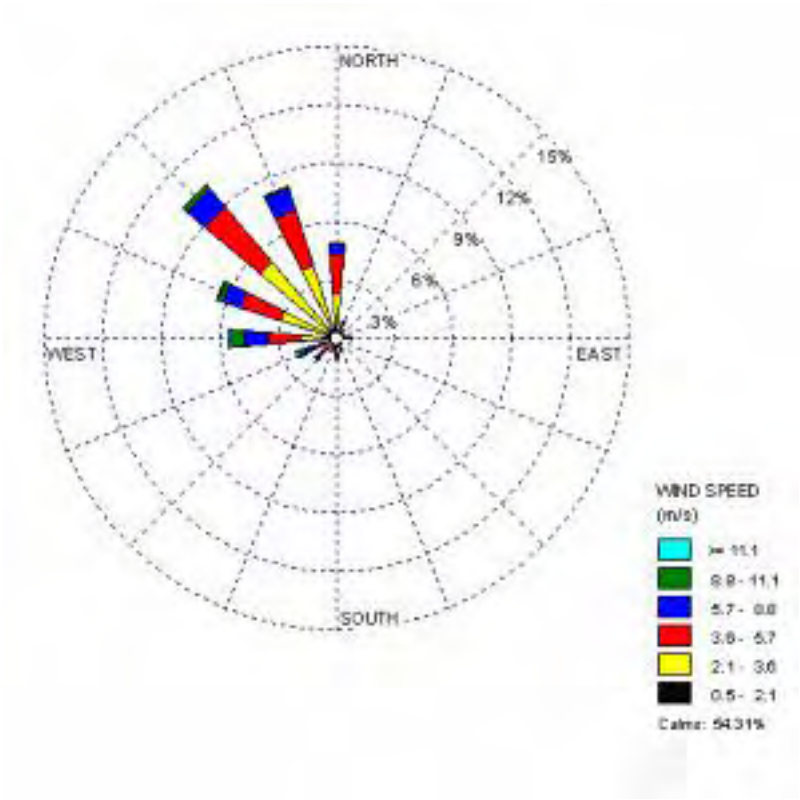


Fig. (6.10): Wind rose at Al-Jafer area in the period (2000-2007)

The meteorological data at Al-Jafer (Jordan Meteorological Department) for 44 years and the one-month wind speed and direction monitoring at Eshidiya industrial area show that the calm and northwest winds are prevailing most of the time. This means that the most probable area (community) that could be affected by the JIFCO proposed project emissions in addition to the existing industries should lie close to the southeast of the Eshidiya industrial site.

The nearest town to Eshidiya industrial site is Al-Jafer, which lies to the north at around 45 km away, which means that this town will not be affected by the new project activities emissions most of the time. Taking into consideration the prevailing of calm winds that could not transfer the emissions to far away site, except if these conditions (calm winds) stay for relatively long number of successive days. There is an employees complex (town site) for the two existing IJCC and JPMC industries, that is located at a distance of around 3.2 km north of the proposed JIFCO site, and which will be expanded for JIFCO employees. The employees complex is also upwind of Eshidiya industrial area existing (IJCC and JPMC) and the proposed JIFCO site, thus the complex will not be affected most of the time.

6.3.2 Noise levels

Six days noise monitoring program was conducted at the Workers Club in the town site of the JPMC in Eshidiya (in this town site only workers live). Also, a one day monitoring program was conducted at the storage tanks area in Aqaba. The noise monitoring program aimed at determining the existing noise level at the nearest inhabited area, in order to assess the expected impact of the project on potentially impacted areas and to allow the future assessment of any changes to current levels.

Since the monitoring sites are located in a heavy industrial area, the monitoring results are compared with the permissible limits of equivalent sound level of the Jordanian Noise Regulations for 2003 (75 dB(A) at day time and 65 dB(A) at night time). Also, IFC regulations are taken in considerations (70 dB(A) for both day and night time).

The monitoring periods were chosen to cover both day and night time intervals. According to the IFC Regulations, day time is considered from 07:00 to 22:00 and night time from 22:00 to 07:00. The equivalent sound pressure level (L_{Aeq}) was measured for each 1-hour interval.

The gathered data for the monitoring periods for both sites is shown in Table (6.8) to Table (6.14), and the hourly gathered data of the equivalent sound pressure levels (L_{Aeq}) is plotted versus time interval as shown in Fig. (6.11) to Fig. (6.17).

From the results of the background monitoring program, it is concluded that the logarithmic mean equivalent sound pressure levels (L_{Aeq}) during the measuring period are mainly below the permissible limits of 70 dB(A) at day time and 65 dB(A) at night time, taking into account that in this study the more strict regulations are considered.

Following are the noise level results of the program at the monitoring sites (Workers Club in Eshidiya and the storage tanks site in Aqaba) together with the assessment.

Table (6.8) : Sound level measurements [dB(A)]
Site No. : 1 (Workers Club - Eshidiya)
Site Coordinates : 223842, 3314458
Day No. : (1) Thursday
Date : 28/02/2008

Time	L_{Aeq} [dB(A)]	Time	L_{Aeq} [dB(A)]
00:00 - 01:00	39.2	12:00 - 13:00	54.2
01:00 - 02:00	40.2	13:00 - 14:00	54.4
02:00 - 03:00	39.6	14:00 - 15:00	51.7
03:00 - 04:00	50.0	15:00 - 16:00	43.7
04:00 - 05:00	40.0	16:00 - 17:00	46.8
05:00 - 06:00	47.2	17:00 - 18:00	38.9
06:00 - 07:00	45.2	18:00 - 19:00	46.6
07:00 - 08:00	46.3	19:00 - 20:00	40.3
08:00 - 09:00	57.2	20:00 - 21:00	37.3
09:00 - 10:00	57.4	21:00 - 22:00	40.2
10:00 - 11:00	53.6	22:00 - 23:00	36.3
11:00 - 12:00	53.1	23:00 - 24:00	39.6

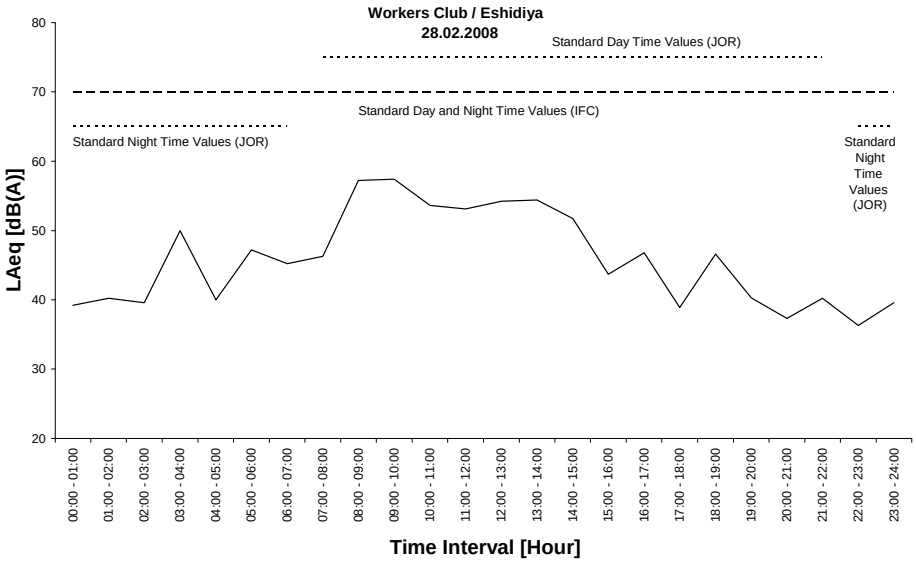


Fig. (6.11): Sound level measurements at site No. 1, day 1

From the results of the first measurement day (Thursday) of the background monitoring program, it is concluded that the hourly equivalent sound pressure levels during day period were within the permissible limits of 70 dB(A). During night period the values were also within the permissible limits of 65 dB(A). In this study the more strict limits are considered, where for day time value the IFC regulations of 70 dB(A) is considered. While, for night time value the Jordanian regulations of 65 dB(A) is considered.

Table (6.9) : Sound level measurements [dB(A)]
Site No. : 1 (Workers Club - Eshidiya)
Site Coordinates : 223842, 3314458
Day No. : (2) Friday
Date : 29/02/2008

Time	L_{Aeq} [dB(A)]	Time	L_{Aeq} [dB(A)]
00:00 - 01:00	37.7	12:00 - 13:00	47.0
01:00 - 02:00	39.7	13:00 - 14:00	44.0
02:00 - 03:00	37.7	14:00 - 15:00	42.5
03:00 - 04:00	49.1	15:00 - 16:00	39.2
04:00 - 05:00	42.2	16:00 - 17:00	44.2
05:00 - 06:00	40.9	17:00 - 18:00	38.6
06:00 - 07:00	44.4	18:00 - 19:00	45.5
07:00 - 08:00	41.2	19:00 - 20:00	34.6
08:00 - 09:00	37.6	20:00 - 21:00	33.1
09:00 - 10:00	37.5	21:00 - 22:00	33.0
10:00 - 11:00	45.3	22:00 - 23:00	30.1
11:00 - 12:00	52.3	23:00 - 24:00	30.9

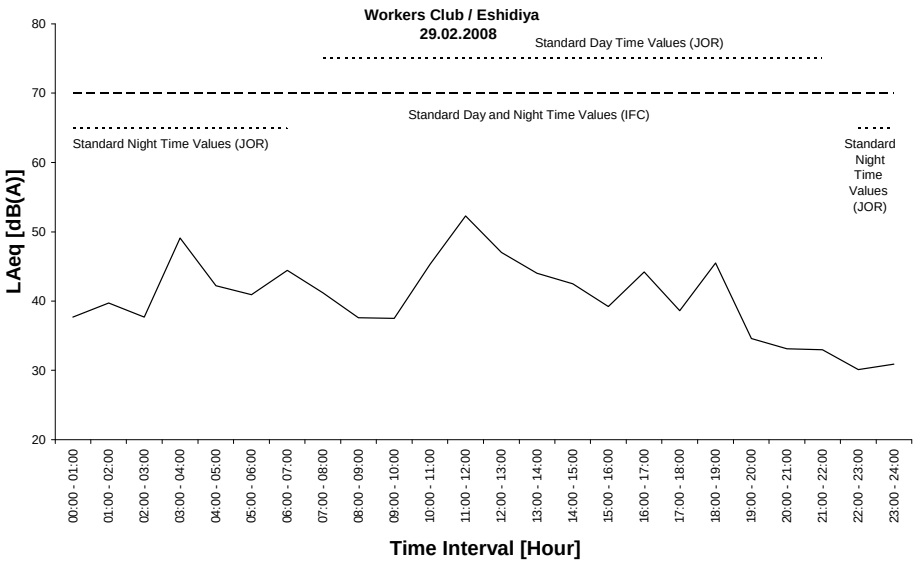


Fig. (6.12): Sound level measurements at site No. 1, day 2

From the results of the second measurement day (Friday) of the background monitoring program, it is concluded that the hourly equivalent sound pressure levels during day period were within the permissible limits of 70 dB(A). During night period the values were within the permissible limits of 65 dB(A).

Table (6.10) : Sound level measurements [dB(A)]
Site No. : 1 (Workers Club - Eshidiya)
Site Coordinates : 223842, 3314458
Day No. : (3) Saturday
Date : 01/03/2008

Time	L_{Aeq} [dB(A)]	Time	L_{Aeq} [dB(A)]
00:00 - 01:00	34.3	12:00 - 13:00	36.1
01:00 - 02:00	29.9	13:00 - 14:00	33.2
02:00 - 03:00	29.5	14:00 - 15:00	47.9
03:00 - 04:00	47.6	15:00 - 16:00	36.0
04:00 - 05:00	43.1	16:00 - 17:00	47.9
05:00 - 06:00	37.1	17:00 - 18:00	37.6
06:00 - 07:00	38.8	18:00 - 19:00	50.5
07:00 - 08:00	34.1	19:00 - 20:00	46.5
08:00 - 09:00	32.7	20:00 - 21:00	43.5
09:00 - 10:00	34.9	21:00 - 22:00	34.2
10:00 - 11:00	44.7	22:00 - 23:00	31.9
11:00 - 12:00	38.3	23:00 - 24:00	29.7

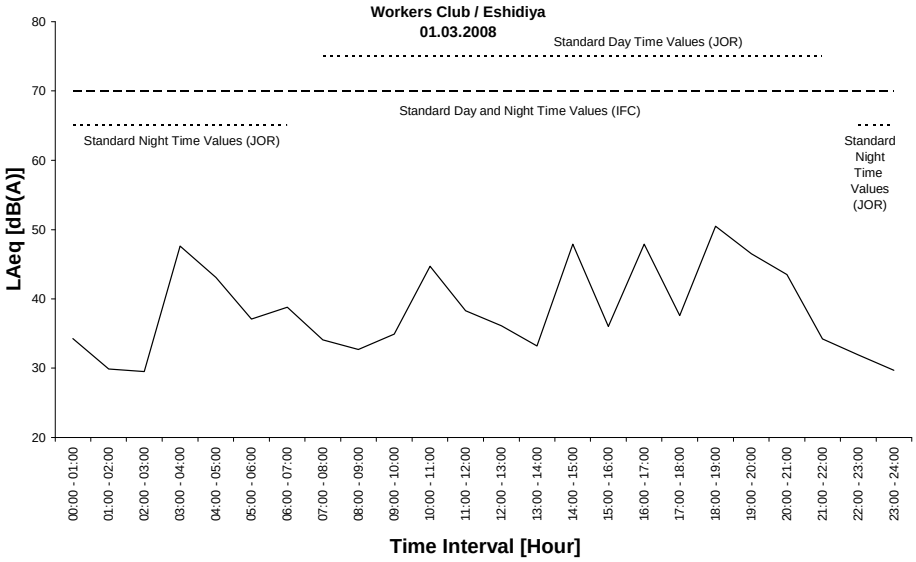


Fig. (6.13): Sound level measurements at site No. 1, day 3

From the results of the third measurement day (Saturday) of the background monitoring program, it is concluded that the hourly equivalent sound pressure levels during day period were within the permissible limits of 70 dB(A). During night period, the values were within the permissible limits of 65 dB(A).

Table (6.11) : Sound level measurements [dB(A)]
Site No. : 1 (Workers Club - Eshidiya)
Site Coordinates : 223842, 3314458
Day No. : (4) Sunday
Date : 02/03/2008

Time	L_{Aeq} [dB(A)]	Time	L_{Aeq} [dB(A)]
00:00 - 01:00	31.9	12:00 - 13:00	36.7
01:00 - 02:00	36.7	13:00 - 14:00	48.7
02:00 - 03:00	30.3	14:00 - 15:00	50.5
03:00 - 04:00	49.5	15:00 - 16:00	47.9
04:00 - 05:00	38.9	16:00 - 17:00	57.9
05:00 - 06:00	41.8	17:00 - 18:00	50.8
06:00 - 07:00	32.9	18:00 - 19:00	48.0
07:00 - 08:00	36.1	19:00 - 20:00	42.1
08:00 - 09:00	37.3	20:00 - 21:00	33.5
09:00 - 10:00	38.1	21:00 - 22:00	31.0
10:00 - 11:00	40.7	22:00 - 23:00	32.3
11:00 - 12:00	39.7	23:00 - 24:00	32.5

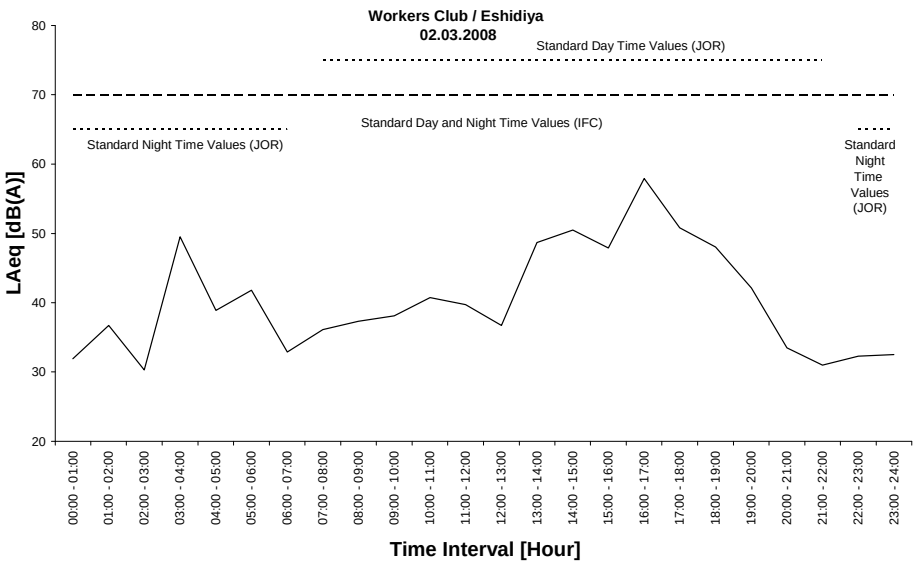


Fig. (6.14): Sound level measurements at site No. 1, day 4

From the results of the fourth measurement day (Sunday) of the background monitoring program, it is concluded that the hourly equivalent sound pressure levels during day period were always within the permissible limits of 70 dB(A). During night period the values were within the permissible limits of 65 dB(A).

Table (6.12) : Sound level measurements [dB(A)]
Site No. : 1 (Workers Club - Eshidiya)
Site Coordinates : 223842, 3314458
Day No. : (5) Monday
Date : 03/03/2008

Time	L_{Aeq} [dB(A)]	Time	L_{Aeq} [dB(A)]
00:00 - 01:00	31.2	12:00 - 13:00	53.5
01:00 - 02:00	39.3	13:00 - 14:00	49.8
02:00 - 03:00	37.2	14:00 - 15:00	51.1
03:00 - 04:00	44.9	15:00 - 16:00	51.1
04:00 - 05:00	37.8	16:00 - 17:00	50.0
05:00 - 06:00	38.8	17:00 - 18:00	42.7
06:00 - 07:00	40.4	18:00 - 19:00	44.0
07:00 - 08:00	51.7	19:00 - 20:00	35.7
08:00 - 09:00	62.0	20:00 - 21:00	34.8
09:00 - 10:00	58.9	21:00 - 22:00	39.0
10:00 - 11:00	58.5	22:00 - 23:00	31.4
11:00 - 12:00	53.9	23:00 - 24:00	31.2

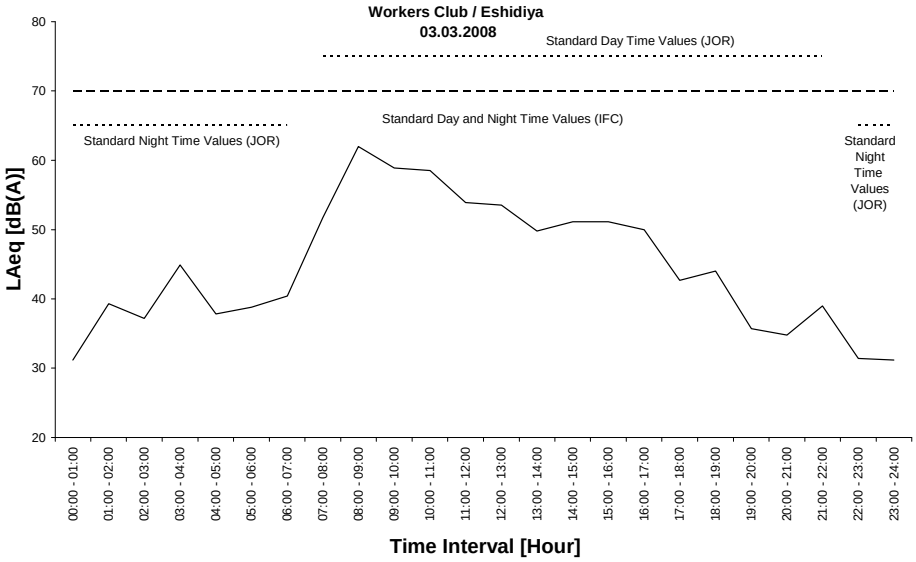


Fig. (6.15): Sound level measurements at site No. 1, day 5

From the results of the fifth measurement day (Monday) of the background monitoring program, it is concluded that the hourly equivalent sound pressure levels during day period were within the permissible limits of 70 dB(A). During night period the values were always within the permissible limits of 65 dB(A).

Table (6.13) : Sound level measurements [dB(A)]
Site No. : 1 (Workers Club - Eshidiya)
Site Coordinates : 223842, 3314458
Day No. : (6) Tuesday
Date : 04/03/2008

Time	L_{Aeq} [dB(A)]	Time	L_{Aeq} [dB(A)]
00:00 - 01:00	34.3	12:00 - 13:00	39.7
01:00 - 02:00	35.0	13:00 - 14:00	38.7
02:00 - 03:00	35.8	14:00 - 15:00	46.9
03:00 - 04:00	46.3	15:00 - 16:00	35.4
04:00 - 05:00	40.9	16:00 - 17:00	42.6
05:00 - 06:00	37.9	17:00 - 18:00	40.5
06:00 - 07:00	34.2	18:00 - 19:00	47.0
07:00 - 08:00	37.1	19:00 - 20:00	40.8
08:00 - 09:00	39.1	20:00 - 21:00	41.7
09:00 - 10:00	38.0	21:00 - 22:00	44.3
10:00 - 11:00	44.0	22:00 - 23:00	43.9
11:00 - 12:00	37.8	23:00 - 24:00	43.7

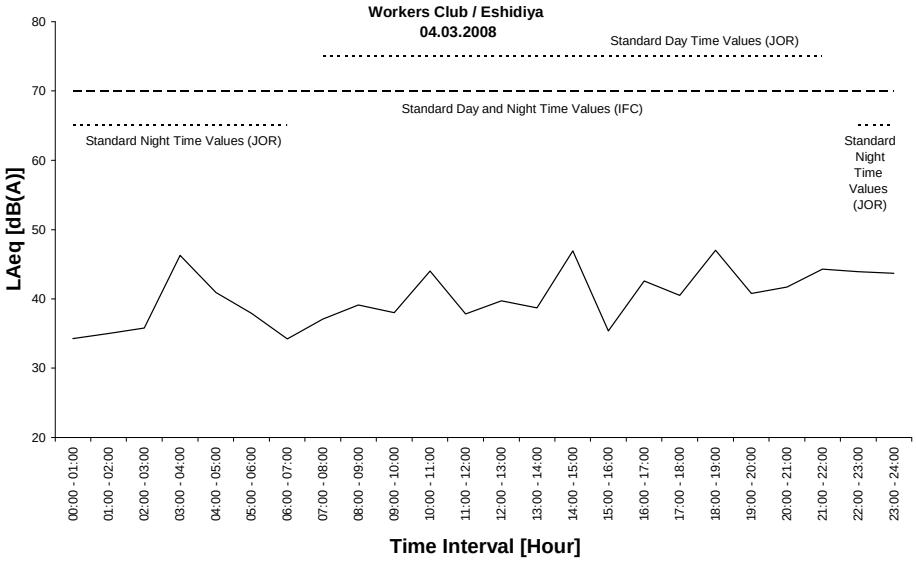


Fig. (6.16): Sound level measurements at site No. 1, day 6

From the results of the sixth measurement day (Tuesday) of the background monitoring program, it is concluded that the hourly equivalent sound pressure levels during day period were always within the permissible limits of 70 dB(A). During night period the values were always within the permissible limits of 65 dB(A).

Table (6.14) : Sound level measurements [dB(A)]
Site No. : 2 (Aqaba Storage Tanks Area)
Site Coordinates : 224915, 3315277
Day : Wednesday
Date : 26 - 27/02/2008

Time	L_{Aeq} [dB(A)]	Time	L_{Aeq} [dB(A)]
09:00 - 10:00	46.9	21:00 - 22:00	46.7
10:00 - 11:00	46.0	22:00 - 23:00	45.6
11:00 - 12:00	46.3	23:00 - 24:00	45.5
12:00 - 13:00	46.1	00:00 - 01:00	45.0
13:00 - 14:00	44.9	01:00 - 02:00	45.2
14:00 - 15:00	44.4	02:00 - 03:00	44.8
15:00 - 16:00	45.1	03:00 - 04:00	46.5
16:00 - 17:00	43.9	04:00 - 05:00	45.7
17:00 - 18:00	43.8	05:00 - 06:00	45.5
18:00 - 19:00	45.4	06:00 - 07:00	47.0
19:00 - 20:00	45.7	07:00 - 08:00	46.4
20:00 - 21:00	44.6	08:00 - 09:00	46.1

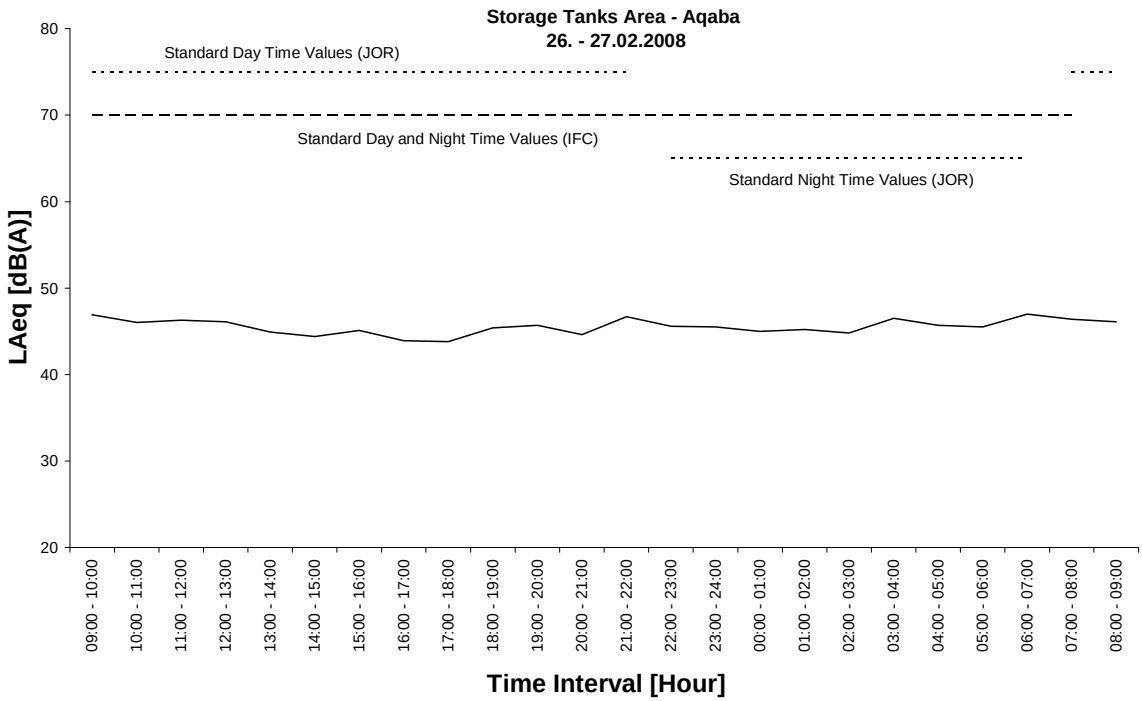


Fig. (6.17): Sound level measurements at site No. 2

From the results of the measurement period of the background monitoring program in the storage tank area in Aqaba, it is concluded that the hourly equivalent sound pressure levels during day period were always within the

permissible limits of 70 dB(A). Also, during night period the measured values were always within the permissible limits of 65 dB(A).

From the hourly gathered data of the equivalent sound pressure levels (L_{Aeq}), the logarithmic mean equivalent sound pressure levels ($L_{\tilde{A}eq}$) were calculated for day and night periods for both sites and presented in Table (6.15) and Figure (6.18).

Table (6.15): Logarithmic mean equivalent sound pressure levels ($L_{\tilde{A}eq}$) at the selected sites

Site	Date	$L_{\tilde{A}eq}$ Day [dB(A)]	$L_{\tilde{A}eq}$ Night [dB(A)]	Standard Day Value [dB(A)] (JOR)	Standard Night Value [dB(A)] (JOR)	Standard Day and Night Value [dB(A)] (IFC)
Eshidiya	Thursday 28.02.2008	52.0	44.0	75	65	70
	Friday 29.08.2008	44.3	42.2			
	Saturday 01.03.2008	43.9	40.2			
	Sunday 02.03.2008	48.7	41.4			
	Monday 03.03.2008	54.5	38.8			
	Tuesday 04.03.2008	42.3	41.3			
	L_{Aeqavg}.	**45.9**	**39.9**			
Aqaba	Tuesday - Wednesday 26 – 27.02.2008	**45.6**	**45.7**			

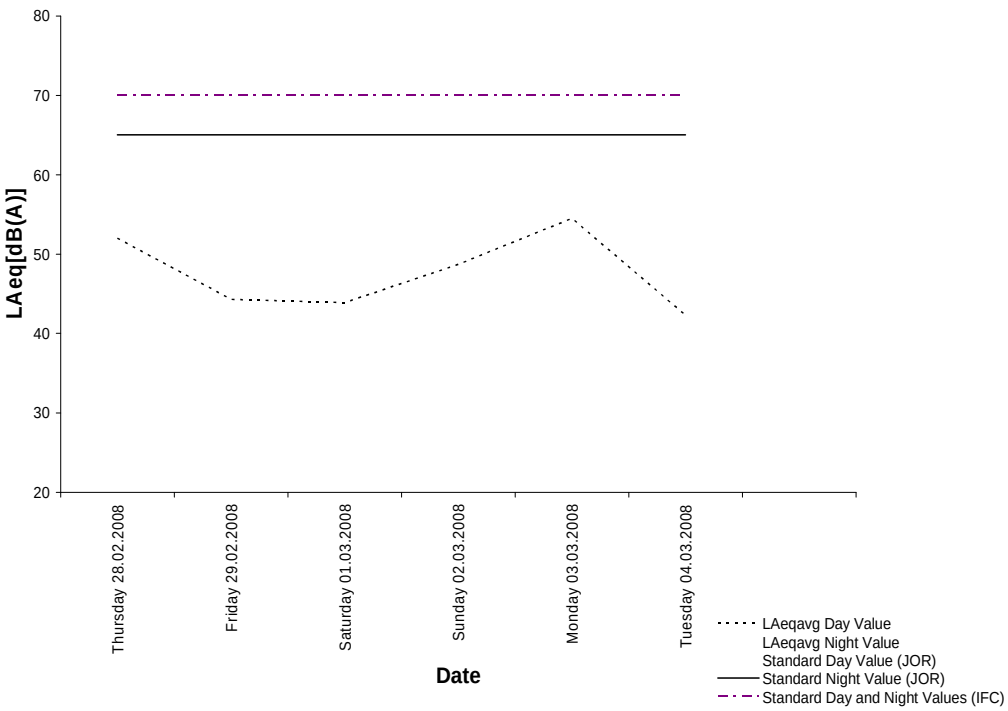


Fig. (6.18): Logarithmic mean equivalent sound pressure levels measurements at the selected site (Workers Club - Eshidiya) for 6 days measurements

From the table above, it is clear that all of the logarithmic mean equivalent sound pressure levels during day and night periods for both sites were within the permissible limit of day and night periods. Also, for Eshidiya site it is noted that the logarithmic mean equivalent sound pressure level during night period (**39.9** dB(A)) is lower than the value during day time (**45.9** dB(A)) which is due to the fact that some industrial activities in this area (mining) were off during night time. While, for Aqaba site the logarithmic mean equivalent sound pressure level for both day and night periods was almost the same. Thus indicates that the same activities take place during day and night time.

6.4 Impact Evaluation

6.4.1 Air Quality

Existing knowledge

This section presents an assessment of air quality impacts associated with the proposed JIFCO project different phases in Eshidiya industrial area, the proposed phosphoric acid storage tanks in Aqaba and the project related transportation between Eshidiya and Aqaba. The cumulative air quality impact of the proposed project and the existing industries (IJCC and JPMC mining) will be presented in a separate chapter.

Emissions from the activities of the proposed JIFCO project will be mainly as follows:

During construction phase in ***Eshidiya*** and ***Aqaba***:

- Project construction activities would generate substantial amounts of dust, which might have significant impact if not mitigated in a safe manner. Dust pollution will mainly be caused by earthmoving operations used for construction the project in Eshidiya and the phosphoric acid storage tanks in Aqaba such as soil excavation, materials mixing, vehicles movements on unpaved roads, soil piling areas and improper management of construction materials.

- In addition, air pollutants may be emitted by vehicles and other construction equipments causing short-term degradation of the air quality at the construction areas and the transportation roads.

During operation phase:

Eshidiya

- Sulphuric acid plant: The transportation of the raw sulphur granules, unloading (trucks discharge), storage in the site and conveying from the store to the smelter could emit sulphur dust. If fine sulphur particles are emitted and their concentrations in the air are between the lower and upper flammable limits of suphur, this could cause fire hazard in the existence of ignition source. In addition to the dust that could be generated from the cleaning of the vanadium pentoxide (V_2O_5) catalyst cleaning.

  The tail gases from the final absorber stack could emit sulphur dioxide (SO_2) and acid mist (H_2SO_4 and sulphur trioxide SO_3). SO_2 emissions may be originated from bad conversion efficiency and gas bypassing. SO_3 may be emitted due to bad absorption efficiency and vapor pressure of sulphuric acid. While, H_2SO_4 emissions may be originated from mist formation, vapor pressure or problems in the tower design. The company will install double contact double absorption (DCDA) process to increase the sulphuric acid production efficiency and reduce the environmental impact.

  The following emissions (SO_2, NO_x, PM10 and CO) are expected from the burning process at the start-up boiler, taking into consideration that this boiler will be operated for few days during the sulphuric acid plant start-up.

- Phosphoric acid plant: Various process steps involving phosphate rock raw materials unloading to the plant hoppers, conveying to and stocking in three-sided store, transferring to the raw ball mill and milling including the discharge from the conveyor to the mill, screening and the discharge of return back oversize-milled phosphate to the ball mill could emit dust. The company will install de-dusting system to reduce the emitted dust mainly from the ball mill in order to comply with the Jordanian standards (JS: 1189/2006) maximum allowable dust limit from the stationary sources of the phosphoric acid plant of 50 $\mu g/m^3$. Also, all conveying belts will be covered as well as a de-dusting unit for unloading of phosphate rock will be installed.

  The main gaseous pollutants of this plant are the fluoride gases, mainly the hydrogen fluoride (HF) and the silicon tetrafluoride (SiF_4) that are produced in phosphate rock digestion process with the sulphuric acid and

that could be also emitted from the phosphoric acid production, filtration and evaporation process. This is because fluoride is present in most phosphate rocks to the extent of 2 - 4%; 20 - 40 kg/ton rock or about 60 - 120 kg/ton P_2O_5. The company will install a scrubbing system to reduce the outlet emission of fluorides to 5 µg/m^3 and the resulted fluosilicic acid will be sent to JPMC Aluminum Fluoride plant in Aqaba.

In addition, mineral phosphate rocks have natural radioactivity, i.e. those of sedimentary origin contain uranium within a range of 0.005-0.02% and those of igneous origin contain thorium. Uranium in mineral phosphate is mainly distributed between the phosphoric acid and the by-product phosphogypsum. The main product of uranium decay is radium (^{226}Ra). Radium is carried very largely into the by-product gypsum because its sulphate is insoluble. Phosphogypsum will be dumped to the east of the phosphoric acid plant in large quantities that may be a source of radioactive pollution mainly if the dust is blown off the stacks by wind and because of the dispersion of radon gas (^{222}Rn son of radium).

Aqaba

- Phosphoric acid storage tanks: The storage and handling facilities of phosphoric acid at the storage zone in Aqaba/ Industrial zone of 5 storage tanks is not considered as air pollution source in regard to the public health, since the vapor pressure of phosphoric acid is quite low at the ambient temperature. In case of phosphoric acid leakage, mainly the employees will be impacted of the resulted odor and possible breathing problems.

Eshidiya and Aqaba

- Transportation: The transportation of sulphur granules from JPMC site to Eshidiya as well as the transportation of phosphoric acid and fluosilicic acid from Eshidiya to Aqaba will increase the traffic load on the main Aqaba-Amman highway (Eshidiya-Aqaba segment).

  The heavy-duty trucks and tankers that will be used will cause short degradation of these roads air quality mainly due to the more particulate matter, gaseous pollutants (SO_2, CO, NO_x and VOCs) and greenhouse gases (CO_2, CH_4 and N_2O) that will be originated from them. The movement of these vehicles on un-paved roads will contribute more in dust emissions.

During decommissioning phase:

- The activities of demolition of buildings and disassembling of equipment will generate dust, and gaseous and particulate emissions from vehicles and other machinery that will be used during decommissioning activities.

Table (6.16) summarizes the evaluation of residual impacts on the air quality regarding the public health.

Table (6.16): Evaluation of the project impacts on air quality regarding the public health

Impact	Geographical Extent	Level	Frequency	Duration	Direct (D) Indirect (ID)	Reversible (R) Irreversible (IR)	Likelihood	Significant	Positive/ Negative	Remarks
Dust and gaseous emissions generated from construction activities.	L	L	L	M	D	IR	L	No	Negative	Mitigation measures are required
Project on increasing the air pollution during operation phase.	M	M	H	H	D	IR	M	Yes	Negative	Mitigation measures are required
Dust and gases generated from demolition of buildings and disassembling of equipment.	L	L	L	L	D	IR	L	No	Negative	Mitigation measures are required

Significance criteria:

Geographical Extent	L: Limited to project area.	M: May reach outside project area.	H: Will reach outside project area.
Level	L: Will not change existing level	M: Will change existing level slightly	H: Will change existing level severely
Frequency	L: Occurs only once/rarely	M: Occurs during abnormal conditions	H: Occurs continuously.
Duration	L: During specific activity	M: During construction phase	H: During operational phase, continuously.
Likelihood	L: Impact is not likely to occur	M: May occur	H: Will occur.

Assessing of project impact on air quality

This section will concern with quantitatively assessing of the proposed JIFCO impact on the air quality because of its stack emissions and due to the transportation activities. While the cumulative impact of the new JIFCO project and the existing two industrial activities in Eshidiya (IJCC and JPMC) will be evaluated in chapter (11).

Air quality impact of the stack emissions:

JIFCO

The company will have the following process stacks: sulphuric acid final absorber, phosphate rock ball mill, phosphoric acid plant and start-up boiler. Table (6.17) shows the expected emissions from each stack.

Table (6.17): Expected emissions from the proposed JIFCO project stacks

Process	Expected emissions
H_2SO_4 plant final absorber	SO_2 and SO_3
Raw phosphate rock mill	Dust
H_3PO_4 plant	HF and Dust
Start-up boiler	SO_2, NO_X, CO and Dust

The environmental impacts of these emissions are as follow:

- Carbon monoxide (CO): It is an odorless, colorless gas. It is formed when the carbon content of the used fuel is not completely burnt. CO molecules could enter the bloodstream through the lungs, where they bind chemically to the hemoglobin and inhibit the delivery of oxygen throughout the body. Low concentrations can cause dizziness, headaches and fatigue, while high concentrations can affect the mental alertness and vision, and could be fatal.

- Sulphur oxides (SO_2 and SO_3): They could react rapidly with water in the atmosphere, as well as with other pollutants, to form sulphate aerosols. These gases are the major constituent of acid rain that could harm the vegetation and buildings. Sulphuric acid aerosols are strong pulmonary irritants. In addition, SO_2 can cause lung problems, including breathing problems and permanent damage to lungs.

- Nitrogen oxides (NO_x): They are mainly produced from burning fuels. NO_x are the major contributor to smog and acid rain. They react with volatile organic compounds (VOCs) to form smog and ground level

ozone that could harm humans by causing respiratory problems. Acid rain can harm vegetation and buildings. In addition, nitrate aerosols can reduce visibility.

- Hydrogen fluoride (HF): It can cause discomfort above an ambient concentration of about 8 mg HF/m^3 and acute discomfort between 30-50 mg HF/m^3, including irritation of the eyes, nose, pharynx and upper chest. Prolonged exposure to fluoride, especially by ingestion, can cause fluorosis, the symptoms of which include mottling of the teeth, pains and stiffness.

  Vegetation can be severely damaged by proximity to industrial fluoride emissions. Pine trees are particularly susceptible. Moreover, fluoride contamination of vegetation is cumulative and can lead to problems with herbivorous animals.

- Dust: Size of the dust particles is generally divided into two principal groups: coarse particles larger than 2.5 µm and fine particles smaller than 2.5 µm. Aside from reducing visibility and soiling clothing, microscopic particles in the air can be breathed into lung tissue becoming lodged and causing increased respiratory disease and lung damage. Particulates are also the main source of haze, which reduces visibility.

  Inhalation of dust may also result in enhanced exposure to radiation since phosphate rock generally contains enhanced levels of radioactive substances like Ra^{226}, Pb^{210} and Po^{210}.

The dust and gaseous emissions of this plant shall comply with Jordanian standards of maximum allowable limits of air pollutants emitted from the stationary sources (JS: 1189/2006), see Table (6.18)

Table (6.18): JS 1189:2006 some pollutants maximum allowable limits that emitted from the stationary sources and IFC regulations

Pollutant	JS Maximum allowable limit (mg/Nm^3)	IFC maximum allowable limit (mg/Nm^3)	JS Notes
Dust	50	50	Emitted from cement, phosphate and fertilizers manufacturing, nonferrous and ferrous casting, boilers and petroleum refinery
SO_2	6500	2000	Emitted from petroleum derivatives combustion, until existing of lower sulfur content fuel or after 5 years, which closer
	3000	---	Emitted from nonferrous manufacturing
	1500	450 (2 kg/ton acid)	Emitted from sulphuric acid plant
SO_3/ H_2SO_4	150	60 (0.075 kg/ton acid)	
NO_x (Calculated as NO_2)	200	200	Resulted from combustion processes at temperature less than 1200 ºC
	1500		Resulted from combustion processes at temperature more than 1200 ºC
	300		Resulted from other activities excluding fuel combustion
TVOCs	20	---	
HF	15	5	
F_2	5	---	

Air quality-forecasting models for fixed sources (computer software) that are internationally approved were used to assess project alone and with IJCC and JPMC impacts on ambient air quality. These softwares take into consideration all the parameters that could affect the emitted pollutants dispersion in the ambient air, the ones of the emission sources and the weather conditions.

The air pollution dispersion model "Super Air" is used. Environmental Research Institute Inc. developed this model by the support of Japan International Cooperation Agency (JICA) and it is used in Japan where all the stack, emissions, area topography and weather parameters are taken into consideration. Also, the model complies with US-EPA requirements.

Gaussian type model is used to predict how pollutants that are about as buoyant as air will disperse in the atmosphere. According to this model, wind and atmospheric turbulence are the forces that move the molecules of a released gas through the air, where the following data are necessary as input for air pollution modeling:

- Pollution source data: These data are related to the stacks including location coordinates, total normal volumetric flow rate, concentrations of pollutants, stack height and effluent gas temperature. The required data for modeling provided by the company are shown in Table (6.19).

- Weather conditions data: These include wind speed, wind direction and stability of the atmosphere.

The dispersion of pollution was simulated at a height of 1.5 m (approximately the average height of human's nose), giving the ground level concentration of the different pollutants in different areas. The calculated effective stack height was used in the modeling.

The following pollutants were modeled: SO_2, SO_3, NO_x, CO, HF and dust (PM10). For each pollutant, pollution dispersion was simulated for the following cases:

1. Moderately unstable conditions at wind speed of 1 m/s (B1), with northern wind.
2. Neutral conditions at wind speed of 4 m/s (D4), with northern wind.
3. Moderately stable conditions at wind speed of 2 m/s (F2), with northern wind.

These cases could cover all possible weather scenarios at the prevailing wind direction, taking into consideration that the resulted pollutant ground level concentrations at other wind directions will be more or less the same, since this part concerns the effect of the company alone.

The outcome of the model for the different simulated cases is the ground level concentration of the pollutants in different parts of the area including the maximum ground level concentration represented in mesh format.

The ground level concentration obtained from air pollution modeling for gaseous pollutants are compared to the maximum allowable limits specified in the Jordanian air quality standards (1140/2006) and IFC regulations.

Table (6.19): Data related to the stacks of the proposed JIFCO project at Eshidiya industrial area

Source	North Coordinate	East Coordinate	Stack Height (m)	Total Volumetric Flow Rate (Nm^3/ hr)	Effluent Gases Temperature (°C)	Max. Concentration (mg/Nm^3)					
						SO_2	SO_3	HF	NO_x	CO	PM10
H_2SO_4 plant	923600	259450	55	310,000	82	1140 (399.2 ppm)	70 (19.6 ppm)				
Raw phosphate rock mill	923530	259780	50	70,000	40						50
H_3PO_4 plant	923600	259780	50	120,000	62			5 (5.6 ppm)			20
Start-up boiler	923700	259590	50	50,000	210	2300 (805.4 ppm)			150 (73.1 ppm)	100 (80.0 ppm)	50

Source: JIFCO plant

All the results of air pollution modeling displayed graphically in mesh format are shown in Figs. (6.19) to (6.36). Tables (6.20) to (6.25) show the maximum ground level concentration (C_{max}) and the distance at which it occurs (D_{max}) for all modeling cases.

<u>SO_3 Modeling Results</u>

C_{max} ranged between 0.001 and 0.005 ppm for all modeling cases. This is occurred at all atmospheric and effluent conditions tried in the model. SO_3 modeling results are summarized in Table (6.20) below. Thus, the planned JIFCO project is not expected to increase the levels of SO_3 in the ambient air, see Figs. (6.19) to (6.21).

Table (6.20): The model estimates of SO_3 maximum one hour ground level concentration

Stability and wind speed	Max. gr. level conc. (C_{max}), ppm	Distance from final absorption stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.005	1.5
D4	0.002	3.0
F2	0.001	30.0

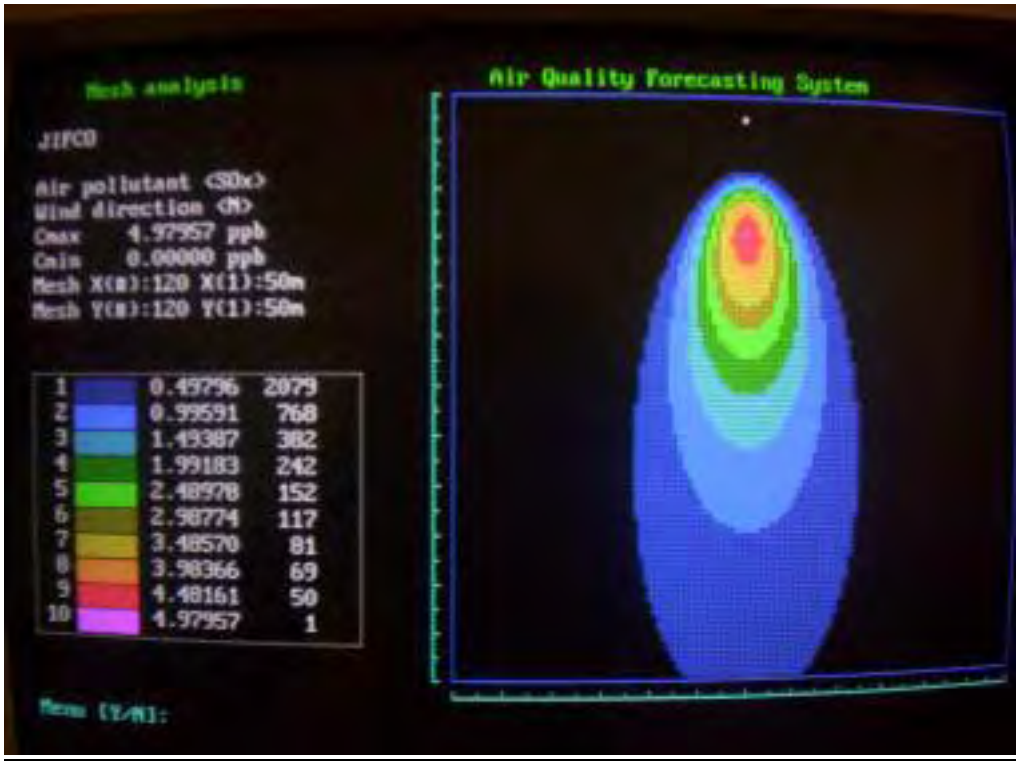


Fig. (6.19): One hour ground level concentrations of SO_3 estimated by modeling at stability class B, north wind and wind speed of 1 m/s

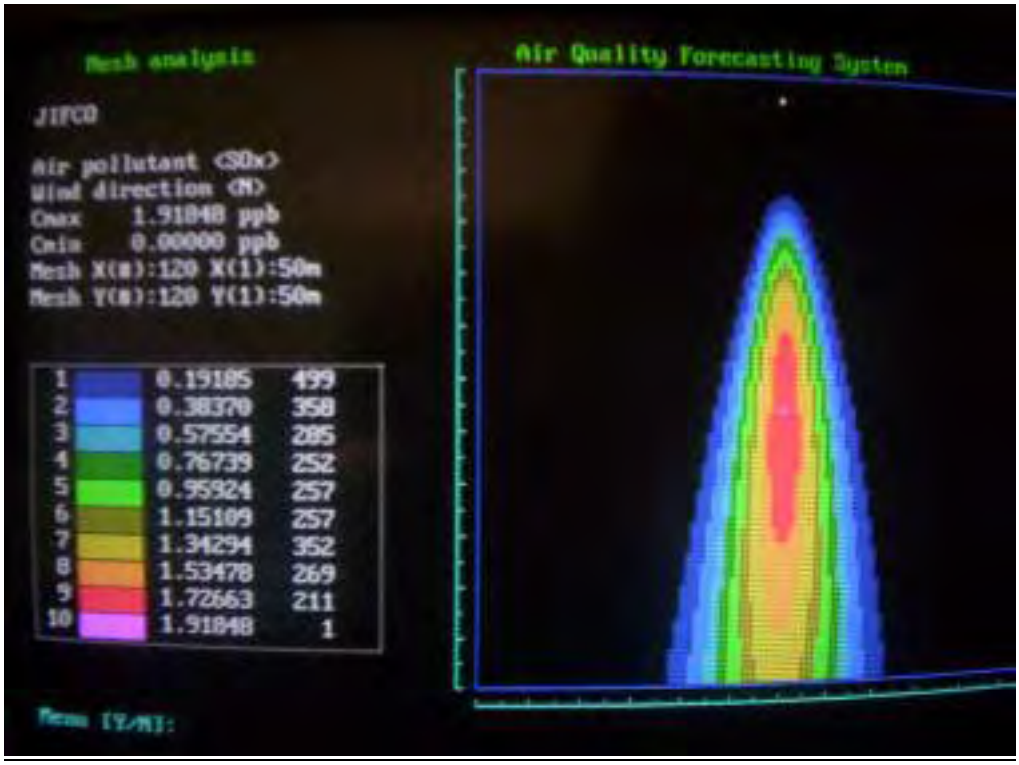


Fig. (6.20): One hour ground level concentrations of SO_3 estimated by modeling at stability class D, north wind and wind speed of 4 m/s

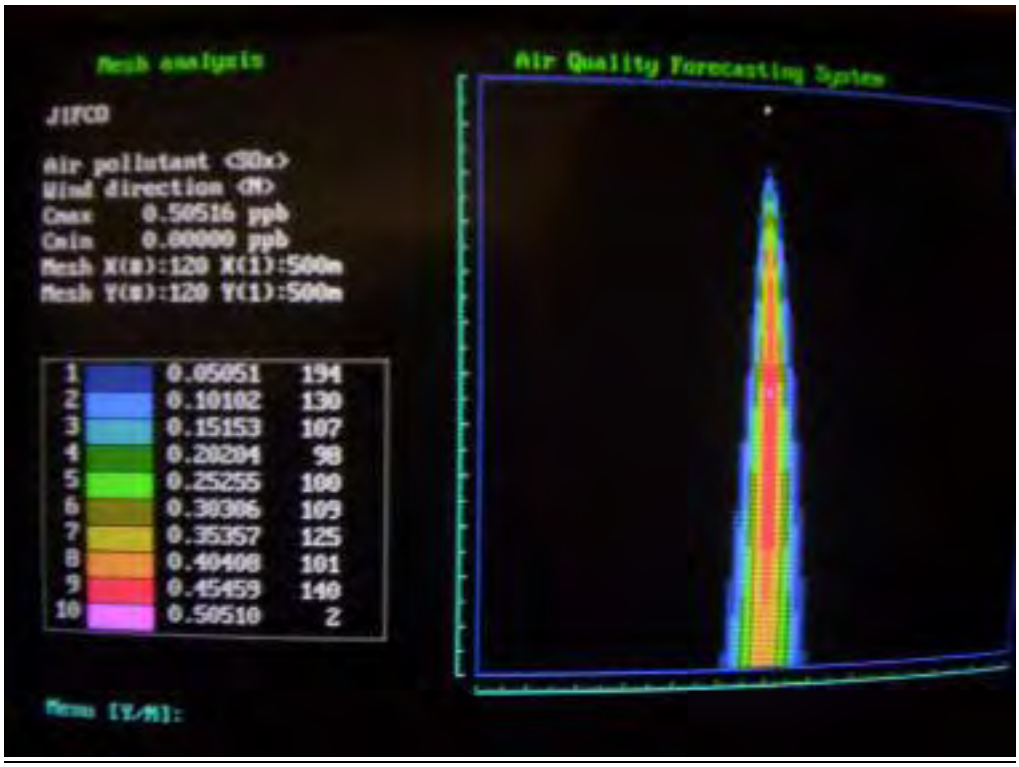


Fig. (6.21): One hour ground level concentrations of SO_3 estimated by modeling at stability class F, north wind and wind speed of 2 m/s

SO_2 Modeling Results

C_{max} ranged between 0.017 and 0.142 ppm for all modeling cases. This occured at all atmospheric and effluent condition tried in the model. SO_2 modeling results are summarized in Table (6.21) below.

The maximum one-hour ground level concentration (C_{max}) of SO_2 does not exceed the maximum allowable hourly limit of 0.300 ppm specified in the Jordanian Ambient Air Quality Standard; JS 1140/2006 for all modeling cases (Figs. (6.22) to (6.24)).

The proposed JIFCO project will not affect the levels of SO_2 in the ambient air, since the maximum forecasted ground level concentration will occur at a distance of 1.5 km which is inside JIFCO project borders.

Table (6.21): The model estimates of SO_2 maximum one hour ground level concentration

Stability and wind speed	Max. gr. level conc. (C_{max}), ppm	Distance from final absorption stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.142	1.5
D4	0.056	3.0
F2	0.017	24.0

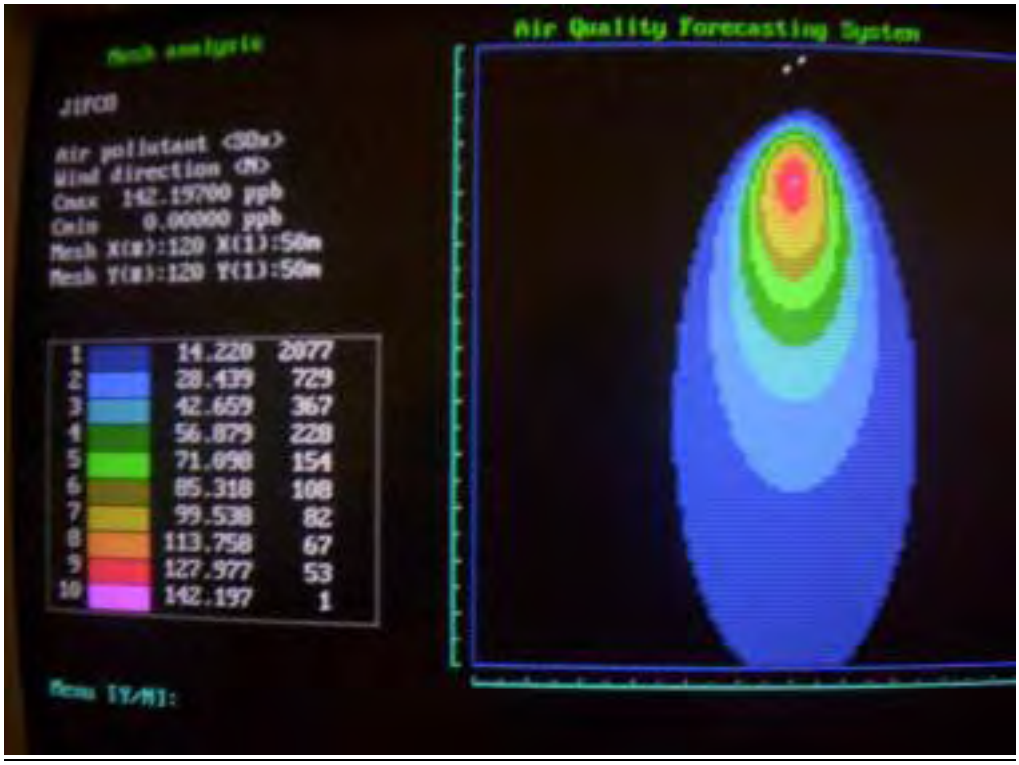


Fig. (6.22): One hour ground level concentrations of SO_2 estimated by modeling at stability class B, north wind and wind speed of 1 m/s

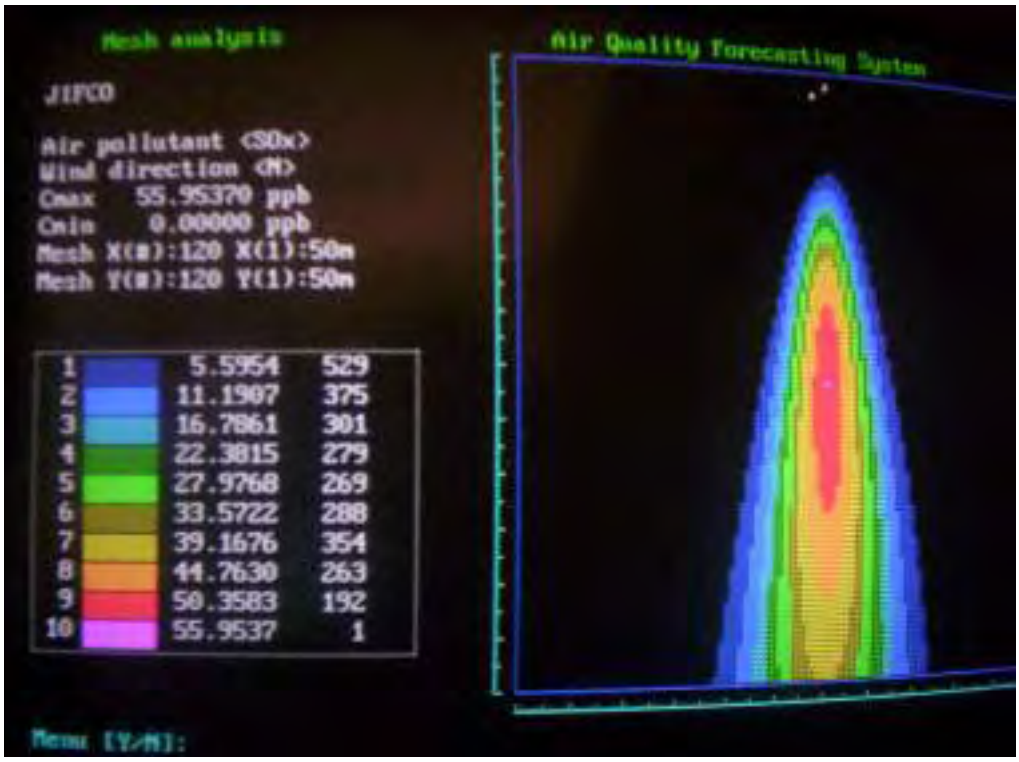


Fig. (6.23): One hour ground level concentrations of SO_2 estimated by modeling at stability class D, north wind and wind speed of 4 m/s

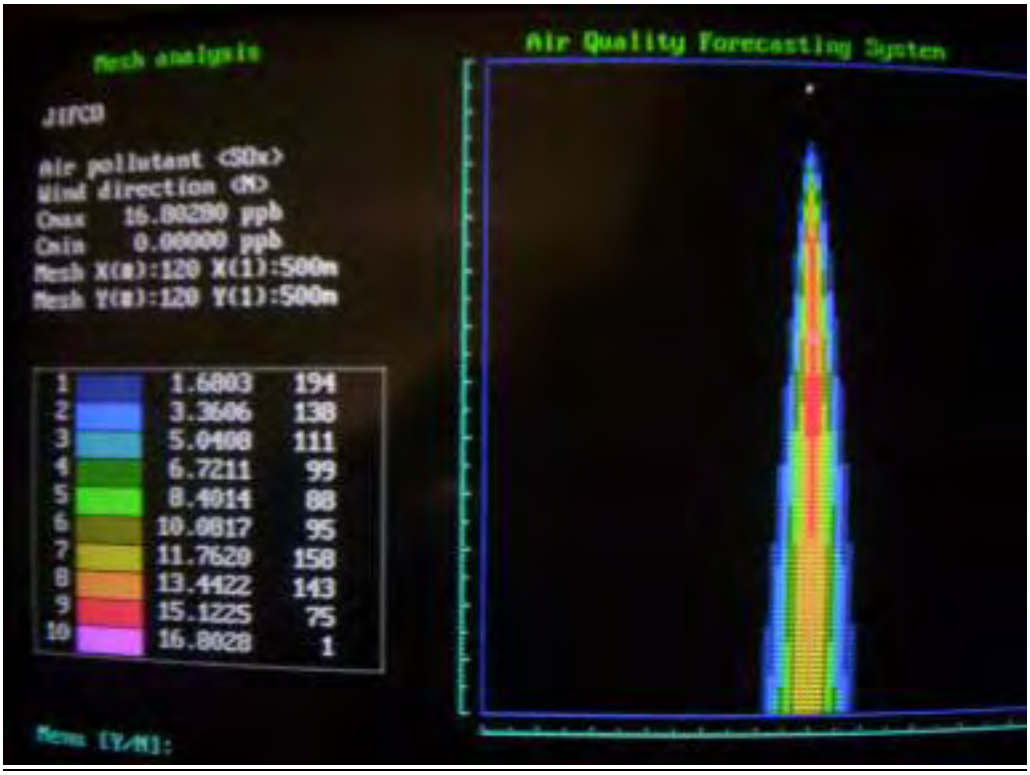


Fig. (6.24): One hour ground level concentrations of SO_2 estimated by modeling at stability class F, north wind and wind speed of 2 m/s

NO_x Modeling Results

The maximum ground level concentrations of NO_x obtained from modeling are all well below the maximum NO_2 allowable hourly limits of 0.210 ppm specified in JS 1140/2006 and 0.097 ppm specified in IFC regulations for all modeling cases (Table (6.22) and Figs. (6.25) to (6.27)). C_{max} ranged between 0.001 and 0.004 ppm. In addition, the maximum NO_X concentration will be inside the planned JIFCO project borders.

Table (6.22): The model estimates of NO_x maximum one hour ground level concentration

Stability and wind speed	Max. gr. level conc. (C_{max}), ppm	Distance from start up boiler stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.004	1.0
D4	0.002	2.3
F2	0.001	16.0

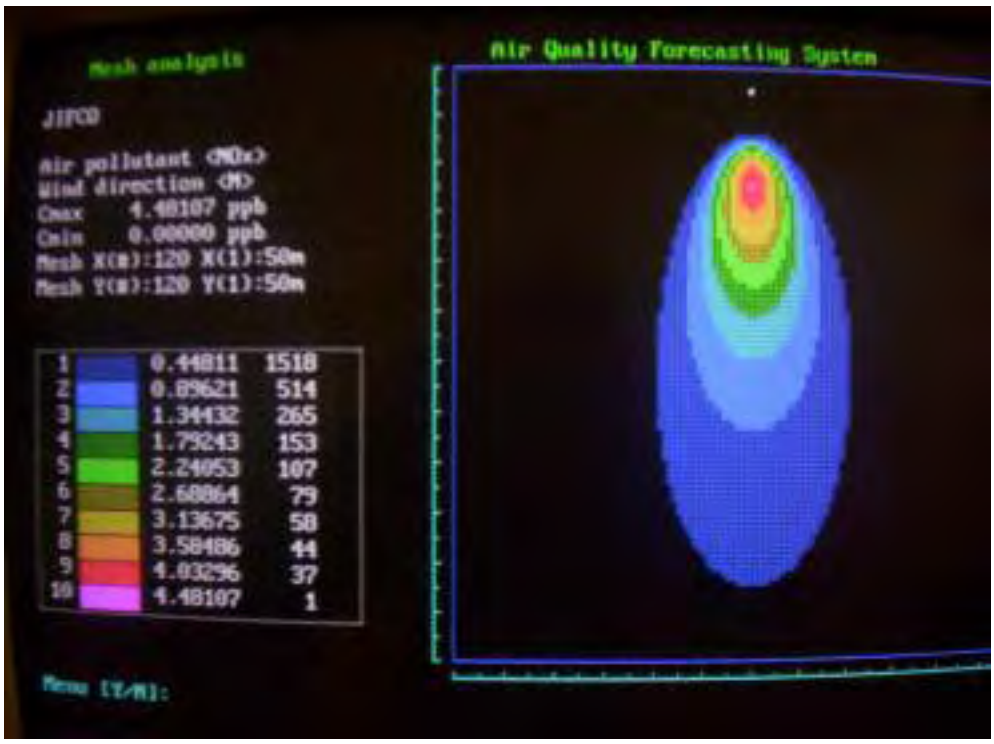


Fig. (6.25): One hour ground level concentrations of NOx estimated by modeling at stability class B, north wind and wind speed of 1 m/s

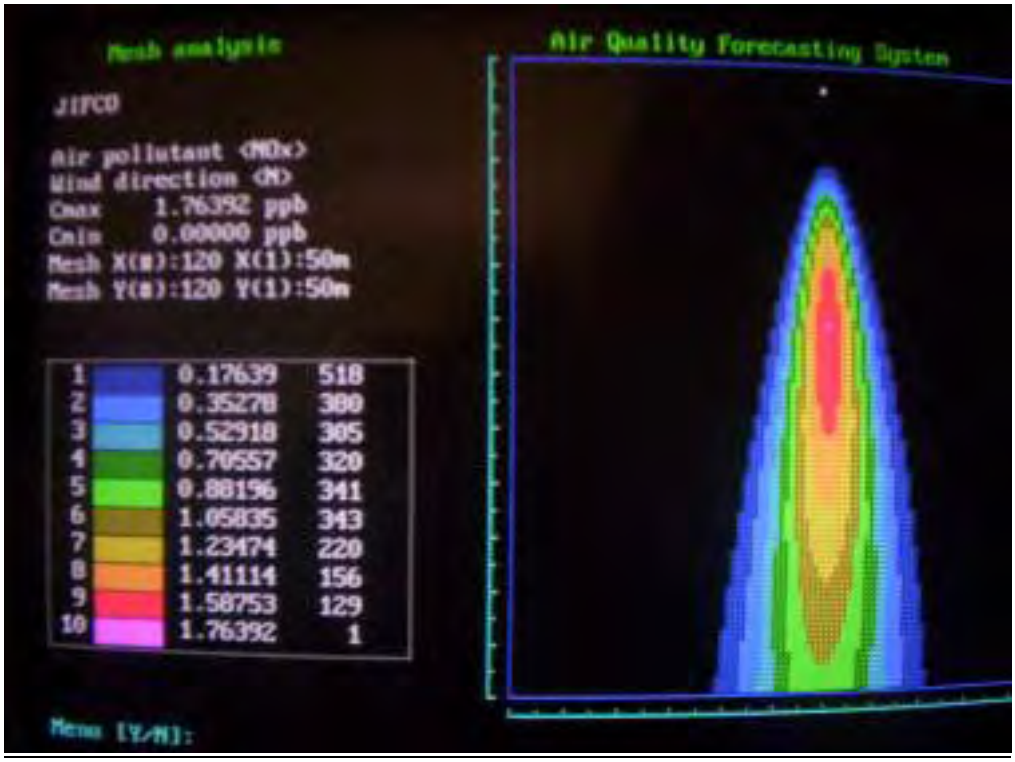


Fig. (6.26): One hour ground level concentrations of NO_X estimated by modeling at stability class D, north wind and wind speed of 4 m/s

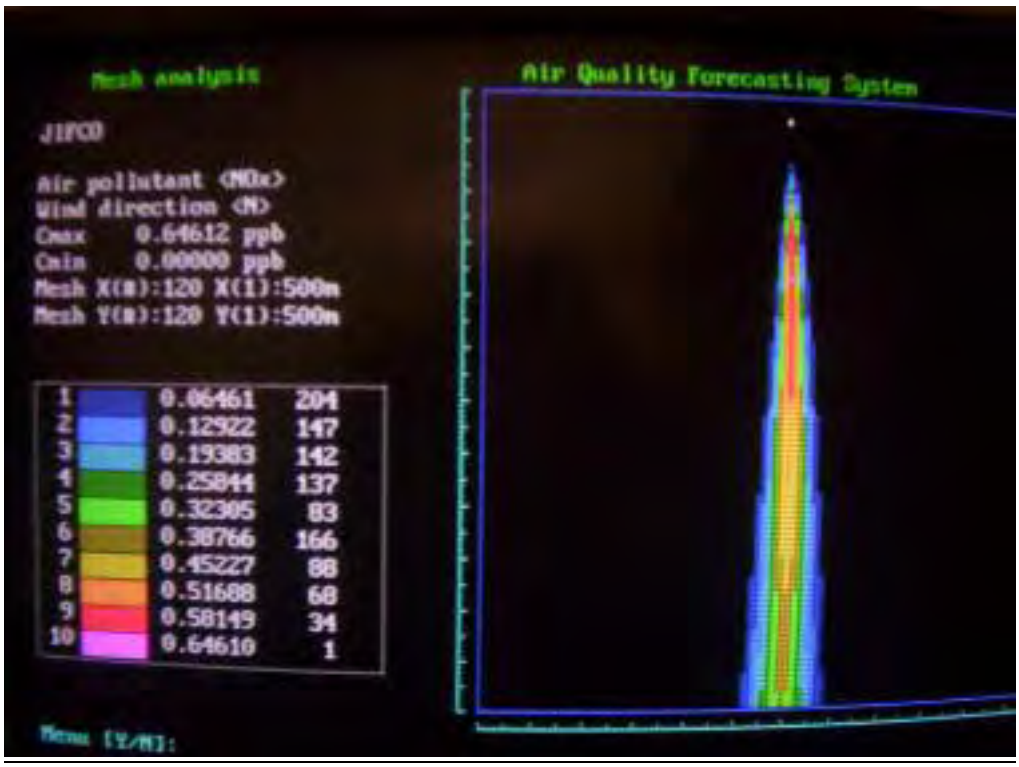


Fig. (6.27): One hour ground level concentrations of NO_X estimated by modeling at stability class F, north wind and wind speed of 2 m/s

CO Modeling Results

The resulting estimated CO maximum ground levels are well below the hourly limits of 26 ppm specified in Ambient Jordanian Standards and of 24 ppm specified in IFC regulations (Table (6.23) and Figs. (6.28) to (6.30)). C_{max} ranged between 0.001 and 0.005 ppm. Therefore, the proposed JIFCO start-up boiler does not seem to affect the levels of CO in the ambient air.

Table (6.23): The model estimates of CO maximum one hour ground level concentration

Stability and wind speed	Max. gr. level conc. (C_{max}), ppm	Distance from start up boiler stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.005	1.0
D4	0.002	2.3
F2	0.001	16.0

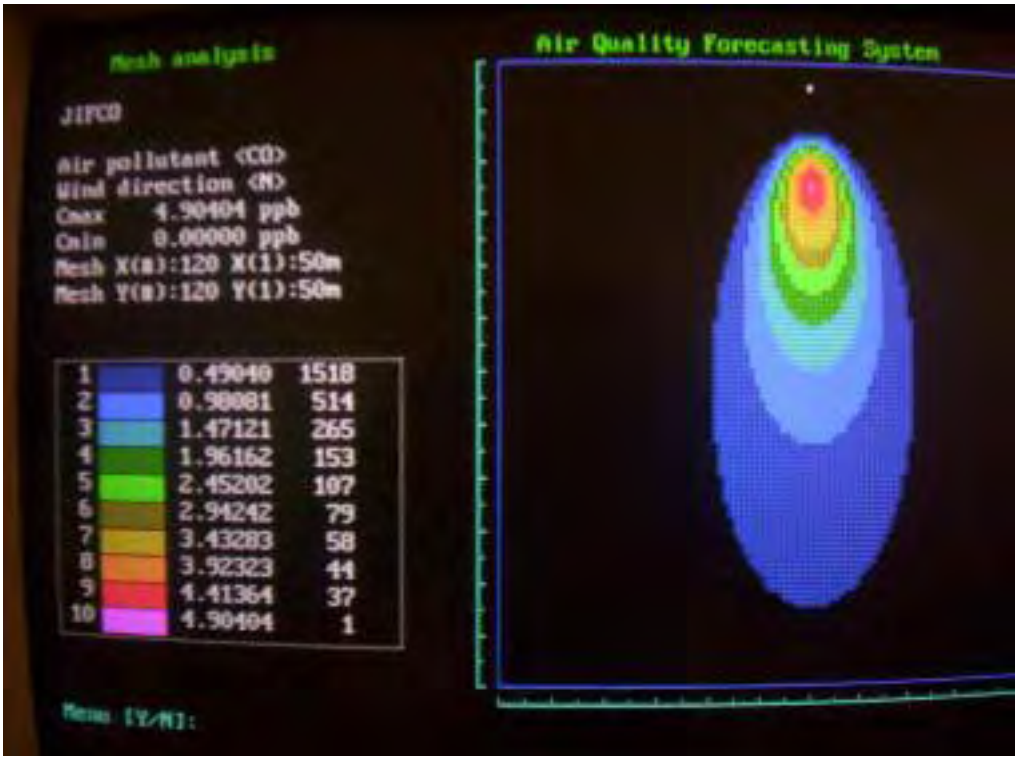


Fig. (6.28): One hour ground level concentrations of CO estimated by modeling at stability class B, north wind and wind speed of 1 m/s

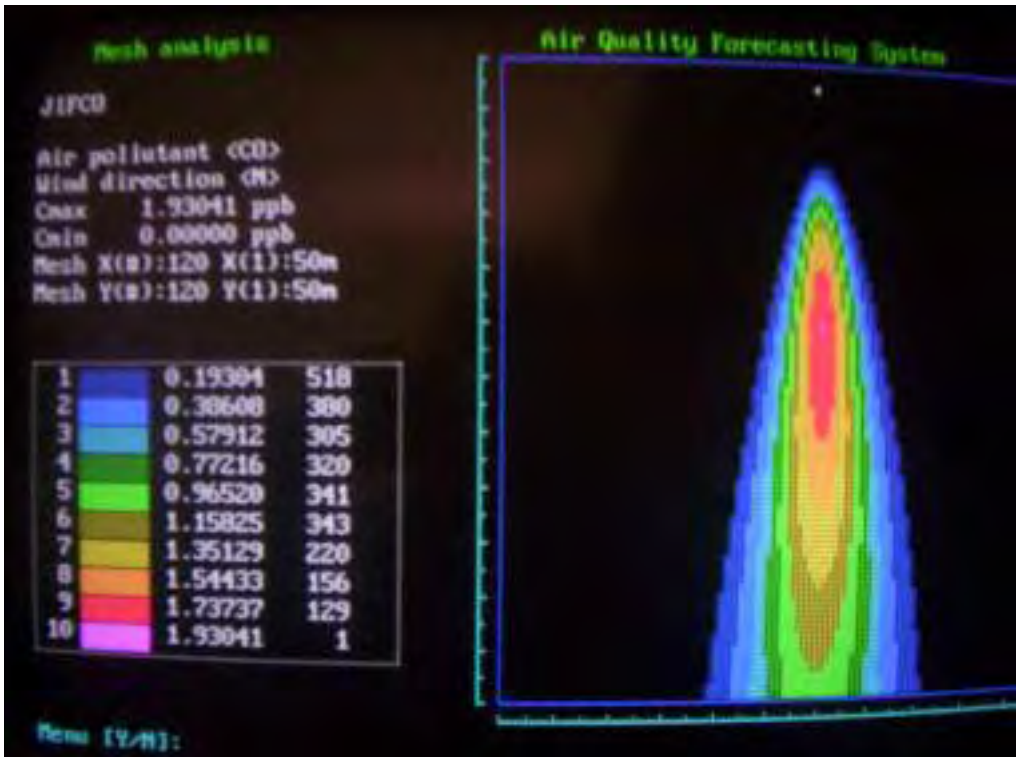


Fig. (6.29): One hour ground level concentrations of CO estimated by modeling at stability class D, north wind and wind speed of 4 m/s

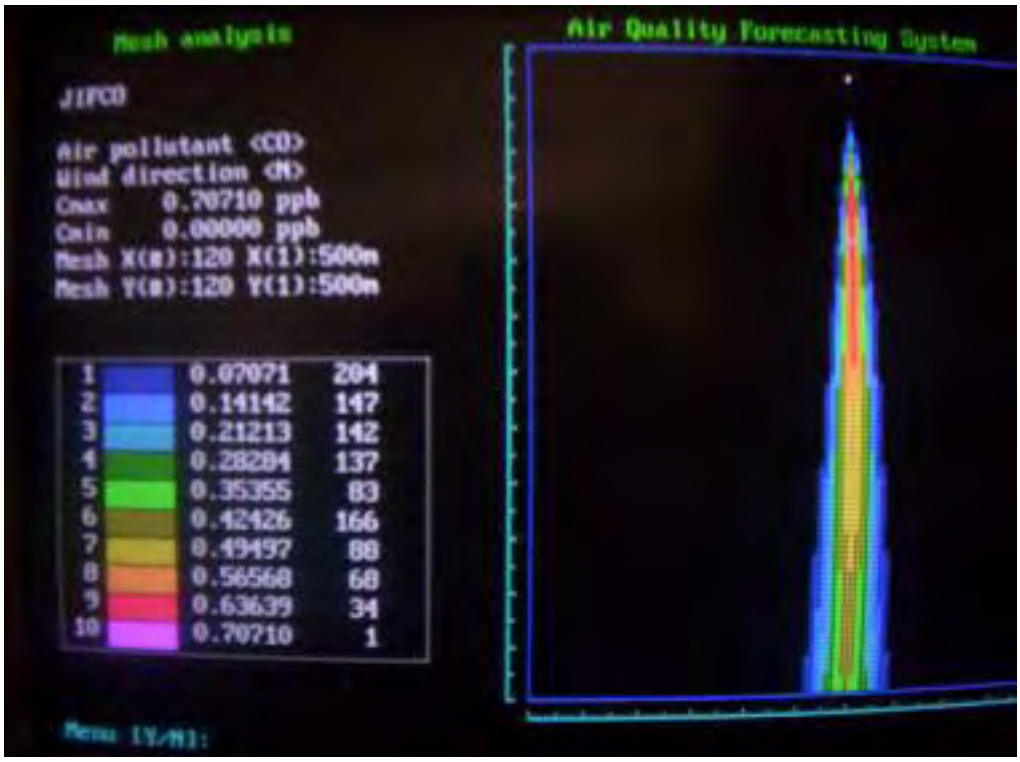


Fig. (6.30): One hour ground level concentrations of CO estimated by modeling at stability class F, north wind and wind speed of 2 m/s

Dust (PM10) Modeling Results

PM10 C_{max} ranged between 3.8 and 18.9 µg/m^3 for all modeling cases. This occurs at all atmospheric conditions tried in the model. PM10 modeling results are summarized in Table (6.24) below.

There is no maximum allowable hourly limit for PM10 specified in the Jordanian Ambient Air Quality Standard, JS 1140/2006 nor in IFC regulations. Regarding that, the JS PM10 daily limit is 120 µg/m^3, the planned JIFCO project will not affect the PM10 levels, taking into consideration that the company design values of dust emissions comply with the dust emission limit specified in JS 1189/2006 of 50 mg/m^3 and the maximum concentration will be inside the JIFCO project border. The results of PM10 air pollution modeling are shown in Figs. (6.31) to (6.33).

Table (6.24): The model estimates of dust (PM10) maximum one hour ground level concentration

Stability and wind speed	Max. gr. level conc. (C_{max}), µg/m^3	Distance from start up boiler stack at which C_{max} occurs (D_{max}) downwind (km)
B1	18.9	0.7
D4	5.9	2.0
F2	3.8	10.0

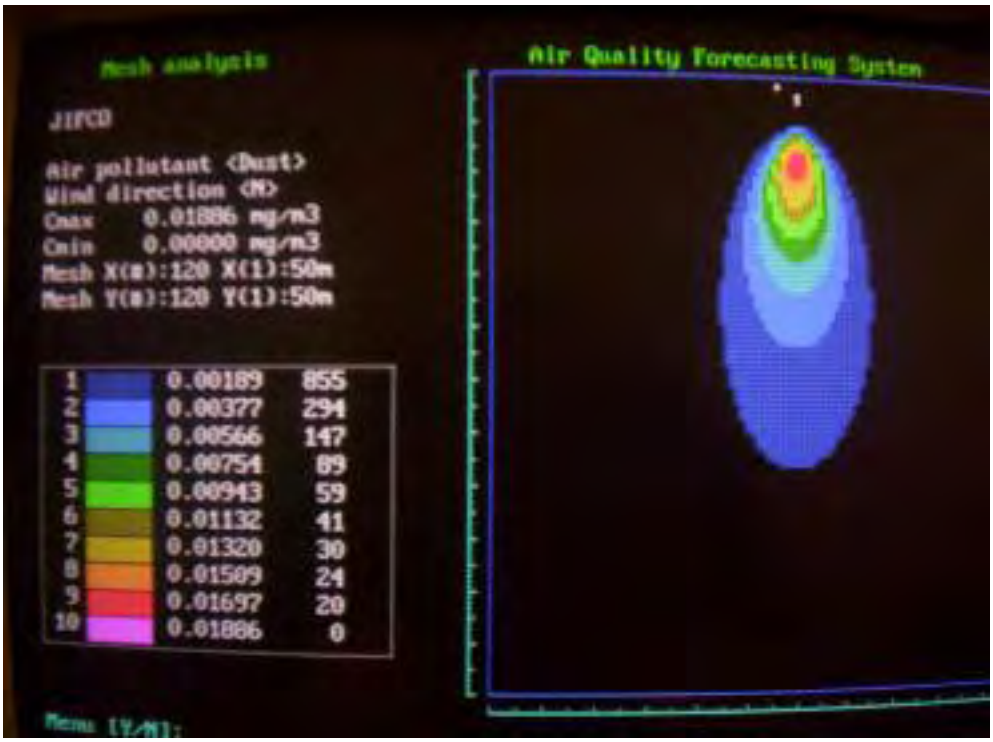


Fig. (6.31): One hour ground level concentrations of Dust estimated by modeling at stability class B, north wind and wind speed of 1 m/s

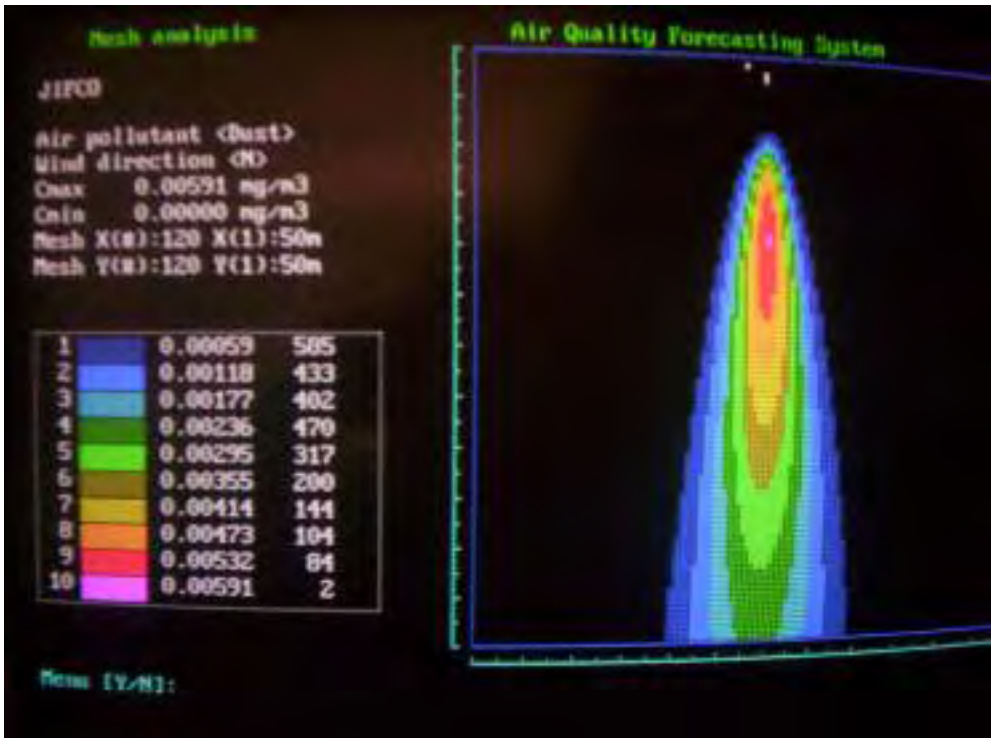


Fig. (6.32): One hour ground level concentrations of Dust estimated by modeling at stability class D, west wind and wind speed of 4 m/s

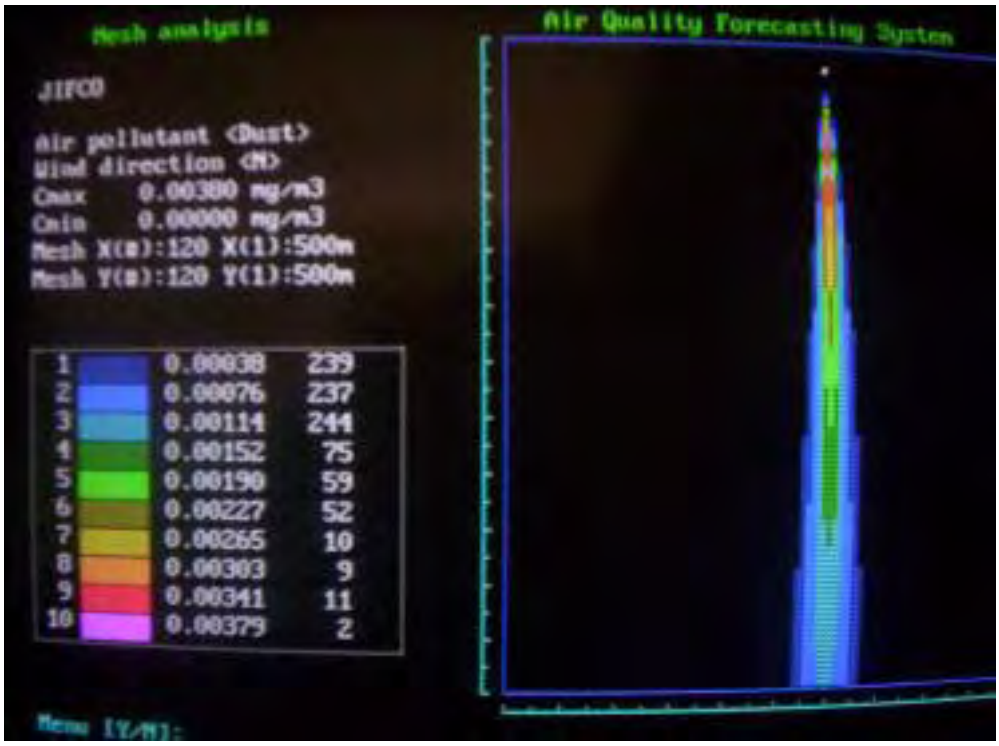


Fig. (6.33): One hour ground level concentrations of Dust estimated by modeling at stability class F, north wind and wind speed of 2 m/s

HF modeling Results

HF C_{max} ranged between 0.017 and 0.699 µg/m^3 for all modeling cases. This occurs at all atmospheric conditions tried in the model. HF modeling results are summarized in Table (6.25) below.

There is no maximum allowable hourly limit for HF specified in the Jordanian Ambient Air Quality Standard, JS 1140/2006 nor IFC regulations. Taking into consideration that IFC daily limit is 1 µg/m^3 this indicates that the proposed JIFCO plant will not affect the HF levels. The results of HF air pollution modeling are shown in Figs. (6.34) to (6.36).

Table (6.25): The model estimates of HF maximum one hour ground level concentration

Stability and wind speed	Max. gr. level conc. (C_{max}), µg/m^3	Distance from H_3PO_4 plant stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.699	1.3
D4	0.435	2.6
F2	0.017	37.0

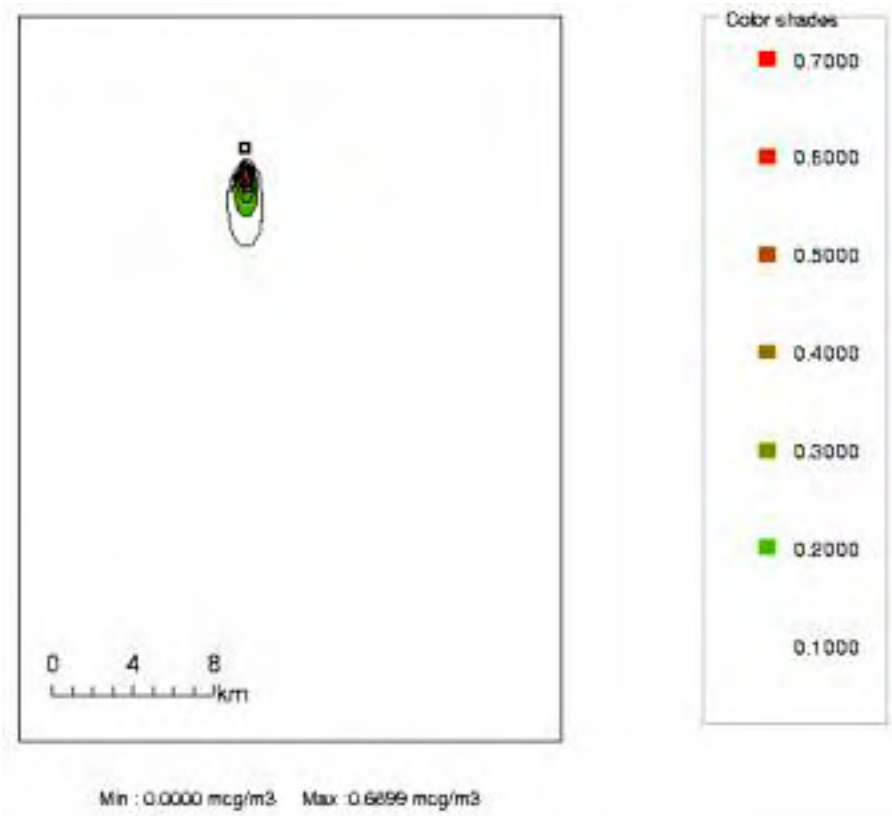


Fig. (6.34): One hour ground level concentrations of HF estimated by modeling at stability class B, north wind and wind speed of 1 m/s

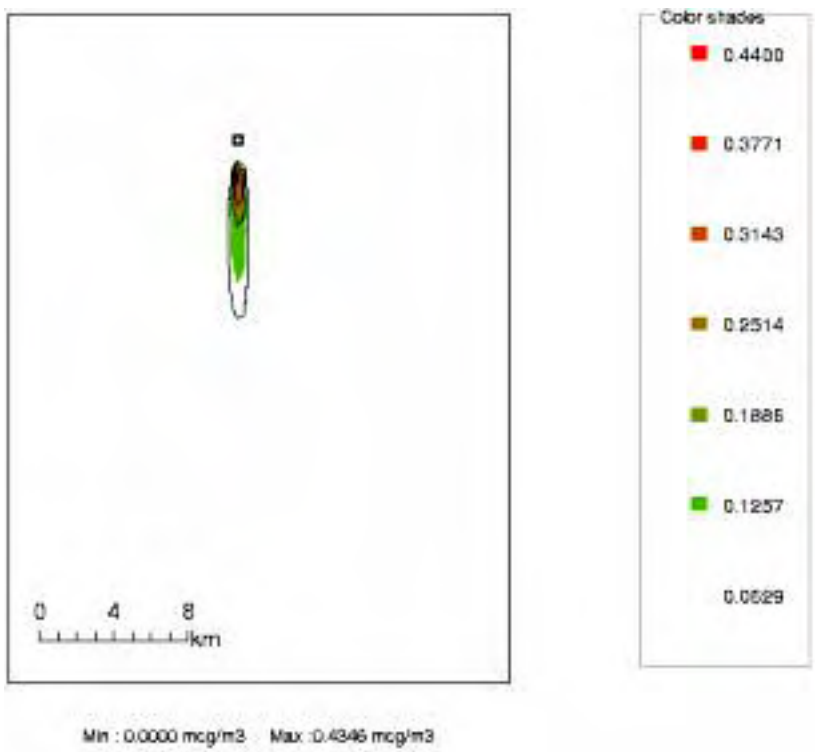


Fig. (6.35): One hour ground level concentrations of HF estimated by modeling at stability class D, north wind and wind speed of 4 m/s

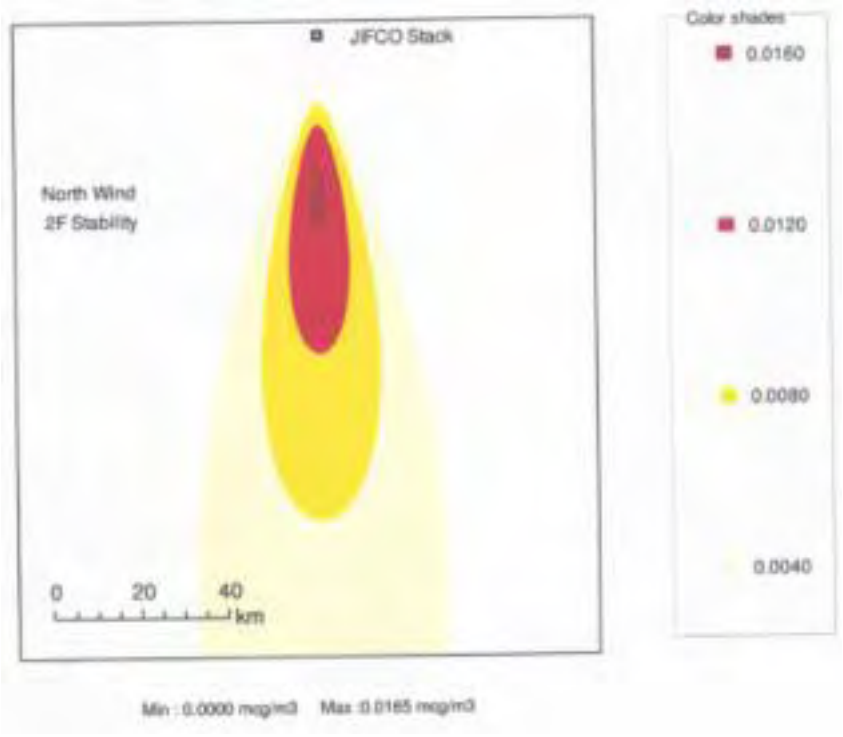


Fig. (6.36): One hour ground level concentrations of HF estimated by modeling at stability class F, north wind and wind speed of 2 m/s

Air quality impact of transportation

There will be a degradation of the air quality at Eshidiya-Aqaba corridor because of phosphoric acid and fluosilicic acid transportation by tankers from JIFCO site in Eshidiya to Aqaba (phosphoric acid storage tanks site and JPMC site) as well as the transportation of raw sulphur granules by trucks from JPMC/ Aqaba to Eshidiya. The Intergovernmental Panel on Climate Change (IPCC) air pollutants emission factors of heavy-duty vehicles, yearly number of used tankers and trucks, the sulphur content in the used diesel, etc. are used to estimate the yearly emissions of SO_2, CO and NO_x and the greenhouse gases CO_2, CH_4 and N_2O in tons per year.

Around 41,844 tankers and trucks (see section (11.3) in Chapter 11) will yearly cut a distance of 175 km in two sides (total of 175 * 2 = 350 km) from Eshidiya to Aqaba, and around 70 km in Aqaba borders (total of 140 km).

The IPCC emission factors will be used to estimate the produced annual tons of carbon monoxide (CO), nitrogen oxides (NO_X), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and non methane volatile organic compounds (NMVOCs) that could be originated from heavy-duty tankers, see Table (6.26).

Table (6.26): IPCC estimated emission factors for Diesel Heavy-duty vehicles*

Gas Type	Emission Factor (g/km)	Remarks
CO	9.0	This represents the European moderate controlled vehicles. See Table 1-39 in page 1.82 in the reference.
NO_x	10.0	
NMVOCs	1.9	
CO_2	770.0	
CH_4	0.06	
N_2O	0.03	

* Reference: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual.

In addition the SO_2 emission factor is calculated according to the below equation, regarding that any abatement technology is not provided. The required data provided by Jordan Petroleum Refinery Co. Ltd. about the used diesel that are shown in Table (6.27) is used.

SO_2 Emission Factor (g/km) = 2 (g SO_2/g S) * (wt% S content/100 (g S/ g fuel)) * Fuel density (g/l) * fuel consumption (l/km)

Table (6.27): Average characteristics of Diesel* and SO_2 emission factor

Fuel Type	Diesel
Density (kg/m^3)	841.0
Sulfur Content (wt %)	1.070
fuel consumption (l/km)	50 liter diesel per 100 km is estimated
Emission factor (g/km)	9.0

* Source: Jordan Petroleum Refinery Co. Ltd. for the period (1/1-31/8/2006).

As a result of above information, estimations and calculations, the proposed JIFCO project transportation within Aqaba and Eshidiya will increase the air pollution and the greenhouse gases inventory in the yearly rates as shown in Table (6.28).

Table (6.28): Estimated increase of some air pollutants and greenhouse gases as a result of the project transportation activities

Type	**Estimated generation (ton/year)**	
	Eshidiya-Aqaba	**Inside Aqaba borders**
SO_2	131.8	52.7
CO	131.8	52.7
NO_X	146.5	58.5
NMVOCs	27.8	11.3
CO_2	11'276.9	4'510.8
CH_4	0.9	0.4
N_2O	0.4	0.2

These emissions are estimated to slightly increase the pollutants and greenhouse gases inventory of around 3%, taking into consideration that the currently large number of vehicles that pass Amman-Aqaba desert highway (3,713,145 in two directions, yearly). In addition, it is worth to mention that the transportation will share in the formation of other air pollutants such as ozone (O_3), particulate matter, black carbon (BC), odor, etc.

6.4.2 Noise

Existing knowledge

During the construction phase, the maximum expected sound level from the used construction machineries will not exceed 110 dB(A) at 1 m distance, (Noise Control for Buildings and Manufacturing Plants). During the operation phase, the maximum expected outdoor sound level generated from the plant will not exceed 70 dB(A) at the border of the plant site and also from the used road machineries at the operator will not exceed 90 dB(A) (Wolfgang Pietzsch).

Assessing of residual impact of noise

During the construction of the project, different types of excavation and construction machines will be used such as jackhammers, graders, backhoes, heavy trucks and tankers. It is anticipated that these machineries give a maximum noise level of 110 dB(A) at the operator. If these vehicles are operating at the boundary, this level will be reduced by 6 dB(A) by doubling the distance (H.Nyffenegger).

The noise level from construction activities is not expected to impact the nearest actual residential area which is Al-Jafer at a distance of 45 km from the proposed plant's site in Eshidiya. Also, it is not expected to impact the town site of JPMC (labor camp) site. At a distance of 3200 m (from the fence of the plant's site to the border of the town site of JPMC in Eshidiya, the free field noise level from the site (110 dB(A)) will be attenuated to a value of 39.9 dB(A). It is clear from Table (6.15) that the background noise at the measurement site which is the Workers Club (39.9 – 45.9 dB(A)) is equal to or higher than the expected source noise which may be generated by the different activities of the project. Therefore, the activities of the new project will not contribute in the existing noise level at the town site.

On the other hand, it is useful to note that the level of noise generated from the transportation machineries of raw materials and products (90 dB(A)) will reach the limit set in the regulations at a distance around 18 m (65 dB(A)), while the level of noise generated from the loading and unloading activities will reach the limit set in the regulations at a distance around 177 m (65 dB(A)). Thus, it is recommended to take this information in future planning of the area in coordination with the neighbors and the related authorities.

During the operation phase, the maximum expected outdoor sound level generated from the plant will not exceed 70 dB(A) at the border of the plant's site, which will be attenuated to 0 dB(A) at the border of the town site

at a distance of 3200 m. Also, the highest noise from heavy road vehicles associated with the plant and transportation will be 90 dB(A) which will be attenuated to 42 dB(A) at distance of 250 m from the road to the border of the town site of JPMC, which is within the permissible values of day and night times.

In the storage tanks area in Aqaba the source noise generated from the construction activities (110 dB(A)) at a distance of 110 m from the site boundary to the offices of the IJCC will be attenuated to a value of 69 dB(A), while the background noise is about 45 dB(A), so the construction activities of the project at the storage tank site in Aqaba will generate the noise level of 69 dB(A) which is below the permissible value for industrial area which is 70 dB(A) for day time but above the permissible value for industrial area which is 65 dB(A) for night time, but no construction activities shall be done during night time which is between 22:00 to 07:00.

Table (6.29) summarizes the evaluation of residual potential impacts of noise on public health.

Table (6.29): Evaluation of residual potential impacts of noise on public health

Impact	Geographical Extent	Level	Frequency	Duration	Direct (D) Indirect (ID)	Reversible (R) Irreversible (IR)	Likelihood	Significant	Positive/ Negative	Remarks
Noise generated from construction activities	L	L	M	M	D	R	L	No	Negative	Mitigation measures are not required
Noise generated from operation phase	L	L	M	H	D	R	L	No	Negative	Mitigation measures are not required

Significance criteria:

Geographical Extent	L: Limited to project area.	M: May reach outside project area.	H: Will reach outside project area.
Level	L: Will not change existing level	M: Will change existing level slightly	H: Will change existing level severely
Frequency	L: Occurs only once/rarely	M: Occurs during abnormal conditions	H: Occurs continuously.
Duration	L: During specific activity	M: During construction phase	H: During operational phase, continuously.
Likelihood	L: Impact is not likely to occur	M: May occur	H: Will occur.

6.4.3 Solid Waste

Existing knowledge

During the construction phase, domestic solid waste will be produced by the workers. The amount of waste produced by the workers per day is estimated to be 0.75 kg per worker. This number is according to the mean value of the domestic solid waste per person in Jordan. About 1000 worker will work in the construction phase of the project which will extend to three years, but not all of the 1000 workers will work simultaneously.

During operation phase about 600 workers will work in Eshidiya site. They will produce 450 kg domestic solid waste daily.

In addition to domestic solid waste there will be construction waste and debris. Also, during operation phase gypsum will be produced as waste with an amount of 2.8 million ton per year. The filter cake from the sulphur purification unit will be about 3 ton per day. Also, hazardous waste will be produced during operation phase which is the used catalyst (vanadium pent-oxide).

6.4.4 Wastewater

Existing knowledge

Domestic wastewater will be produced during construction phase from the workers. About 1000 person will work during this phase but they will not all work simultaneously. It is estimated that each worker will generate about 100 liter per day domestic wastewater.

During operation phase about 720 m^3 per day domestic wastewater will be produced from different utilities in the plant and from the labor camp.

There will be no industrial wastewater, where all generated industrial wastewater will be collected in sumps and reused in the process. About 744 ton per day of fluosilicic acid will be produced as a by-product and will be used by JPMC in Aqaba to produce aluminum fluoride.

6.5 Mitigation Measures

6.5.1 Air Quality

Construction Phase

- Dust resulting from the construction activities should be minimized as much as possible. Following are some examples that could be taken: water slightly all active construction areas to reduce dust generation, cover all trucks hauling soil, sand, and other loose materials, cover stockpiled soils, sand and cement, and try to remove them promptly and strictly limit truck speed on unpaved roads.

- In addition, it is recommended to apply some other measures such as turning off the vehicles and machinery when not used for extended periods, scheduling the deliveries of the construction materials during off-peak hours and using the minimum number of vehicles.

- To reduce vehicular emissions to limits within national and international standards, it is necessary to regularly monitor these emissions, test the opacity and conduct periodical maintenance of vehicles and machinery that will be used in ***all phases.***

Operation Phase

- The suitable type of de-dusting system that is reliable and of high efficiency shall be installed in all dust emission points such as the phosphate rock discharge point to the ball mill.

- It is important, not only to install de-dusting systems such as cyclones and bag filters i.e. at the stack of phosphate rock ball mill, but also apply regular maintenance and check of the performance of the installed dust protection equipments. In addition, this will ensure meeting the dust emission concentration to the Jordanian Standards limit of 50 mg/Nm^3. For example, the regular maintenance and performance check of the bag filters should be done at least once every six months and spare bag filters should always be available at the company.

- To reduce the dust emission from material storage areas, the phosphate rock and sulphur stockyards walls should be high enough and built against the prevailing wind direction. This means that the outdoor phase of the stockyards wall should be against the northern and western winds. Moreover, during material transportation, conveyor belts in enclosed

galleries (covered conveyor belts) are necessary to carry all materials that can cause pollution such as sulphur granules.

- Cover well all the trucks that will haul the sulphur granules from ***Aqaba*** to ***Eshidiya*** to prevent the sulphur spillage during transportation and the possibility of grinding it by the vehicles. The company shall import the granular sulphur not the fine one.

- The installation of on-line continuous SO_2 gas analyzer at the sulphuric acid final absorption stack will be so helpful to assist the plant control on air quality and the efficiency of the SO_2 to SO_3 converter. By this system, appropriate corrective action i.e. in case of vanadium oxide malfunction can be taken in earlier times.

- During the operation phase, on-line continuous monitoring of dust emissions from the ball mill stack is also recommended.

- The radioactivity of phosphoric acid and phospho-gypsurn should be measured from time to another in order to take the required actions in case of high level of radioactivity and to have baseline data for the existing situation.

- To reduce the possible dispersion of phosphate rock and sulphur dust by wind, good housekeeping measures such as frequently cleaning/sweeping the plant grounds could be applied.

- Build green belt around the area of the proposed project to provide a barrier between the project site and the surrounding area. The green belt helps to capture the fugitive emissions generated in the project activities.

- The unplanned stoppages should be prevented as possible, since they could generate more air pollution emissions than at the normal operation, such as the emissions of SO_2, CO and NO_x from the start-up boiler and more SO_2 emissions from the sulphuric acid plant.

- The loading of sulphur and phosphate rock from the trucks to the stores shall be managed well to avoid dust emissions, such as applying the most appropriate angle of loading.

- Apply water spray on the gypsum stacks during the southern windy days to reduce the generation of dust.

- The sulphuric acid absorption unit as well as the hydrogen fluoride scrubbing unit should have sufficient capacities to handle the sudden load increase of gaseous pollutants (SO_3 and HF).

6.5.2 Noise

- Equipment and vehicles shall be maintained in line with manufacturer's recommendations to meet relevant standards.

- Vehicles and machines shall be used responsibly, e.g. machines will not be left idling for long periods if they are not in use.

- During the operation phase, the heavy equipment shall be selected, properly operated for the right purpose, inspected and maintained regularly to keep them up to the established standard to reduce their potential generated noise.

- During the operation phase, strict speed limits and safety signs shall be posted along the roads. Drivers shall be trained on defensive driving to reduce potential increase in noise, accidents and dust emissions.

- During the operation phase, a periodical maintenance to all transportation and heavy vehicles shall be done. The vehicles shall be replaced after the mentioned operational life time.

- During operation phase regular checks on the effectiveness of operational systems and noise should be done.

6.5.3 Wastes

- All types of wastes (domestic and hazardous) resulting from construction, operation and decommissioning activities at both sites shall be managed in an environmentally safe manner and according to related regulations. All domestic solid wastes to be disposed of shall be collected in compatible closed containers and then transferred to the authorized waste disposal site with prior coordination with the relevant authorities or the company shall contract a private company to manage this issue. All hazardous waste (oils and others) shall be collected and managed according to the regulation of hazardous waste management and handling issued by the Ministry of Environment. Waste oils shall be collected and

sent to the Jordan Petroleum Refinery Company or sold to a licensed collector of the used oil. The management of used oils shall be according to the regulations of management and handling of used oil issued by the Ministry of Environment.

- The spent catalyst (vanadium pentoxide) shall be sent back to the supplier.

- Gypsum will be piled in a prepared adjacent area east of the plant area.

- Sulphur filter cake will be pilled in the gypsum disposal area.

- During the construction phase, toilettes shall be available to be used by the workers. The generated domestic wastewater shall be collected in a container or sealed pit and transported to the nearest wastewater treatment plant. Certain control system shall be in place to ensure collection and transportation of the wastewater in an environmental safe manner.

- Domestic wastewater generated by workers during operation phase will be treated in an activated sludge treatment plant which will be constructed in Eshidiya site. The treated wastewater will be used to irrigate the green belt which will be planted around the Eshidiya site. The excess sludge produced shall be disposed of according to the local standards.

- For Aqaba site, the company shall establish a treatment unit or a sealed pit to handle the domestic wastewater generated during construction and operation phase in order to ensure zero discharge. Approval from local authority (ASEZA) is necessary.

- The quantity of produced by-product (fluosilicic acid) shall be registed and the amount send to JPMC shall be also registed. If there is any surplus amount, the related authorities such as Ministry of Environment shall be informed.

6.5.4 Additional required mitigation measures for other issues

Safety measures are the most important factors that shall be implemented so as to reduce the probability of accidents impact on public and the surrounding environment. These measures include, but not limited to, the following:

- During all phases of the project, environmental, occupational health and safety, operation and monitoring plans shall be established according to the applicable standards and regulations to protect workers, public health and environment.

- An emergency response plan shall be prepared for all emergency cases, such as earthquakes, leak from phosphoric acid storage tanks in Aqaba or from the pipeline connecting the storage tanks with the jetty. The pipeline shall be protected against collisions.

- The storage tanks in Aqaba and Eshidiya shall be constructed according to the international codes and standards and in coordination with the civil defense to apply its regulations.

- The vehicles drivers shall have good skills in driving transport trucks and well trained to handle with any oil or chemical spillage. There shall be limits for trip duration to avoid drivers' overtiredness. Also, the vehicles shall be frequently maintained to avoid any spillage of such materials. The transport vehicles shall be placarded.

- Wind breakers shall be constructed around the site to reduce dust dispersion especially from the storage areas of sulphur and phosphate.

- The potential of reuse of gypsum (e.g. in cement industry, leveling the roads) and the rehabilitation of the mining sites in Eshidiya shall be explored by the company during the operation phase and revised frequently with the related institutions.

- Before and during decommissioning phase of any site, prior coordination with relevant authorities shall be established to define site rehabilitation requirements according to the applicable established codes, standards, and regulations at the time.

- During the decommissioning phase, strict decommissioning operation plan shall be established to include environmental and occupational health and safety procedures according to established codes, standards, and regulations that are applicable at the time of decommissioning to protect health and environment.

6.6 Risk Assessment

Each industry activity that is dealing with hazardous chemicals is exposed to the probability of accident occurrence. Therefore, this section discusses the most probable accidents that could happen in JIFCO project, H_2SO_4 and H_3PO_4 storage tanks, and during the transportation, the consequences of these accidents as well as the required mitigation measures to reduce the probability and severity of the most harmful accidents.

It is worth to mention that the company will prepare hazard and operability (HAZOP) study that concerns all the possible process, materials handling and storage risk inside the borders of the JIFCO project in Eshidiya and Aqaba.

Followings are some major hazardous chemicals that are used, manufactured, stored and transported in JIFCO project in addition to the main required first aid measures in case of specific accidents:

6.6.1 Phosphoric acid

Phosphoric acid, also known as orthophosphoric acid, is a mineral (inorganic) acid having the chemical formula H_3PO_4. Pure anhydrous phosphoric acid is a white solid that melts at 42.35 °C to form a colorless, viscous liquid.

Phosphoric acid is a non-toxic, inorganic, which when pure, is a solid at room temperature and pressure. It is also very polar molecule; therefore it is highly soluble in water.

H_3PO_4 reacts with metals in the presence of heat or humidity and it may form a flammable hydrogen gas. The liquid can solidify at temperatures below 21°C. It is corrosive to ferrous metals and alloys. It is soluble in alcohol and hot water.

<u>Risks on human health</u>

H_3PO_4 is not considered explosive or flammable but it is a corrosive liquid that may cause burns on skin and eye. The inhalation of H_3PO_4 mist can severely irritate the upper respiratory tract and may cause coughing, choking and burns of the mucous membranes. Other initial symptoms for H_3PO_4 exposure are dizziness, headache, nausea and weakness. Physical findings may include hypotension, rapid pulse and moist rales.

In severe exposures, death due to anoxia may occur within a few hours after onset of pulmonary edema symptoms. Circulatory collapse may develop and if uncorrected it may lead to renal failure. Death may result within a short time from asphyxia, circulatory collapse or aspiration of even minute amounts. All these effects depend on the concentration and duration of exposure.

Accidental release measures

- If H_3PO_4 vapors are released accidentally they should be reduced with water spray.
- Do not touch spilled material. If spills were small, absorb with sand or other non-combustible material, collect spilled material in appropriate container for disposal, keep unnecessary people away, isolate hazard area and deny entry.

Recommended measures to follow during the transportation, storage and handling of phosphoric acid

When unloading of bulk vehicles at storage yard, personnel shall wear chemical goggles and rubber or neoprene gloves. All fittings shall be properly secured prior to energizing unloading system. Care should be taken to avoid acid contact when disconnecting lines/hoses after unloading.

Dike area shall be available around storage tanks and the tanks shall be electrically grounded. The chance of an acid spill from storage tanks is very small; with the highest risk being a leak from the tank because of corrosion, but corrosion with phosphoric acid is a relatively slow process and starts with a small hole in the tank. Normally, the leak will be seen and the tank emptied before a significant spillage can take place. The risk is minimized if the tank is adequately bounded.

During the handling of phosphoric acid the following safety measures should be considered:

- Do not get in eyes, on skin, or on clothing.
- Avoid breathing mist or vapor.
- Wash thoroughly after handling.

Safety showers and eye washing facility shall be provided at any location where skin or eye contact can occur. Contaminated protective clothing and breathing apparatus should be washed with water before removing the face mask and protective suit and place them in containers provided for this purpose.

First aid measures

In case of inhalation: Move the exposed worker to uncontaminated area, and give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.

In case of eye contact: Immediately flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

In case of skin contact: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get immediate medical attention.

In case of ingestion: If swallowed drink plenty of water, do not induce vomiting. Get immediate medical attention.

6.6.2 Fluosilicic acid

Fluosilicic acid (H_2SiF_6) is a by-product from the reaction of phosphate rock with sulfuric acid. The quantity of fluosilicic acid produced depends on the composition of the phosphate rock used but is normally in the range 20-30 kg/t P_2O_5.

Fluosilicic acid is fuming colorless liquid with pungent odor. The substance decomposes by heat producing toxic fumes including hydrogen fluoride. The solution in water is a strong acid. It reacts violently with bases. It reacts with water or steam to produce toxic and corrosive fumes. It attacks glass, stoneware and many metals forming flammable gases.

Risks on human health

The substance is corrosive to the eyes, the skin, and the respiratory tract and on ingestion. Inhalation of the vapor of this substance may cause lung oedema, cough and shortness of breath. The symptoms of lung oedema often do manifest until few hours then aggravated by physical effort. It also may cause burns, pain and redness to the skin and eyes. Abdominal cramps, vomiting and shock are also symptoms that may result due to exposure. Rest and medical observation are therefore essential. The substance may have effects on the bones and teeth resulting in fluorosis on long run.

Recommended measures to follow during the transportation, storage and handling of fluosilicic Acid

Road transport

Management of fluosilicic acid emergencies shall consider the following:

- Tankers shall have bottom discharge nozzles with no provision of compressed air on the tanks utilized for unloading purposes.
- Clean up personnel will need personal protection equipment and respiratory protection.
- Source of water supply and eyewash facilities may also be needed for clean up personnel.
- Bags of neutralizing agent or chemical absorbent will be required for spill.
- A manual tool such as shovel may be required to scoop up neutralized acid/lime/soda ash residue.

Handling of fluosilicic acid

The following measures shall be considered during handling:

- Proper protective clothing to be worn includes: PVC jacket and pants, PVC gauntlet gloves, goggles and face shield, chemical resistant safety boots.
- A safety shower and eyewash shall be available.
- Do not breathe vapor or mist.
- Avoid contact with skin, eyes and clothing.
- Do not touch damaged containers or spilled material unless wearing appropriate personal protective equipment.
- Change and wash clothing, and personal protective equipment if contaminated, or before storing and/or re-using.
- The floor of the work area shall be adapted to enable recuperation or neutralization of all the product spilt if leakage occurs.

Storage of fluosilicic acid

The storage place must be well ventilated and away from heat as well as strong bases. The acid should be kept in a tightly closed container.

First aid measures

Fluosilicic acid is corrosive and cause burns. Decompose when heated with possible emanation of toxic hydrofluoric acid vapors. It emits also toxic fumes under fire conditions.

In case of skin contact

- Remove all contaminated clothing and shoes.
- Wash skin with soap and large amounts of water for at least 20 minutes. Then rub with calcium gluconate gel.
- Remove to fresh air and rest in half upright position. If not breathing give artificial respiration. If breathing is difficult, give oxygen.
- Flush with copious amounts of water or saline for at least 20 minutes. Assure adequate flushing by separating the eyelids with fingers. A

shower and eye bath shall be installed near the work stations. After first aid seek medical attention.

In case of inhalation

- Remove casualty to fresh air and keep at rest.
- Oxygen or cardiopulmonary resuscitation if necessary.
- Victim to lie down in the recovery position, cover and keep him warm.
- Consult a physician.
- Take victim immediately to hospital.

In case of eye contact

- Immediate attention is required.
- Take victim immediately to hospital.
- Rinse immediately with plenty of water, also under the eyelids for at least 15 minutes.
- In the case of difficulty of opening the lids administer an analgesic eye wash.

In case of ingestion

- Call a physician immediately
- Take victim immediately to hospital
- If victim is conscious:
  If swallowed rinse mouth with water
  Do not give anything to drink
  Do not induce vomiting
- If the subject presents nervous, respiratory or cardiovascular disorders: administer oxygen
- If victim is unconscious but breathing:
  Artificial respiration and/or oxygen may be necessary

6.6.3 Sulphur

Sulphur, in its native form, is a yellow crystalline solid. In nature, it can be found as the pure element and as sulfide and sulfate minerals. It is an essential element for life and is found in two amino acids, cysteine and methionine. Its commercial uses are primarily in fertilizers, but it is also widely used in gunpowder, matches, insecticides and fungicides. Sulphur is odorless when pure but dust may generate slightly acidic odor/taste sensation.

Sulphur may combust slowly in air with pale flame which may be hard to see, especially in low humidity atmospheres. Solids are difficult to ignite and requires relatively intense heat source.

Risks on Human Health

Special dangers of sulphur is hydrogen sulphide which may be emitted by the decomposition of sulphur, this may cause depression in the nervous system and thus result in headaches, nausea, vertigo, salivation, unconsciousness and death.

Sulphur is generally recognized as safe, but studies show that people exposed to sulphur dioxide frequently present respiratory and ophthalmological problems, as well as bronchitis and sinusitis. Sulphur dust may cause eye and airway irritation. It has possibly acidic taste and effect on mucous fluid, tearing, saliva, etc.

Recommended measures to follow during the transportation, storage and handling of sulphur

Road transport

Mitigation measures that will be implemented during transportation from Aqaba:

- Dust emissions control by the use of water sprays in the event of a dry spell during uploading and downloading of trucks.
- Prevent wind blown sulphur from entering the environment by the use of proper sheltering of material during road transport.

Accidental release

Mitigation measures that will be implemented during accidental release:

- Remove all sources of ignition.
- Evacuate and ventilate the area of spills.
- Wear self-contained breathing apparatus, rubber boots and heavy rubber gloves.
- Wear disposable coveralls and discard them after use.
- Clean up spills in a manner that does not disperse dust into the air and place in closed containers.
- Use non-sparking tools and equipments.
- Reduce dust and prevent scattering by moistening with water.

Storage and handling of sulphur

- Always store in a safe and dry place.
- Delivery to and recovery from storage should incorporate requirements for minimizing abrasion etc.
- Flames, smoking, and matches shall be prohibited in such areas. Cutting and welding operations shall be permitted for repair work, provided due precautions are taken against ignition of dust.

- Conveying machinery shall be bonded and grounded to prevent the accumulation of static electricity.
- It is recommended to increase wall heights around the stockpile.
- Wind breaks or fences might be installed, if necessary.
- Sulphur possesses corrosive properties and therefore shall be protected from electronic equipment.
- Do not expose the sulphur to high temperatures and humidity
- It is important to avoid the accumulation of powder in the air since it could cause an explosion. Sensitive to the impact of a moderate mechanical explosion while the likelihood of explosion grows when there are small particles in the air exposed to static charge.
- A well prepared fire extinguishing system shall installed nearby the storage (NFPA approved) where the involved employees should have the required awareness and training of how dealing in this case.

First aid measures

In case of inhalation

Remove victim from further exposure and restore breathing, if required. If a person is affected by decomposition products, remove immediately to fresh air and obtain medical attention. Administer artificial respiration if breathing is irregular or has stopped.

In case of eye contact:

Thoroughly wash eyes in water for at least 15 minutes.

In case of skin contact

Wash contaminated skin with soap and water. If irritation persists seek medical assistance.

In case of ingestion

First aid not normally required; obtain medical attention if large amounts have been ingested.

6.6.4 Sulphuric acid

Sulfuric acid (H_2SO_4) is a strong mineral acid. It is soluble in water at all concentrations. One of its principal uses include ore processing, fertilizer manufacturing, oil refining, wastewater processing, and chemical synthesis. Sulphuric acid is produced from sulphur, oxygen and water via the contact process.

The corrosive properties of sulphuric acid are accentuated by its highly exothermic reaction with water. If water is added to the concentrated sulphuric acid, it can react, boil and spit dangerously. One should always add the acid to the water rather than the water to the acid. Usually burns from sulphuric acid are potentially more serious than those of comparable strong acids.

Risks on human health

Sulphuric acid is not considered toxic besides its obvious corrosive hazard, and the main occupational risks are skin contact leading to burns and it could be fatal if inhaled causing respiratory tract burns and mucous membrane burns.

Exposure to the vapors may cause a burning or stinging sensation in the eyes with lacrimation, blurred vision and conjunctival congestion. Splashes of acid in the eyes may produce deep corneal ulceration, kerato-conjunctivitis and palpebral lesions with severe sequelae. Irreparable corneal damage and blindness as well as scarring of the eyelids may occur. Severe sulphuric acid eye burns have included glaucoma and cataract as complications in the most severe cases. Contact with diluted acid may produce more transient effects from which recovery may be complete.

Recommended measures to follow during storage and handling of sulphuric acid

In general it is recommended to avoid contact with combustible materials. Do not touch spilled material. Do not get water inside container. Stop leak if possible without personal risk. Reduce vapors with water spray. Do not get water directly on material. Only personnel trained for the hazards of this material should perform clean up and disposal.

Storage

- Store in dry area at ambient temperature.
- Keep container tightly closed, avoid contact with light.
- Keep away from: heat sources, combustible materials, reducing agents, bases, metals, organic materials, oxidizing agents.

Handling

- Use recommended safety clothing/equipment by handling with sulphuric acid
- Reduce/avoid exposure and/or contact
- Observe strict hygiene
- Keep container tightly closed
- Do not discharge the residue/waste into drain systems

- Avoid contact of the substance with water
- Remove contaminated clothing immediately

First aid measures

In case of inhalation: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.

In case of eye contact: Immediately flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

In case of skin contact: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get immediate medical attention. Thoroughly clean and dry contaminated clothing before reuse.

In case of ingestion: If swallowed, drink plenty of water, do noy induce vomiting. Get immediate medical attention.

6.6.5 Project risk

Different accidents could occur such as the fire hazard from sulphur dust, the toxic effect from the leakage of sulphur dioxide gas, corrosive effect from the leakage of sulphuric acid transporting pipes as well as the sulphuric acid and phosphoric acid storage tanks in addition to the spillage of sulphur granules, phosphoric acid and flousilicic acid during transportation.

There are some international guidelines of volatile chemicals (that could spread on or off site the JIFCO plant during the accident occurrence) such as the dispersion of sulphur dioxide during pipe rupture. The following paragraphs describe these parameters in detail.

The Emergency Response Planning Guidelines (ERPGs) were developed by the ERPG committee of the American Industrial Hygiene Association as planning guidelines, to anticipate human adverse health effects caused by exposure to toxic chemicals. The ERPGs are three-tiered guidelines with one common denominator of 1-hour contact duration as follow:

ERPG 1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without

experiencing other than mild transient adverse health effects or perceiving a clearly defined and objectionable odor.

ERPG 2: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

ERPG 3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

The Immediately Dangerous to Life or Health (IDLH) level is a limit originally established for selecting respirators for use in workplaces by the National Institute for Occupational Safety and Health (NIOSH). A chemical's IDLH is an estimate of the maximum concentration in the air to which a healthy worker could be exposed without suffering permanent or escape-impairing health effects. All of these figures for SO_2 and SO_3 are shown in Table (6.30).

Table (6.30): Some international guidelines of SO_2 and SO_3 that are produced at JIFCO

Type	ERPG 1	ERPG 2	ERPG 3	IDLH
SO_2	0.3 ppm	3 ppm	15 ppm	100 ppm
SO_3	2 mg/m^3	10 mg/m^3	30 mg/m^3	

The lower explosive limit (LEL) and the upper explosive limit (UEL) for sulphur dust are 35 mg/m^3 and 1400 mg/m^3 respectively. LEL is the minimum concentration of flammable material in the air needed for a fire or an explosion to occur if an ignition source is present. While UEL is the maximum concentration of flammable material in the air that can sustain a fire or an explosion if an ignition source is present.

The associated risk of the waste heat boiler that works at high pressure of 40 barg and produces steam at 400 ºC, should be covered by the HAZOP study that will be prepared by the company. In addition, the failure rate (critical event frequency) according to database (Rijmond) of the pressure vessel, atmospheric storage tank and piping rupture and leakage are shown in Table

(6.31) below. Tanks of the fuel oil and all chemicals shall have secondary containment using impermeable liners and surrounded by dikes.

Table (6.31): Rijmond database failure rates

Mode of failure	Failure rate
Piping (≤ 50 mm dia.) rupture	$1 * 10^{-10}$ /m per hour
Piping (≥ 50 and ≤ 150 mm dia.) rupture	$3 * 10^{-11}$ /m per hour
Piping (≥ 150 mm dia.) rupture	$1 * 10^{-11}$ /m per hour
Piping (≤ 50 mm dia.) significant leakage	$1 * 10^{-9}$ /m per hour
Piping (≥ 50 and ≤ 150 mm dia.) significant leakage	$6 * 10^{-10}$ /m per hour
Piping (≥ 150 mm dia.) significant leakage	$3 * 10^{-10}$ /m per hour
Pressure vessel catastrophic rupture	$1 * 10^{-6}$ per year
Pressure vessel serious leakage	$1 * 10^{-5}$ per year
Atmospheric storage tank catastrophic rupture	$6 * 10^{-6}$ per year
Atmospheric storage tank serious leakage	$1 * 10^{-4}$ per year

It is clear that the most possible risk on the public health (off site the company) could happen during the transportation, therefore the most appropriate safety measures should be taken at this stage and well drivers should be chosen who should have regular safety training.

The main source of phosphoric and flousilicic acid risk is the possibility of acid spillage mainly in case of collision. A regular check of the tankers should be done before filling them with the acid to ensure the prevention of leakage during transportation in which some mitigation measures should be installed to reduce the impact such as the existence of collection tray.

7. CULTURAL HERITAGE AND ARCHEOLOGY

7.1 Introduction

Cultural heritage and archeology study was carried as part of the environmental and social impact assessment of the project taking into consideration that it was identified as a valued environmental component during the scoping session. The archaeological heritage constitutes the basic record of past human activities. Therefore, its protection and proper management is essential to enable archaeologists and other scholars to study and interpret it for the benefit of present and future generation.

This chapter presents the cultural heritage and archeology study conducted by a team of archeologists in the two sites of the proposed project (plant and storage sites). The impacts that may result from establishing the project on archeology are assessed and suitable mitigation measures are given in this chapter. It is important to note that the protection of archaeological heritage must be based upon effective collaboration between professionals from many disciplines as well as it also requires the cooperation between the government and the public.

7.2 Issues and Concerns

The major issues of concerns raised during the scoping session regarding cultural heritage and archeology were as follows:

- Potential damage to archaeological or heritage sites while landscaping and sites preparation activities.
- The discovery of any archaeological remains while excavation in the project sites

7.3 Existing Conditions

In order to establish the archeological baseline data for the study, archeological survey was carried out by a team of specialists. The methodology adopted for this study is based on literature review, field investigation and documentation including the photographic techniques, and data analysis in order to set the necessary mitigation measures and recommendations.

Literature survey

Most of the available references, database and information related to the study were reviewed such as Jordan Antiquities Database and Information System (JADIS), Department of Antiquities, and the libraries of American Center of Oriental Research (ACOR) and British Council for Research in Levant (BCRL).

Field work survey

The study team investigated the plant site in Ma'an and the storage site in Aqaba in addition to the surrounding area for both sites. The survey was conducted on foot, hence survey members walked at a distance of 20-30 m from each other.

The field survey and investigations revealed that there are no obvious archeological features or any other archeological remains in both sites.

7.4 Impact Evaluation

As a result of the archeological survey, the existing information proved that no surface antiquities exist at the project sites. Therefore, there is no potential impact with regard to surface antiquities destruction. Still, precaution and management measures should be taken into consideration regarding the need to conserve any chance find sites during construction activities.

CHANCE FIND PROCEDURES

Mitigation plan

This mitigation plan has the following two main components, where each is related to a project phase:

- Tendering
- Construction monitoring program

Tendering

Pre- tender meeting

All pre-qualified contractors will be called to a pre-tender meeting where issues of special interest or concern will be outlined. With regard to cultural resources the contractors will be briefed on:

- Chance find procedures
- Their coordination responsibilities with and to the cultural resources management (CRM) monitoring groups

Bid Documents

To support the stipulations of the tender meeting, contract bid documents should include a set of final engineering plans, the contractor should be informed about the process of chance find procedures, and how to coordinate with related parties if any site revealed during construction.

It shall be the responsibility of the contractor to obtain all information available from the supervisor of the Cultural Resources Management Office of the Department of Antiquities regarding the location of any known archaeological site near the construction area, and he shall make this information available to the Engineer's representative as soon as he obtains it. It shall also be the contractor's responsibility to notify the supervisor of the Cultural Resources Management Office of the Department of Antiquities of any antiquities is encountered far away from the surrounding zone of the project. If any remains found by chance during construction, the Department of Antiquities in coordination with the contractor will assess the discovered remains and may carry out an emergency salvage excavation. Salvage excavation means archaeological excavation conducted during construction phase. It should be conducted only when an archaeological site / remains is found by accident (chance find) during construction. The available short time for salvage excavations cannot be considered an authorization to destroy the discovered remains or site.

In addition to that, the contractor must take into consideration the following issues:

- Borrow areas: The location of borrow and dumping areas selected by the contractor should be inspected (if not included in the final engineering plans), to prevent antiquities being damaged by quarrying or borrow excavation.

- Excavation and observation of construction: In areas where the Department of Antiquities suspects the existence of remains, a representative from the department should be present during the opening of any excavation or borrow pit to identify and record any archaeological remains found.

Construction monitoring program

Site access

Regular and frequent site inspections will be required to ensure effective monitoring of the performance of the contractor with regard to compliance with applicable guidelines, regulations and statutes, and contract specifications. For the proposed program monitoring and during the construction phase, it will be necessary for authorized agents from the Department of Antiquities to have guaranteed access to all sites related to any project component.

Monitoring program

Two forms of inspection will be required:

- Event specific: These will be pre-programmed events such as the opening and demarcation of a borrow area.
- Random inspections: Additional site inspections should be carried out on a regular basis but not necessarily to a structured pattern.

7.5 Mitigation Measures

Following the instructions given above, during the construction phase, it is essential to provide strict instructions to the contractor to pause construction work and excavations in case of discovering any antiquities or archeological items. Such discoveries should be reported to the Director of Department of Antiquities or to the nearest Public Security Center. The Department of Antiquities may in such cases recommend certain measures to protect the found items.

8. SOCIO-ECONOMIC CONDITIONS

8.1 Introduction

The establishment of the phosphoric acid plant and its storage tanks in Ma'an and Aqaba governorate can enhance the socio-economic development of the southern part of Jordan. This chapter provides the existing socio-economic conditions in the study area, the potential impacts of the project on socio-economic conditions and the assessment of the project effects in that regard. The main objective of the socio-economic study is to evaluate the long term effects that are expected from the project activities and investigate how the proposed project would change the quality of life of current and future residents of communities in the project area. Other objectives of this study are to establish baseline data with regard to socio-economic conditions and recommend proper mitigation measures to reduce the negative impacts and enhance the positive ones.

8.2 Social and Demographic Characteristics of the Project Areas

The phosphoric and sulphuric acids plants site will be located in Ma'an governorate specifically at Al-Jafer sub-district. The nearest two areas to the plants site are: Al-Jafer area (45 km from the plants site) and Ma'an sub-district (75 km from the plants site). The storage tanks for the phosphoric acid will be located in Aqaba governorate.

Both Aqaba and Ma'an governorate are located in the south of the Kingdom. Ma'an governorate is the largest governorate. It covers 33,163 square kilometers representing 37% of the Kingdom’s area. Ma’an is very important to Jordan due to the huge phosphate reserves in Eshidiya, the water reserves in the Disi aquifer, and the magnificent tourist sites in Petra and Wadi Rum.

While Aqaba governorate is strategically important to Jordan as it is the country's only seaport, which plays an important role in the economic life of Jordan and has many attractions to offer the vacationer. Aqaba city is the main city in the governorate. It is best known today as a diving and beach resort. However, industrial activity remains important to the area, and the city is an exporter of phosphate and other minerals. The city is also an important administrative center within the far south of Jordan.

8.2.1 Population

The population of Jordan was estimated at 5,473,000 in the year 2005 with a population growth rate of 2.6% and a population density of 61.6 people per square kilometer. The population of Ma'an and Aqaba were estimated at 104,100 and 115,100 respectively. The population density of Ma'an is 3.2 people per square kilometer which is the lowest in the kingdom, while the population density of Aqaba is 16.7 people per square kilometer.

Ma'an governorate is divided into four districts as shown in Table (8.1). It is clear that the population is most concentrated in Ma’an district (53%) which is divided into 5 sub-districts. The population of Al-Jafer sub-district (the district where the company will establish) is 6,740 (6.5% of the population of Ma’an governorate). Al-Jafer sub-district is divided into 4 areas (Al-Jafer, Eshidiya, Al-Modawarah and Btn Alghol area).

Aqaba governorate is divided into two districts; the concentration of the population in Aqaba district (83%) is higher than in Quaira district (17%).

Table (8.1): Estimated population of Ma’an and Aqaba governorate, 2005

Administrative Division	Population
Ma'an Governorate	104,100
1. Ma’an district	55,690
Ma’an sub-district	29,570
Lel sub-district	8,250
Jafr sub-district	6,740
▪ Al-Jafer	5,235
▪ Eshidiya	201
▪ Al-Modawarah	1,339
▪ Btn Alghol	2
Athroh sub-district	4,010
Mraighah sub-district	7,120
2. Petra district	26,860
3. Shobak Qasabah district	12,180
4. Huseiniya district	9,370
Aqaba Governorates	115,100
1. Aqaba district	95,760
Aqaba sub-district	91,070
Wadi Araba sub-district	4,690
2. Quaira district	19,340

The town of Ma'an consists of a group of large and small social units. A unit is defined as a group that has its own diwan. If a large social unit consists of several smaller sub-units, which are recognized socially, then each of these smaller sub-units would have their own diwan while the large unit would not have a diwan. On the other hand, if the large unit does not acknowledge the existence of smaller sub-units, then it would have its own diwan. For example, the Al Kreishans is a large social unit consisting of three smaller sub-units: Al Mar'ee, Al Hwarain and Al Halalat. Al Kreishans, therefore, have three recognized diwans none of which are in the name of the Al Kreishans due to the belief that the sub-units are not the same. The opposite also exists whereby the Al Mahameed is a large social unit with a diwan in its name. There are no diwans for the smaller sub-units, which form the Al Mahameeds. The sub-units of the Al Mahameeds are: Al Bahry (or Al Ibrahim), Aal Abu Karaki and Al Abboud. This means that the internal structure of the Al Mahameeds does not acknowledge sub-units within the unit in the belief that all the units have joint origins.

The signs on which the name of the diwans are written do not mention the word asheera (tribe) as happens in other parts of the kingdom. However, the people when referring to the names of the diwans, use the word asheera. Thus, the name of the social unit is written on the diwan's sign (e.g. the diwan of Al Mar'ee and the diwan of Al Halalat and so on). Diwans are very important in the life of the individual and the group in the town of Ma'an. There are at least 40 diwans in the town of Ma'an.

8.2.2 Age distribution

The Jordanian society is characterized by the domination of the youth. More than 37% of the population is under the age of 15 years. This is also true for Ma'an and Aqaba, where the percentages of population under the age of 15 are 43.4% and 40.9% respectively, see Table (8.2). This impacts the needs of the local community and its aspirations, and the private and government development efforts. In addition, this structure could affect how events develop in the town especially if it is connected with a lack of job opportunities as many sociologists believe.

Table (8.2): Age distribution, 2005

Age group	Age distribution (%)				
	Jordan	Aqaba Governorate	Ma'an Governorate	Al-Jafer Area	Al-Eshidiyah Area
Less than 15	37.6	43.4	40.9	46	0
15 – 24	22.4	20.2	23.6	22	15
25– 35	14.5	14	13.6	14	46
35-64	21.7	20.6	19.3	16	39
More than 65	3.8	1.9	2.8	2	0

8.2.3 Gender distribution

Gender distribution of population of Jordan, Ma'an and Aqaba governorate is shown in Table (8.3).

Table (8.3): Gender distribution, 2005

Sex	Gender distribution (%)			
	Jordan	Aqaba Governorate	Ma'an Governorate	Al-Jafer District
Male	51.5	51.2	52	54.2
Female	48.5	48.8	48	45.8

8.2.4 Education

Jordanians are relatively well educated, illiteracy rate is 10.3% for those above 15 years old (5.6 % for males, and 5.1% for females). In Jordan, there are 5,497 secondary schools, 50 colleges, 8 public (including Al Hussein University in Ma'an) and 13 private universities and 49 vocational training centers.

Table (8.4): Educational levels, 2006

Educational level	Aqaba Governorate	Ma'an Governorate	Al-Jafer Area	Eshidiya Area
Illiterate	7,766	10,055	1,265	34
Less than secondary	28,108	28,741	1,082	34
Secondary	12,873	9,728	346	19
Intermediate Diploma	5,378	3,789	54	23
Bachelor and above	4,464	3,891	93	91

8.2.5 Economic characteristics For Ma’an and Aqaba

The following section highlights the economic characteristics for both Aqaba and Ma'an governorate.

Household income and expenditure

Most of Ma'an and Aqaba governorate is desert with a desert climate. The scarcity of the rainfall makes it impossible for the people of Ma’an to depend on rain-fed agriculture. People usually depend on commerce and government jobs (especially in the army or in the port of Aqaba). Nowadays the number of people working in large industries in Ma’an and Aqaba is increasing. The industries include phosphate mining, fertilizers factories, and power generation.

The average family size in Aqaba and Ma'an is 6.2 and 6.8 respectively, with an average annual income of 5,615.5 JD in Aqaba and 6,419.4 JD in Ma'an. The average family size in Al-Jafer district is 8 persons, and the average annual income is 1200 JD, which is very low compared to the whole kingdom. Table (8.5) shows the relative distribution of household income in Ma’an and Aqaba in comparison with the income distribution for the whole country.

Table (8.5): Relative distribution of household by average monthly income (%), 2006

Average Monthly Income (JD)	Kingdom	Ma’an	Aqaba
Less than 100	7.5	2.8	3.8
100-199	44	52.3	41.1
200-299	30.4	36.4	32.4
More than 300	18.1	8.5	22.7

Labor force

The unemployment rate in Ma'an governorate is around 19.1% compared to 14.3% nationally. In Aqaba, the unemployment rate is 8.9% which is relatively low compared to the whole kingdom.

Table (8.6) shows the percentages of the economically and not economically active persons in both Aqaba and Ma'an governorate.

Table (8.6): Economically and not economically active persons (%), 2007

Activity status	Jordan	Ma'an	Aqaba
Not economically active	60.4	63.5	58.1
Economically active	39.6	36.5	41.9
Employed	34	29.5	38.1
Unemployed	5.7	7	3.7

Table (8.7): Number of employed and unemployed people in Al-Jafer district

Administrative division	Employed	Unemployed
Al-Jafer area	950	438
Eshidiyah area	201	0

Fig (8.1) shows the residential distribution in Al-Jafer sub-district according to their economic activities, where more than 50% of residents are working in agricultural and hunting while 25% of residents are working in government jobs and 5% are working in teaching.

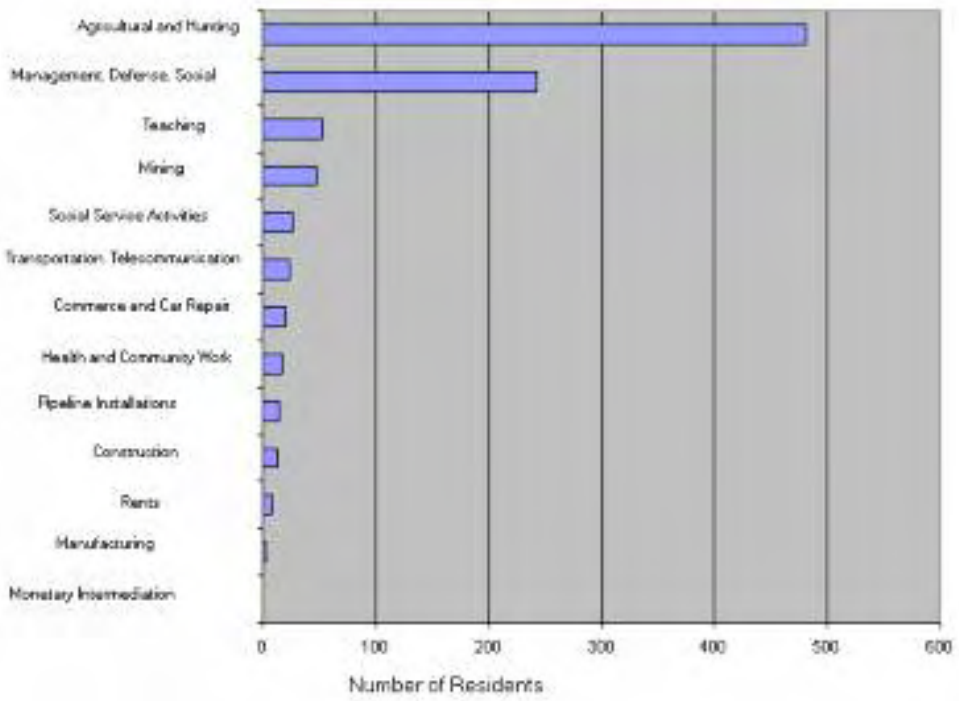


Fig. (8.1): Residential distribution according to the economic activities in Al-Jafer sub-district

8.2.6 Infrastructure and basic services in Ma'an and Aqaba governorates

Roads and transportation

The road network in Ma'an governorate has a total length of 919 km. These roads connect the cities and villages in the governorate and connect the governorate with the rest of the kingdom. The total length of the highway roads in Ma'an governorate is 561 km that used for transportation between south and north areas in the kingdom. Travelers to Saudi Arabia and Egypt and tourists to Aqaba and Petra also use Ma'an highways. Other types of roads like secondary and village roads exist in the governorate connecting the cities and villages. The length of the secondary roads is 246 km and the length of the village roads is 112 km.

The city of Aqaba is an important economic place. It has the only seaport for the kingdom; most of the import and export operations are done through Aqaba port. It is also used by travelers to Saudi Arabia and Egypt. Aqaba is linked with the rest of the kingdom by two highways. The first highway (called Ghur Al Safi) links Aqaba with the north where it goes from Ghur Al Safi through Wadi Araba and Tafila governorate to the rest of the kingdom. The main use of this highway is to transport Potassium to be exported from the port of Aqaba. The second highway (called the Desert Highway) links Aqaba with the north through Ma'an governorate. It also links Aqaba with Iraq. The total length of the highway roads in Aqaba governorate is 342 km.

There are also other types of roads in the governorate such as secondary and village roads. The length of the secondary roads is 92 km and the length of the village roads is 89 km.

Health care

Ma'an governorate has a good level of health services, which is provided mainly by the Ministry of Health. There are 194 hospital beds in the governorate i.e. 10.4 beds for every 10,000 citizens. There are two hospitals in the governorate. The first is the Ma'an Hospital in the town of Ma'an and the second is the Queen Rania Al Abdullah Hospital in Wadi Musa. Ma'an governorate also has the following Ministry of Health facilities and centers: 38 health centers, 21 village clinics, 18 maternity and child health centers, 13 dental clinics and 12 pharmacies. In Al-Jafer area there is one primary health center and there is no maternity or child health center.

Health care in Aqaba governorate is provided by the Ministry of Health, the Armed Forces and the private sector. There are 199 hospital beds in the governorate i.e. 11.5 beds for every 10,000 citizens. There are three hospitals in the governorate (2 private and one government hospital).

Aqaba governorate also has the following Ministry of Health facilities and centers: 10 health centers, 9 village clinics, 8 maternity and child health centers, 10 dental clinics and 22 pharmacies.

The Health Directorate in the both governorate monitors and tests the drinking and purified water. It also monitors food and medicine sold in the governorate and provides school health care services.

Tourism services

The only tourist attraction site in Ma'an governorate is the ancient city of Petra, which became one of the new seven wonders. Petra was built on a terrace around the Wadi Musa or Valley of Moses. It was the capital of the Arab Kingdom of the Nabateans. It also flourished under Roman rule after the Nabateans were defeated in A. D. 106. Tourism service in Ma'an in general and particularly in Petra consists of 26 hotels (13% of the total number of hotels in the kingdom). The hotels include 1,752 rooms and 3,287 beds.

Aqaba is one of the important tourist sites in the kingdom due to its location on the Red Sea and its relatively warm climate in winter. The tourism services in Aqaba consist of 27 hotels (13.6% of the total number of hotels in the kingdom). The hotels include 2,188 rooms and 4,198 beds.

Communication

Communication service in Aqaba and Ma'an governorate includes telecommunication system and mail services which is provided by private and public sectors.

Jordan Telecom is the only operator of fixed lines. Out of a population of 5.5 million, there are about 613,089 fixed line subscribers. Jordan Telecom also provides mobile service, and Internet service. There are currently three mobile phone operators in Jordan. The number of telephone subscribers in Ma'an and Aqaba governorate is 6,756 and 3,459 respectively.

Educational services

- Schools

Education in Ma’an and Aqaba governorate is administered by three educational directorates which are:

A) The Ministry of Education.

B) Armed Forces.

C) Private sector.

Table (8.8) shows the number of schools and class units in Ma'an , Aqaba governorate and in Al-Jafer area

Table (8.8): Number of school and class units in Ma'an and Aqaba governorate, 2005

Administrative division `	Schools			
	Male	Female	Mixed	Total
Ma’an governorate	58	23	139	220
Aqaba governorate	27	20	61	108
Al-Jafer area	2	2	---	4

- Universities and community colleges

In the governorate of Ma’an there is one university (Al Hussein University), while there are no universities in Aqaba governorate. There is one community college available in Ma’an governorate. It offers a diploma degree (two years). The college is under the umbrella of Al-Balqa University in Balqa governorate, which administers the community colleges in Jordan. Also, there is one community college in Aqaba governorate.

- Vocational training

The vocational training in the kingdom is under the administration of the Ministry of Education. There is a branch for vocational training corporation (VTC) in both Ma’an and Aqaba that is responsible for the preparation of skilled workers through long-term, mid-term, and short-term programs. There are also programs for skills upgrading, instructor and supervisory training, and industrial extension training. The programs combine institutional and non-institutional types of education and training. There is one vocational training center being established in Al-Jafer area.

8.3 Impact Evaluation

8.3.1 Issues and concerns

Construction phase

- Employment and training.
  - Introducing new job opportunities and new local businesses.
  - Employment from local community.
- Business prosperity.
- Not giving priority, for local contractors and employees during construction works.
- Earthquakes
  - Improper design of storage facilities to withstand earthquake risk (earthquake rating in Aqaba is high).
- Stress on roads and highways, due to transporting raw materials, equipments and heavy machinery.
- Construction of storage tanks in Aqaba on sight seeing (visual impact)
- Not supporting the neighboring local communities.
- Grievance Mechanism.

Operation phase

- Employment.
  - Employment from local community.
  - Prior training and capacity building for all employees before project launching.
  - Availability of benefit package for employees including medical insurance, and social security.
- Business prosperity.
- Transporting sulphur by railway from Aqaba site to Eshidiya site.
- Demographic structure.
- Settlement.
- Cultural traditions.
- Traffic congestion and accident by the loaded trucks.
- Loads by trucks on public roads infrastructure.
- Considering an alternative road for transporting of raw materials and products (Eshidyia-Rum-Rashediyah-Aqaba).
- Economic benefits.
- Community health.

- Supporting municipalities and helping them to improve the landscape.
- Contributing to social development of local communities (especially remotes ones) close to the project site.
- Grievance Mechanism.

Decommissioning phase

- Reuse or recycle of the disassembled machines.
- Employment termination.
- Loss of business associated with the project.
- Visual impact.
- Grievance Mechanism.

8.3.2 Existing conditions

The company management is committed to participate in the improvement of the socio-economic conditions of the local communities as much as possible and applicable and in cooperation with the local authorities.

- Employment
  - The construction phase will take around 3 years. The major expected activities during construction phase will include opening and paving new access and internal roads, and the construction of sulphuric and phosphoric acid plants including the associated buildings and utilities. Thus, the work during the construction phase requires both skilled and non-skilled labor. The total number of employees during the construction phase is expected to reach 1000 persons.
  - Regarding the operation phase, the total number of employees is expected to reach 600 employees in Eshidya site.
  - The company sets a policy that 75% of the employees during the operation phase will be from the local community, and 40% of the employees during the construction phase will be from the local community.
  - The company will provide social security and health insurance benefits to their employees.
  - Regarding the child labor, the company will follow the Jordanian labor law which mentions the following: The labor code sets the minimum legal working age at 16 years. In February 2003, HM King Abdullah II issued a Royal Decree requiring that the

minimum age for employment of children working in hazardous occupations is 18 years instead of 17. Minors are not allowed to work more than 6 hours per day and must be given a brake after 4 hours of work, and may not work during weekends and holidays, or at night. Before hiring a minor, a prospective employer must obtain a guardian's written approval, the minor's birth certificate, and a health certificate. An employer that violates these provisions faces a fine. The fine doubles for subsequent infractions.

- Land acquisition

  The sulphuric and phosphoric acid plants will be built within the administrative boundaries of Al-Jafer sub-district. The land is currently owned by the government and it is declared by the government as a free zone area. JPMC has a license to mine, exploit, produce and market phosphate and its product in this area.

  The project site area is 1.7 km^2 (for sulphuric and phosphoric acid plants) and 1.7 km^2 for gypsum disposal. The land area for the project is desert and was not used by local population. So, no physical or economical displacements are required.

  The storage tank will be built at Aqaba industrial area; the land is currently owned by the government where JIFCO will rent it from Aqaba Development Corporation (ADC). ADC is a private shareholding company. It is currently wholly owned by the Government of Jordan (50%) and ASEZA (50%). It was formed to take full responsibility for the development of ASEZ's strategic assets in a manner consistent with the 2001-2020 Master Plan of Aqaba.

- Traffic congestion and accident

  The company will depend on the Desert Highway to transport its product and by-product from the project site to Aqaba and to transport the raw materials from Aqaba to the project site.

  The production capacity of the plant is 1,500 tons phosphoric acid /day as pure P_2O_5. Since the concentration of P_2O_5 produce is 52%-54%, then the total quantity of the produced acid is estimated at 2,808 tons/day. This quantity requires around 81 trucks/day (assuming that truck capacity is 35 tons and the plant works 317 day/year) to be transported through the Desert Highway.

The company will also transport fluosilicic acid (by-product produced) to be used by JPMC as a raw material in its plants in Aqaba. Additionally, the company will receive sulphur in Aqaba and transport it to the project site in Eshidiya through the Desert Highway.

- Indigenous people in Eshidiya

  Eshidiya is located in the middle of the way between Ma'an and Al-Modawarah. The nearest town to Eshidiya is Al-Jafer, which is the center of Al-Jafer district, 45 km to the north of the project area. Eshidiya is in a center of a triangle, in which Ma'an, Al-Jafer, and Al-Modawarah are the three angles. These are the main urban locations in the area. The area is part of the southern Badia. It is a desert with a few numbers of inhabitants belonging to some Bedouin tribes. Those people traditionally depend on livestock for living, and therefore they keep moving searching for grass and water.

  But, nowadays the number of people who depends on that way has decreased. Today many Bedouins are living in towns or villages and they work in the army or in the phosphate production in Eshidiya.

- Settlement camp for the employees

  During the project life, the company will construct a settlement for workers inside the existing town site of the JPMC employees which is for bachelors only. The existing town includes the following:
  - 18 buildings having 560 apartments (two rooms apartments or two rooms and living room).
  - Medical laboratory
  - Health center.
  - Bank.
  - Employees club.
  - Mining association office.
  - Two ambulances.
  - Cafeteria.
  - Civil Defense station
  - Police station

The company intends to upgrade the existing health center to meet the IFC requirements otherwise, a new health center will be built.

8.3.3 Evaluation of impact

- Employment

  The company is expected to employ around 1000 and 600 employees during the construction and operation phases respectively. The company will give the priority for 75% of the employees during the operation phase and for 40% of the employees during the construction phase to be from the local community.

  So, this will have a positive social and economic impact on the local communities. As mentioned before, according to the company management, the priority of the employment during the construction and operation phase will be given to the local community. The company is also committed to provide the necessary training to the employees.

  The company will be responsible for providing social security and health insurance to their employees. Also, the company will have its own health center which will provide services to employees or the company will upgrade the existing health center to meet the IFC requirements.

- Business prosperity

  It is expected that the project will enhance business prosperity in Al-Jafer and Ma'an sub-district where the workers will represent a new purchase power to be injected into the local market; they will increase the demand for several goods and services in the market, then small shops, food and beverages store will be positively affected. On other hand, the project will increase the demand on spare parts and vehicle maintenance workshops in the area.

- Considering an alternative road for transporting of raw materials and products (Eshidyia-Rum-Rashediyah-Aqaba)

  The company will depend on route 1 (see Fig. (8.2)) to transport its product and by-product from the project site to the storage area at Aqaba and to transport the raw materials from Aqaba to the company. The trucks trip will start from Eshidiya passing through Ma'an to Aqaba and vise versa. The trucks will enter Ma'an sub-district border and will be far from local community living there.

Fig. (8.2): Company trucks traveling route

The suggested route 2 (see Fig. (8.3)) contains around 20 km as agricultural road, which is not designed for such loads and trucks. In future and if the governments upgrade this route, the company will use it since it is shorter than route 1.

Fig. (8.3): Alternative route

- Transporting sulphur by railway from Aqaba site to Eshidiya site

  The existing railway is very old and needs a lot of maintenance, as well as it needs extension from the project site at Eshidiya to the railway loading station. So, this option could not be implemented now.

- Loads by trucks on public roads infrastructure

  Transportation of product and raw materials will increase the daily number of vehicles passing through Desert Highway by 2.9% for each side. Taking into consideration that the Desert Highway is designed for heavy loads; the stress of the project transportation activity is not expected to be of major contribution.

- Visual impact

  The project area is characterized as a desert with rare vegetation cover. Negative visual impact may result from pilling of debris and excess soil resulting from construction activities and decommissioning phase.

  Also, during the construction and operation phases several types of wastes will be generated such as domestic wastewater, domestic solid wastes, tires, discarded metal parts and used oil.

  Since the distance from the project site to the nearest residential area in Al-Jafer is around 45 km, the visual impact is not expected to have a significant impact if the company takes proper mitigation measures to avoid any unsuitable scenes. While during the operation phase, the company will plant a green belt around the boarder of the plant, using the treated domestic wastewater for irrigation, which will have positive visual impact.

  The storage tanks will be constructed in the southern industrial area in Aqaba and will be far from sight seeing. So, they will not have any visual impact.

- Tourism

  As concluded in Cultural Heritage and Archeology Chapter, the project sites have not any archeological remains and are far away from any tourist attraction site. Thus, the project will have no impact on tourism.

- Demographic structure

  Any increase in socio-economic activity in the local community by the project will raise the socio-economic opportunities and benefits (employment, business prosperity). These in turn might slow the current urban drift of young people from their areas, and thus will enhance the stability of demographic structure within the project area.

- Settlement

  The establishment of this project is expected to raise the socio-economic activity including the business prosperity in the area. This will aid in overcoming current degrading and debilitating situation, since it will encourage the Bedouin to settle down and inhabit the area.

  During the meeting with Bedouins who pastures their camels near the project site, they informed us that they already considered alternative routes to send their camel through because of the existing projects in the area, and that they don't have any problems from pasturing in other areas.

- Cultural traditions

  The company will give priority for 75% and 45% of the employees to be from local community during construction and operation phase respectively. In case of lack of skilled worker in the local community, the company will hire employees from other governorates. Also, the company will hire skilled and non skilled workers from India.

  This will increase the contact between the local community and other communities from the kingdom and India which might accelerate the decline of local cultural traditions. This effect could be minimized taking into consideration that the company will established its own settlement inside the existing town city that belong to JPMC.

- Community health

  Transportation of hazardous material will be expected to have negative impact on health and safety of the local residents if any spills, leaks and accidents take place. This can be minimized if the company put strict instructions for their trucks drivers.

8.4 Public Consultation

In order to get a true image about the expected impacts of the project on the close local communities to the project, a survey was conducted where Ma'an and Al-Jafer areas were visited and many persons were interviewed.

A questionnaire was developed in order to examine the potential socio-economic impacts of the project on the societies and economical performance. Also, a brief description of the project was written in Arabic as introduction and included within each questionnaire and was presented for those who are illiterate.

The aim of this survey is to investigate and to get the opinion of Ma'an and Al-Jafer residential toward the project and to explore how differences in livelihood, cultural and socio-economic conditions influences the attitude and perceptions of people in the community.

In order to reflect a true image of the majority of people and stakeholders in the project area, a representative sample of 78 persons (from both genders) was chosen through visiting several homes as well as some local organizations such as: Al-Jafer Municipality, Women Community Gathering the Hashemite Fund for Human Developments, Ma'an Governorate, Community Development Organization at Al-Jafer sub-district, Ma'an Industrial Chamber, Al-Jafer Court and Al-Jafer Civil Defense. In addition to that the study team interviewed those organizations managers and got their feedbacks.

Table (8.9) through Table (8.11) shows the selected sample according to gender, education and material status.

Table (8.9): Gender distribution of the selected sample

Sex	Frequency	Percent	Cumulative Percent	
Female	28	35.9%	35.9%	
Male	50	64.1%	100.0%	
Total	78	100.0%	100.0%	

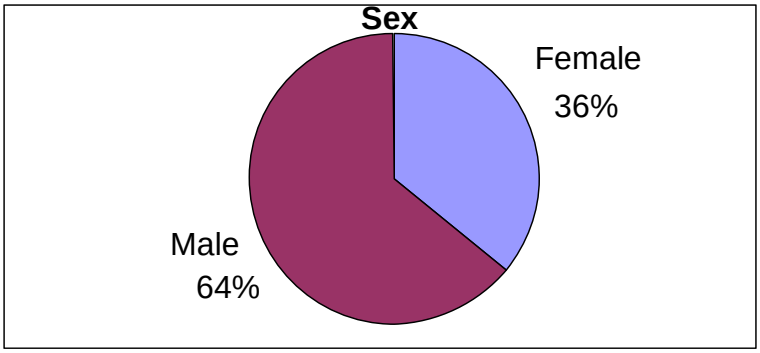


Fig. (8.4): Gender distribution of the selected sample

Table (8.10): Material status of the selected sample

Status	Frequency	Percent	Cumulative Percent	
Married	44	56.4%	56.4%	
Single	34	43.6%	100.0%	
Total	78	100.0%	100.0%	

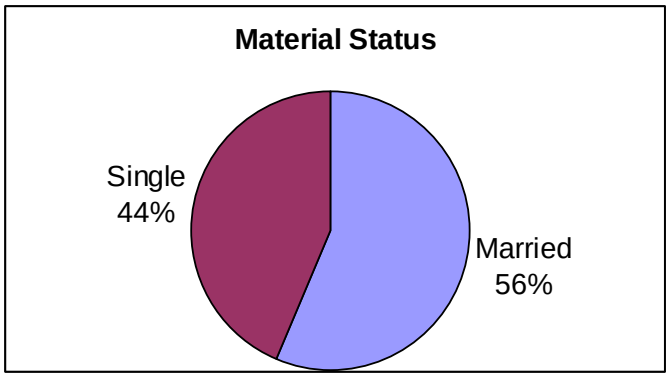


Fig. (8.5): Material status of the selected sample

Table (8.11) Educational level for the selected sample

Educational level	Frequency	Percent	Cumulative Percent	
Illiterate	4	5.2%	68.8%	
Elementary	16	20.8%	20.8%	
high school	33	42.9%	63.6%	
University	24	31.2%	100.0%	
Total	77	100.0%	100.0%	

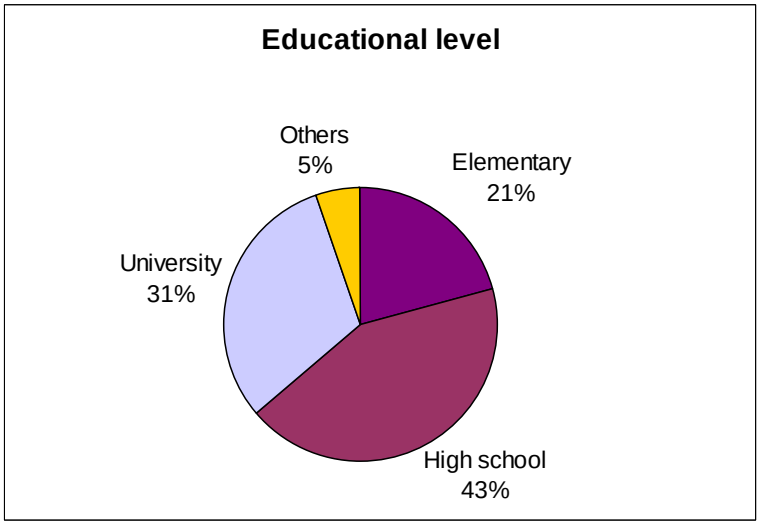


Fig. (8.6): Educational level for the selected sample

8.4.1 Result and analysis

The investigation was started by enquiring about living status of inhabitants in the project area. This was done by asking people about the reason of living in the area (original people or because of the work) and size of their family. Also, the interviewees were asked if they own any land near the project area and the type of their land (residential, commercial and agricultural). Tables (8.12) through Table (8.15) show the results of such questions.

Table (8.12): Reasons for living in the area

Why do you live here?	Frequency	Percent	Cumulative Percent	
Because of the work	5	6.4%	6.4%	
Original residential	73	93.6%	100.0%	
Total	78	100.0%	100.0%	

Table (8.13): Number of the interviewed residents having their own land in Al-Jafer or in Ma'an sub-district

Do you own a land in Al-Jafer or in Ma'an sub district?	Frequency	Percent	Cumulative Percent	
Yes	44	56.4%	56.4%	
No	34	43.6%	100.0%	
Total	78	100.0%	100.0%	

Table (8.14): Land use of the interviewed residents land

If the answer to the previous question is "Yes" then what is the usage of the land?	Frequency	Percent	Cumulative Percent	
Agricultural	13	29.5%	29.5%	
Commercial	4	9.1%	38.6%	
Residintial	27	61.4%	100.0%	
Total	44	100.0%	100.0%	

Table (8.15): Family size of the interviewed residents

2. How many members in your family?	Frequency	Percent	Cumulative Percent	
1	14	18.4%	18.4%	
2	7	9.2%	27.6%	
3	12	15.8%	43.4%	
4	5	6.6%	50.0%	
5	3	3.9%	53.9%	
6	5	6.6%	60.5%	
7	7	9.2%	69.7%	
8	4	5.3%	75.0%	
9	2	2.6%	77.6%	
10	4	5.3%	82.9%	
11	1	1.3%	84.2%	
12	10	13.2%	97.4%	
15	1	1.3%	98.7%	
18	1	1.3%	100.0%	
Total	76	100.0%	100.0%	

Afterwards, people opinion toward the project was investigated. Major findings were as follow:

- 97% of the residents met know that the phosphate rock is one of the most important natural recourses for Jordan.
- 92% of the residents met think that the project will increase employment rate.
- 82% of the residents met think that the project will increase business prosperities in the area.
- 50% of the residents met think that the project will negatively affect the visual impacts.
- 46% of the residents met think that existing foreign employees has negative impact on the area.

- 82% of the residents met think that the project will raise their living standards.

During the survey, it was found that the people are familiar with the importance of the project and they are with the project idea, although several issues and concerns were raised up, such as:

- Not giving priority of employment to the local community.
- Over pumping of water from Al-Jafer aquifer, which is already has been depleted in last 30 years (see water resources chapter).
- Pollution and dust emission which will negatively affect their health (see public health chapter).
- Traffic accidents and traffic jam.
- Not considering safety issues in the company.
- Existing of foreign employees in the area and affecting the culture tradition.

8.5 Mitigation Measures

Following are the proposed mitigation measure to minimize the negative impacts and to enhance the positive ones.

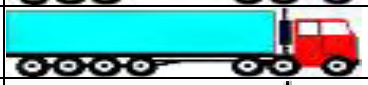
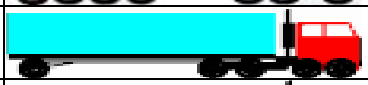
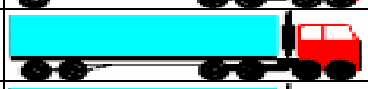
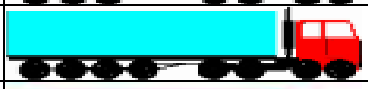
- Employment
  - The project is expected to create temporary jobs for both skilled and non-skilled employees during construction and operation phase. So, it is highly recommended that JIFCO give a priority for local community (Al-Jafer and Ma'an area). This can be done in cooperation with the labor directorate in Ma'an governorate.
  - In order to make the local employment more successful, it is recommended that JIFCO arranges with the vocational training center in Ma'an governorate to build and upgrade the capacity of the potential local workers, having basic qualification, on the skills jobs needed by the project.
  - The company shall follow the Jordanian/International regulations regarding child labor.
  - The employment procedure should be established according to an approved criterion (such as the qualification is one of the main criteria).
  - In case of project decommissioning, it is recommended to help terminated employees to find new jobs and to pay them fair compensation.

- Business prosperity
  - The company should get supplies, food, spare parts (if available having requisite quality and competitive price) from local stores during both construction and operation phases.
  - The company should give priority for local contractor to provide employees with suitable transportation and other services on competitive rates basis.
  - The company should contribute to social development of local communities (especially remotes ones) that are close to the project site.

- Traffic congestion and accident

  To reduce the risk of accidents and traffic jams to a minimum along the roads, the following mitigation measures should be adopted:
  - Strict instructions should be issued for drivers not to overload trucks transferring materials, see Table (8.16)
  - During construction phase, transportation of material to the project site (where congested public access crossings are used) should be avoided during the Rush hours.
  - During the operation phase, strict speed limits and safety signs shall be posted along the roads and drivers shall be trained on defensive driving to reduce potential increase in accidents.
  - During construction activities, warning and traffic signs shall be posted so as to prevent accidents.
  - High qualified and trained drivers should be chosen and directed to follow Jordanian traffic regulations.
  - Well maintained appropriate trucks to transport products should be used.
  - The trips of truck transporting the product should be organized to avoid the probability of traffic congestion caused by the use of large number of trucks at the same time.

Table (8.16): Maximum allowable gross axial loads for various classes of trucking vehicles

No	Shape	Gross WT (Ton)	Class Code	Vehicle Class
1		*21*	11	2 Axles Truck
2		38	1111	2 Axle Truck with 2 Axle Trailer
3		44	2111	2 Axle Truck with 2 Axle Trailer
4		27	21	3 Axle Truck
5		45	1121	3 Axle Truck with 2 Axle Trailer
6		51	2121	3 Axle Truck with 3 Axle Trailer
7		32	22	4 Axle Truck (Dually Steered Front Axles)
8		50	1122	4 Axle Truck with 2 Axle Trailer (Dually Steered Front Axles)
9		51	2122	4 Axle Truck with 3 Axle Trailer (Dually Steered Front Axles)
10		31	32	5 Axle Truck (Dually Steered Front Axles)
11		54	1132	5 Axle Truck with 2 Axle Trailer (Dually Steered Front Axles)
12		10	2132	5 Axle Truck with 3 Axle Trailer (Dually Steered Front Axles)
13		33	111	2 Axle Trailer Head and 1 Axle ½ Trailer
14		40	211	2 Axle Trailer Head and 2 Axle ½ Trailer
15		44	311	2 Axle Trailer Head and 3 Axle ½ Trailer
16		48	411	2 Axle Trailer Head and 4 Axle ½ Trailer
17		40	121	3 Axle Trailer Head and 1 axle ½ Trailer
18		47	221	3 Axle Trailer Head and 2 Axle ½ Trailer
19		51	321	3 Axle Trailer Head and 3 Axle ½ Trailer
20		55	421	3 Axle Trailer Head and 4 Axle ½ Trailer
21		45	122	4 Axle Trailer Head and 1 Axle ½ Trailer (Dually Steered Front Axles)
22		*52*	222	4 Axle Trailer Head and 2 Axle ½ Trailer (Dually Steered Front Axles)
23		51	322	4 Axle Trailer Head and 3 Axle ½ Trailer (Dually Steered Front Axles)
24		10	422	4 Axle Trailer Head and 4 Axle ½ Trailer (Dually Steered Front Axles)
25		38	23	5 Axle Truck (Tertiary Steered Front Axles)

- Earthquake impact

  Due to the location of the storage tank in high risk seismic zone, it is obligatory to take into consideration the regulation and design codes of the Ministry of Public Works and Housing against earthquakes.

- Visual impact

  In order to minimize the negative visual impact, the following mitigation measures should be followed:

  - Manage and dispose the excess soil, debris and all types of waste resulting from construction activity and decommissioning phases to a proper dump site specified by the local municipalities.
  - Plant selected trees appropriate for the area to improve the scenery of the site.
  - Reuse or recycle of the disassembled machines.

- Hazardous materials transportation

  JIFCO should follow the Ministry of Transport regulations for year 2003 regarding hazardous materials transportation. Following are those regulations:

  - Truck driver should be trained to handle hazardous materials in proper way.
  - Trucks should design in such a way that no leakage or damage of hazardous materials should happen or end up in an explosion while moving.
  - A printed label on the trucks is necessary to identify the nature of hazardous material.
  - Information about the hazardous materials should be given to the truck driver.
  - It is prohibited to park the hazardous material trucks inside the residential area.
  - Trucks should be equipped by all the means of security (such as having fire extinguishers) and should be regularly checked.

  In addition to that the company should distribute to local residents information to highlight health and safety risks that might be resulted from the project.

- Grievance mechanism

  In order to minimize potential negative impact from the project activity and to maximize positive impacts, the company should

establish a grievance mechanism as part of the management system to ensure that proper consultation, disclosure and community engagement is included throughout the project life continuously.

A policy or process for addressing complaints cannot be effective if no one knows about it. Company's grievance procedures should be documented, publicized and should be clear to the relevant stakeholder groups. Also, the mechanism should be simple and the people should know where to go and whom to talk to as well as to understand the process for handling this issue. As a general rule, the grievance mechanism should not be complicated to use.

Not all grievances can be handled in the same manner. Some serious problems require immediate interventions by senior managers. A simple problem could be solved by the JIFCO community liaison officer.

9. OCCUPATIONAL HEALTH AND SAFETY

9.1 Introduction

Since 1950, the International Labor Organization (ILO) and the World Health Organization (WHO) have shared a common definition of occupational health. It was adopted by the Joint ILO/WHO Committee on Occupational Health at its first session in 1950 and was revised at its twelfth session in 1995. The definition reads: "*Occupational health should aim at: the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention amongst workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological capabilities; and, to summarize, the adaptation of work to man and of each man to his job*".

Each worker has a fundamental right to a healthy and safe working environment. Occupational health and safety program will promote safe and healthy workplaces to help prevent work-related injuries and illnesses. The quality of the work environment through compliance with safety and health standards has to be ensured by surveillance at the workplace. According to ILO Convention No. 161, surveillance of the work environment is one of the main tasks of the occupational health services. The ILO Occupational Health Services Recommendation, 1985 (No. 171) provides that in accordance with national law and practice, data resulting from surveillance of the work environment should be recorded in an appropriate manner and be available to the employer, the workers and their representatives, or to the safety and health committee, where one exists. These data should be used on a confidential basis solely to provide guidance and advice on measures to improve the work environment and the safety and health of workers. The competent authorities should also have access to these data. The data may be communicated to others by the occupational health service only with the agreement of the employer and the workers. Workers concerned should be informed in an adequate and appropriate manner of the results of the surveillance and should have the right to request the monitoring of the work environment.

Education and training can not solve all occupational safety and health problems, and care must be taken that the techniques learned in such programmes are in fact applied appropriately to the identified needs. They are, however, critical components of an effective safety and health programme when employed in conjunction with engineering and technical solutions. Cumulative, interactive and continuous learning is essential to prepare our rapidly changing work environments to meet the needs of workers, especially as regards the prevention of debilitating injuries and illnesses. Those who labor in the workplace as well as those who provide support from the outside need the most up-to-date information available and the skills to put this information to use in order to protect and promote worker health and safety.

It is important to know that, through a constructive worker-management relationship and by treating the workers fairly and providing them with safe and healthy conditions, projects owners may create substantial benefits such as enhancement of the efficiency and productivity of their operations.

This occupational health and safety chapter provides an assessment of the project potential impacts related to physical, mental and social well-being of workers such as: air quality, noise, solid waste, wastewater, residence and treating of workers issues in order to set the necessary mitigation measures to avoid or reduce negative impacts and enhance the positive ones. The assessment is based on information provided by the company and the collected data from other related sources.

9.2 Issues and Interactions Between Project Activities and Occupational Health and Safety

Occupational health and safety (OHS) was identified as a valued environmental component in the Terms of References (TORs) and during the scoping session. The following interactions between the project activities and OHS were identified for the different phases of the project.

9.2.1 Construction phase

- Not having or not following occupational health and safety measures.
- Dust and gaseous emissions generated.
- Noise of construction machinery, vehicles and activities.
- Domestic wastewater disposal.
- Domestic solid waste generated from workers.
- Diseases between workers (foreigners and locals).

- Not considering the safety of workers due to vehicles movement.
- Not constructing a containment area around the storage tanks.

9.2.2 Operation phase

- Not having granulated sulphur.
- Not installing the necessary control devices (e.g.: refrigeration systems, vents, alarm systems) on the storage tanks.
- Not complying with the technical standards for sulphur and phosphate storage in Eshidiya (closed storage facilities).
- Not monitoring air quality in the site.
- Not having a healthy residence for workers.
- Not having or not following occupational health and safety measures.
- Dust and gaseous emissions generated.
- Disposal and / or reuse of solid waste (domestic and sludge).
- Not covering the conveyor belts of raw materials.
- Noise generated from different activities.
- Not having appropriate training and awareness for the workers.
- Disposal of hazardous waste (e.g.: vanadium pentoxide)

9.2.3 Decommissioning phase

- Dust and debris generated from demolition of buildings.

9.3 Existing Knowledge

The company is committed to adhere and go beyond the established standards and regulations for occupational health and safety to protect health and environment. To accomplish its commitments, it will establish the applicable comprehensive OHS programs, guidance, operational plans and procedures, and the associated technical and monitoring manuals for all the phases of the project as well as it will adopt well recognized guides to implement its program. The company will adopt a comprehensive OHS policy.

9.4 Mitigation Measures

The company shall adopt the following points in order to have a comprehensive occupational health and safety policy:

- Abide by the relevant laws and Jordan/IFC regulations and design.

- Raise the sense of environmental protection and organize an environmental protecting construction.
- Use qualified materials and dispose wastes in sorts.
- The disposal of domestic wastewater shall be according to the related regulations.
- Minimize noise generation to the permissible values.
- The serious complain of environment would be nil.
- The death accident would be nil, severe injury rate would be as low as possible.
- Guarantee the health of the staff in case of occupational disease.
- Prevent fire and exploding accidents.

All activities that impose unreasonable risks on workers health or safety shall be addressed and mitigated in the occupational health and safety system for either elimination or reduction the risk to an acceptable level and according to established standards and regulations.

An occupational health and safety plan shall be available, which will include:

- Occupational health and safety plan objectives.
- Standards referred to.
- Occupational health and safety management system.
- Management commitments (including responsibilities of company staff).
- Resource management (including training for the employees).
- Realization of product.
- Measurements, analysis and improvement.
- Control of occupational health and safety management system (including identifying the accidents and documentation procedure, prevent / mitigate the risk, emergency response plan, etc).

9.4.1 Occupational health and safety plan objectives

The OHS plan shall be applicable to all stages of the project; from the design stage to the stage when product is transported to markets. It is the programmatic document on the occupational safety, health and environment management and a set of regulations applied in the management within the project department.

The plan shall be applicable to all operating divisions in the management system of the project department and all those concerned and to all offices, working places and construction sites.

9.4.2 Standards referred to

The occupational health and safety management system shall be formulated referring to the following relevant systems:

- Regulation No. 43-1998: Occupational health and safety at work place.
- Regulation No. 42-1998: Medical preventive and treatment care for workers.
- Law No. 8-1996/Article 79: Protection of workers from work environment.
- Law No. 8-1996/Article 78: Emergency tools for workers at work place.
- IFC General environmental, health and safety guidelines, 2007 and performance standards on social and environmental sustainability, 2006.

In addition to other relevant laws and regulations such as ambient air quality standard including dust, noise standard of construction and operation activities, and water and treated wastewater quality standard.

9.4.3 Occupational health and safety management system

The system shall clarify the general requirements of the project departments on the establishment, implementation, maintenance and constant improvement of the occupational health, safety and environment management system and the requirements on the formulation of the system. It is applicable to management on occupational health, safety and environment and documental control within the responsibilities of the project departments and during construction and operation phases.

9.4.4 Management commitments

The project manager is responsible for appointing a person or a staff who is responsible for planning and executing of the occupational health and safety program (including the required training). This program shall include the reward / penalty strategy. He / she is also responsible to make a safe work environment available. He / she has to enhance the workers to give their proposals related to occupational health and safety.

The supervisors are responsible to protect the workers who are working under their supervision. They have to train the workers to make the personal safety tools and equipments available.

The workers are responsible to follow all instructions related to the occupational health and safety. They have to preserve the personal safety tools and equipments. Also, they shall inform the responsible person about all conditions and practices which will endanger the occupational health and safety. If an accident occurs the workers are not allowed to change anything at the accident area until the beginning of the investigation. They have to cooperate with the investigators in order to know the reasons of the accident. The staff shall document all occupational accidents.

9.4.5 Resource management

In order to realize and maintain the occupational health and safety system as well as to improve its effectiveness continuously, the project departments shall provide necessary human resources and infrastructure in time and create a suitable construction and operation working environment. It is very important to have trained human resources to implement the occupational health and safety system.

9.4.6 Realization of product

This section shall clarify how to mastermind and confirm the process of the realization of product and carry out effective controls on it. It is applicable to the plan of the realization of product, the process related to clients, the purchasing, constructing and producing processes, the product identification and traceability, the protection of finished product and the management and control of monitoring and measuring devices.

9.4.7 Measurements, analysis and improvement

This section shall clarify how to plan the measurement supervision and the improvement activities to confirm the fitness of the product, ensure the coordination of the management system and improve its effect. It is applicable to all processes which are suitable for the occupational health, safety and environmental management system of the project departments and product fulfillment.

9.4.8 Control of occupational health and safety management system

The accidents shall be identified and documented in a special procedure. The risk shall be prevented or mitigated. An emergency response plan shall be prepared.

9.4.9 Other mitigation measures related to occupational health and safety

- The employees shall be provided by the company with information regarding their rights under national labor and employment law.

- The working conditions shall comply with the national law.

- The company shall enable means for workers to express their grievances and protect their rights regarding working conditions. The grievance mechanism shall be provided by the company for the workers. Also, the company shall not discourage workers from forming or joining workers organizations of their choosing which will not contradict the local laws and regulations.

- An emergency response plan shall be prepared by the company to deal with fire, accidents, spillage and any other abnormal conditions. This plan shall be well implemented and reviewed by the management staff frequently. The employees shall be trained on all issues related to the emergency response plan. Also, the drivers shall be part of the plan and well trained.

- The company should coordinate and involve the concerned authorities in planning and implementing the emergency response plan.

- Hazard and Operability Analysis (HAZOP) will be prepared to be ready before the operation of the plant.

- All foreigner workers shall have a medical inspection before starting to work in the project.

- The workers shall be provided with all the related issues concerning occupational health and safety.

- Control staff of the company shall visit the work areas frequently to check and be sure that all the occupational health and safety measures are applied.

- Periodic medical inspection shall be done for all workers. If the company proposes to use the existing medical clinic of JPMC, it shall be upgraded to meet the IFC requirements.

- During construction phase, the ground shall be sprayed with water, if required, in order to reduce the dust from vehicle movements and to enable the vehicles drivers to see the workers around. Also on-site trained flag people wearing high-visibility vests shall direct traffic during construction activities. Vehicles shall be outfitted with audible back-up alarms.

- During construction activities, good house-keeping practices should be implemented, such as placing loose construction materials or debris in areas away from foot paths.

- The need for manual transfer of heavy loads should be minimized by good planning of site layout. Lifting devices appropriate to the load shall be used and well maintained.

- Control zones and safety monitoring systems shall be used to warn workers of their proximity to fall hazard zones, as well as securing, marking and labeling covers for openings in floors, roofs or walking surfaces.

- During construction and operation phases, all areas where the equivalent sound level (noise) exceeds 85 dB(A), warning signs will be posted indicating hearing protection is required. Workers will be instructed directly by occupational health and safety responsible person to use the personal hearing-protection equipment. Periodic medical hearing checks should be performed on workers exposed to high noise levels.

- All employees shall have the necessary personal protecting and safety equipment such as dust masks, safety slip retardant shoes, helmet and hearing protection equipment during different phases of the project, which provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems. The personal protective equipment shall be maintained frequently and replaced by new ones after the end of its life time.

- Catering with warm and healthy diet for workers (i.e. high carbohydrates fraction and low meat fraction) shall be provided to all workers during construction phase. Cold fresh water shall be available during both construction and operation phases for all employees all the time.

- During construction activities, a medical support including first aid clinic and ambulance shall be made available.

- During operation phase, eye-wash stations and emergency showers shall be provided close to all workstations where immediate flushing with water is the recommended first-aid response.

- Toilettes shall be available to be used by the workers during the construction phase. The generated domestic wastewater shall be collected in tanks and then transported to the nearest wastewater treatment plant in a safe manner. Certain control system shall be in place to ensure transportation of wastewater to the treatment plant.

- During operation phase, the domestic wastewater from the workers will be treated properly using activated sludge technology. The treated wastewater that will be used for irrigation purposes shall comply with the Jordanian standards.

- During construction and operation phases, adequate lavatory facilities shall be available. Toilette facilities shall be provided with adequate supply of hot and cold running water, soap and hand drying devices. Water provided for lavatory facilities shall meet drinking water quality standards.

- Domestic solid waste generated by workers during construction phase shall be collected in closed bags and disposed in a safe manner in closed domestic solid waste containers. The same can be said to solid waste generated from the personnel during operation phase.

- The residence of the workers shall be constructed in a healthy way and provided with all necessary utilities and services.

- Granulated sulphur should be used and not pulverized (fine) one.

- The storage tanks shall be constructed according to the international standards including all the necessary auxiliary tools and equipments related to safety concerns such as vents and alarm systems.
- The company shall apply appropriate measures to maintain air quality within the considered regulations. Air quality control shall be measured and controlled frequently by the company or by a contractor.

- Passages to emergency exits shall be unobstructed at all times. Exits shall be clearly marked to be visible in total darkness. There shall be enough exits at least two for each work area.

- The workplace shall be designed to prevent the start of fires through the implementation of the related codes applicable to industrial settings. Specific worker training in fire prevention or suppression shall be provided.

- Workplaces shall receive natural light as much as possible and supplemented with sufficient artificial illumination. Also, emergency light shall be activated automatically in case of failure of the artificial light source.

- Safe passageways for pedestrians shall be constructed in the complex. Access ways shall be there for all equipment and installations requiring servicing. Railings shall be installed on stairs, fixed ladders, platforms, permanent and interim floor openings and ramps. All openings shall be sealed by gates or removable chains.

- Unauthorized access to dangerous areas shall be prevented by appropriate measures and signage of hazardous areas, installations, materials, safety measures and emergency exits shall be according to international standards and well known to workers.

- All vessels and pipes containing hazardous materials shall be labeled with the content according to national and international standards, also for piping systems with the direction of flow. Also the workers shall be trained how to use the available information such as Materials Safety Data Sheets (MSDS).

10. MARINE ENVIRONMENT

10.1 Introduction

Coastal ecosystems in general and coral reefs in particular have proven to be highly vulnerable to a variety of human impacts. One of the most important human stressors that may harm marine ecosystems includes industrial activities. Industrial activities affect marine habitats mainly by mechanical damage such as discharges, spills, ship groundings and degraded near shore water quality. In Jordan, the need for coastal facilities has risen dramatically in the last decade due to growing commercial, industrial and recreational activities. Coastal industrial areas are being developed and the existing facilities expanded with great momentum. This generally requires large areas of coastal land and waters for the operation of industrial and commercial installations and transport systems. Consequently, the impacts on the coastal environment are considerable, but often development of the commercial facilities is unavoidable given their intended use and their national and economic significance. Noting the above, requirements to minimize significant impacts must not be overlooked. To address this, effective measures are important to be considered which include the adoption of good management practices during industry operations. It will significantly help to ensure sustainable and optimal balance between socio-economic activities and environmental issues.

This chapter presents the possible environmental impacts of phosphoric acid, flousilisic acid and sulphur on terrestrial and marine environment with special focus to the marine ecosystem at JPMC Industrial Complex site that is located on the southern most portion of the Gulf of Aqaba, Red Sea. Also, this chapter proposes the requested mitigation measures for conservation of the ecosystem in order to avoid any possible adverse impacts on both the terrestrial and marine environment in Aqaba zone.


Fig. (10.1): Arial view of the industrial complex and coastal zone at southern portion of Gulf

10.2 General Facts About The Project

The proposed phosphoric acid storage yard will be adjacent to the industrial jetty at the southern coast of Gulf of Aqaba. The suggested location is about 1.5 km away from the shore line and beside the already existing storage area of the Indo-Jordan Chemicals Company. The new yard is planned to hold five storage tanks with volume capacity of 10,000 metric tones each. Tanks will be made from mild steel with rubber lining from inside. The tanks shall be installed with agitators to keep the phosphoric acid in agitated state to prevent formation of sludge. The storage tanks shall be surrounded with dike wall entirely in order to hold any possible incident of spill and/or tank failure. Storage tanks will be served by special pumps at area suitable to unload land tanker. The pump area will be provided with acid proof brick lining. Incidents of acid spillage due to handling or leakage shall be collected in a sump and pumped back to the storage tank. For safety of persons working in the area, eye washers and safety showers shall be provided at identified locations within the yard.

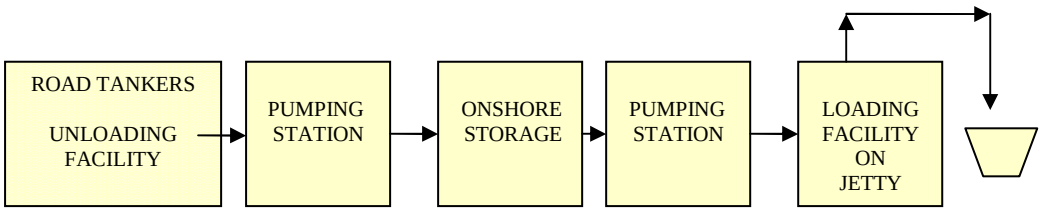
<u>Phosphoric acid handling system</u>

The following systems will be established onshore and at the jetty for the export of phosphoric acid:

- Manifold bay for unloading phosphoric acid from road tankers.
- Phosphoric acid pumping station for unloading from road rankers and transfer to storage tanks.
- Onshore storage tank yard.

- Phosphoric acid pumping station for loading phosphoric acid on the ships from the storage tanks.
- Loading facilities on the jetty (pipeline, manifold and hoses for loading phosphoric acid from the jetty to the ships).
- Water is envisaged to be used for process purposes like flushing pipelines, pumps, and administrative purposes.
- Eye washers and safety showers for personnel safety.
- Slop tank for collecting line, pump and tank drains/washings.
- Operator room.

All the facilities for handling phosphoric acid system will be designed to operate both in summer as well as in winter months. The phosphoric handling system can be schematically described in the following block diagram:



Road tankers for transportation

The road tankers of 35 MT having bottom discharge nozzles and with no provision of compressed air on the tanks are to be utilized for unloading purposes. The road tanker will be made of stainless steel or of carbon steel with interior rubber lining.

Pumping station at road tanker bay

The pumping station at the road tanker bay facilitates filling safely and efficiently the phosphoric acid storage tanks at the tank yard. The road tanker will be connected with phosphoric acid transfer pumps. It is proposed to install at minimum one working and one standby pumps. All of the transfer pumps shall be connected in parallel and connected through isolation valves. Similarly, the discharge lines from the pumps shall be connected to a main pipeline running up to each phosphoric acid storage tanks and will be fitted with valves. At the top of each storage tank one on-off valve will be provided which closes automatically when the tank level reaches 100%. At the tank storage yard the main acid transfer line will be branched off and connected to each tank through on-off valves.

Pumping station at tank storage yard

The pumping station will facilitate loading of the ship through the existing jetty. It will be located near the tank storage yard. Pumps used for loading the ship will be similar to the pumping station used for road tanker unloading bay. The station will consist of one working and one standby pumps. However, the capacities and head of each pump will be higher than those of the road tanker unloading pumps. It is proposed to be at a designed capacity of 650 m^3/hr. These pumps will also be connected in parallel to a main pipeline header up to a manifold on the Jetty. Pipelines from individual tanks will be connected to pump suction header through on-off valves.

Loading facilities at jetty

Currently, an average of 20 small to medium size ships head to the industrial jetty on a monthly basis. Major imported materials are ammonia, sulphur and aluminum hydroxide, while the major exported materials are diammonium phosphate (DAP), potassium chloride (KCl), salt and phosphoric acid. More than half of the coming ships are for importing sulphur. Phosphoric acid is currently exported in amount of 18000 tones/ship with an average number of two ships/month.

The loading facilities on the jetty will consist of a manifold with two branch lines to connect two flexi hoses of suitable length for hooking with the ship manifold. The branch lines on the manifold will be connected to the hoses through on-off valves and flanges. The flexi hoses will have matching flanges on both ends. The flange on one end will match with the flange of the manifold, while the flange on the other end will be matching with the flange of the ship. The operations of the valve will be manual based on the radio communication between the pump station and the ship.

10.3 Existing Environment

The Marine Science Station (MSS) in Aqaba had been carrying out a monitoring program for JPMC since 1996. Emphasis was given to the southern part of the coast (in front of the JPMC Industrial Complex). The program focused on the physical oceanography, seawater chemistry, plankton, coastal geomorphology of coral reef, sediment quality, intertidal and subtidal conditions as well as fish assemblages. The samples were taken from different locations at different depths.

10.3.1 Water quality

Seawater was collected and analyzed from 3 different depths for inorganic nutrients, total phosphorus, organic nitrogen and chlorophyll a in front of the Industrial Complex at the southern most portion of Aqaba Gulf, Red Sea. In addition, in situ records of color, temperature, salinity, pH and dissolved oxygen for surface waters have been generated. The acquired data showed prevalence of ambient Aqaba seawater conditions for most parameters (Badran and Foster, 1998; Abu-Hilal and Al-Moghrabi, 1994).

Industrial Complex environmental features

The industrial site at the southern end of the Jordanian coast of the Gulf of Aqaba has special significance to coastal managers and decision-makers. This is simply because it is the major site for fertilizers industry and power production along the Jordanian coast and theoretically, at least, the most susceptible to pollution. The location of the industrial site along the Jordanian Gulf of Aqaba is a continuation of the rocky habitats that characterizes the southern portion of the Gulf of Aqaba. The sea state is relatively calm with wave actions especially during winter with mean range of temperature and salinity of 21-27 ^{o}C and 40.2-40.7 psu, respectively (Badran and Foster, 1998; Badran, 2001). During summer, water stratification is the dominant phenomena in the upper 250 m of water column, while mixing is dominant during winter and spring following the same characteristics of the Gulf of Aqaba (Badran, 2001; Al-Najjar, 2000; Manasrah 1998 & 2002). Similar to all other coastal stations, water characteristics in front of the Industrial Complex was determined mainly by the natural annual cycle rather than anthropogenic influence. Fringing coral reef is the main building frame at this site and extends for about 5 km southward until the Saudi boarder. It has a clearly distinguished intertidal zone following the pattern of water level change that exists two times a day. Reef flat as well as reef front is considerably rich in coral reef that continue down to a depth of more than 40 m. Coral reef, grass beds and sandy bottoms characterize the habitats at entire site. However, the majority of the reefs are close to land which strongly exposes them to industrial influences as well as natural calamities.

Significance of physical and chemical properties of seawater quality

Water temperature has a pronounced effect on the stability and dissolution of gases such as O_2, N_2 and CO_2 in water, biological productivity of aquatic environment, degree of dislocations of dissolved salts and rate of oxidation of organic matter in natural water.

Additionally, water temperature is considered a critical parameter for aquatic life in any water body. This is because significant changes in the thermal regime of water systems result in major implications to all forms of aquatic life. Thus a decrease or increase of two degrees is probably the maximum range that can be tolerated by aquatic life.

pH is an important parameter in assessing water quality and used for calculating carbonate, bicarbonate, and CO_2 concentration and stability index. It offers a direct measure of the acidity or alkalinity of the sea water. Furthermore, pH greatly affects the toxicity and/or synergistic properties of certain water constituents, ammonia and cyanide. Biological activities in most natural waters are influenced by their pH. Studies have indicated waters with excessive low pH exert a negative impact on aquatic organisms. In marine environment also, low pH affects organisms and may result in diminishing population. Productivity and community structure of aquatic species are liable to be adversely affected by a decrease of about 0.5 to 1.0 pH units in natural surface waters with pH normally within the rang of 6.5 to 8.5 units. Thus, it is obvious that monitoring the pH of the aquatic environment is valuable for water pollution control, particularly in the case of any form of anthropogenic discharges.

Salinity is an important parameter that affects many biological activities in water bodies. Variations in salinity may have pronounced adverse effects on these activities. Salinity changes are used as an indicator on the rate of change of natural factors that affect it. The major processes responsible for salinity distributions are evaporation, precipitation, mixing, climatic conditions and geographical location. Furthermore, salinity may serve to indicate the intrusion of fresh water or wastewater of different composition to the marine environment.

Dissolved oxygen is the most frequently measured gas in water, because it is essential in most biological processes in aquatic environment. The levels of the dissolved oxygen can be indicative of the type of physical, chemical and biological activities in a particular water body. Oxygen is consumed by organisms and it is used for organic matter degradation. If a large amount of an effluent of oxidizable organic matter enters a water body or if the production of organic matter becomes very high, it is very likely that the water gets anoxic and its ability to support life decreases considerably.

Ammonia, nitrate, nitrite, phosphate and silicate are of great importance both for marine phytoplankton and seaweeds. However, the

presence of excessive amounts of the nutrients may lead to 'Eutrophication'. In this process the high fertility of the water allow for a rapid and excessive blooming of phytoplankton with initial over production of oxygen but at the end of the bloom the decomposition of the dead plants strips the oxygen from the water. Eutrophication occurs in areas where a restricted water circulation pattern allows high nutrient (and other pollutants) to build up due to the minimum dilution of the pollutants. The nutrient species involved in eutrophication are ammonia, nitrite, nitrate, and orthophosphate.

General background on water column characteristics of Aqaba Gulf

The Gulf of Aqaba is a narrow, long and deep semi enclosed water basin attached to the longer and wider semi enclosed Red Sea. The Gulf receives no fresh water runoff and the annual rainfall is very small amounting to about 30 mm/year. Waters of the Gulf of Aqaba are typical oceanic oligotrophic. Circulation is weak and exchange through the Strait of Tiran is limited. Slopes of the Gulf of Aqaba are steep and rocky, characterized mainly by coral reef habitats.

The range of fluctuations in the pH (8.30 to 8.38) and alkalinity (2.35 to 2.67 meq/l) of Gulf of Aqaba waters are very small amounting almost to the standard error of the measurements. Dissolved oxygen (DO) concentrations decreased only slightly from the surface down to 400 m from about 7.5 to 6 mg/l. Although, numerically lower than typical oceanic waters, dissolved oxygen concentrations in the upper water during summer and in the entire water column during the mixing season in winter are typical saturation concentrations. The lower numerical values are attributed to the relatively higher temperature and salinity of the Gulf of Aqaba as compared to average oceanic waters. Persistence of oxygen saturation concentrations can be attributed to the well ventilated surface water throughout the year and to the winter deep mixing that ventilates the entire water column down to the bottom. Noteworthy is that waters of the Gulf of Aqaba are never too cold or insufficiently illuminated to limit primary productivity even during winter. Another important reason for the persistence of oxygen saturation is the low organic carbon content of the waters of the Gulf of Aqaba. This results in low oxygen consumption and leaves oxygen concentration primarily as a function of temperature and salinity. The seasonal variation in temperature of water ranges between 20.7 to 27.5 ^{o}C. The Average salinity is 40.5 psu. The high salinity is attributed to the high evaporation rate, and the absence of fresh water inflow as well as the low rain fall. Ammonia concentrations were found to be in the range of below detection to 0.33-0.61 μM. Nitrate concentrations was found in the range

of 0.02 to 2.00 µM. Nitrite concentration was not detected during summer and reached a maximum of 0.33 µM in winter. Phosphate in coastal waters ranges between 0.01 to 0.13 µM. Chlorophyll a in coastal water ranges between 0.08 - 1.15 µg/l.

Water column characteristics of the Industrial complex site on Aqaba Gulf

Circulation and sea level

Circulation was reported to be based on calculations of heat flux and mass balance, rather than actual current measurements. In summer, a three layer water exchange system, where water from the Red Sea. Reports indicated that circulation in the Gulf of Aqaba is quite variable (Fig. (10.2)) in direction with a weak dominance towards the southeast to southwest, 135-225°. Dominant current speed along the Jordanian coast is between 4.0 to 15.0 cm sec^{-1}.

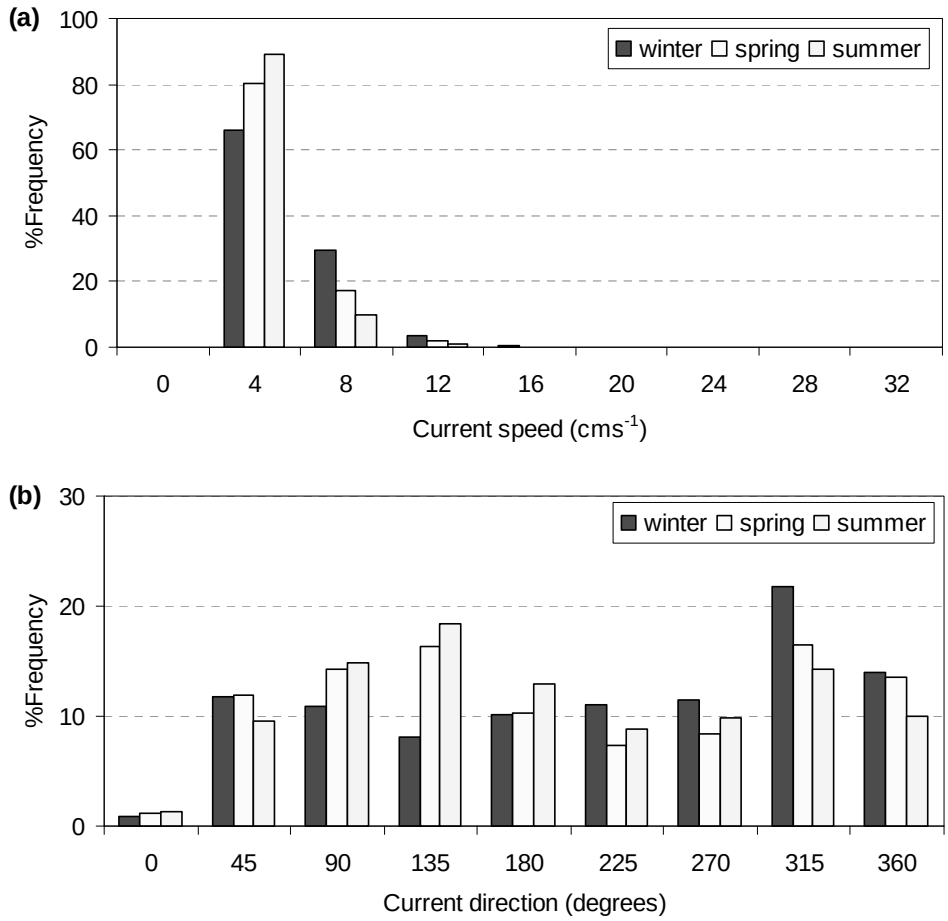


Fig. (10.2): Percent frequency distribution of current speed and direction measurements in the upper 40 m of the water column at the marine reserve of Gulf of Aqaba during winter, spring and summer

Color and transparency

Using the MOOPAM (1989) scale of seawater color, coastal seawater at different locations examined showed constant scale of 1 in front of the Industrial Complex.

Transparency is shown in Fig. (10.3). The high transparent water is due to the water clarity indicated by the color. Other factors that favor such high water transparency are the low primary productivity of waters of the Gulf of Aqaba, the high solar radiation and low cloud cover all around the year.

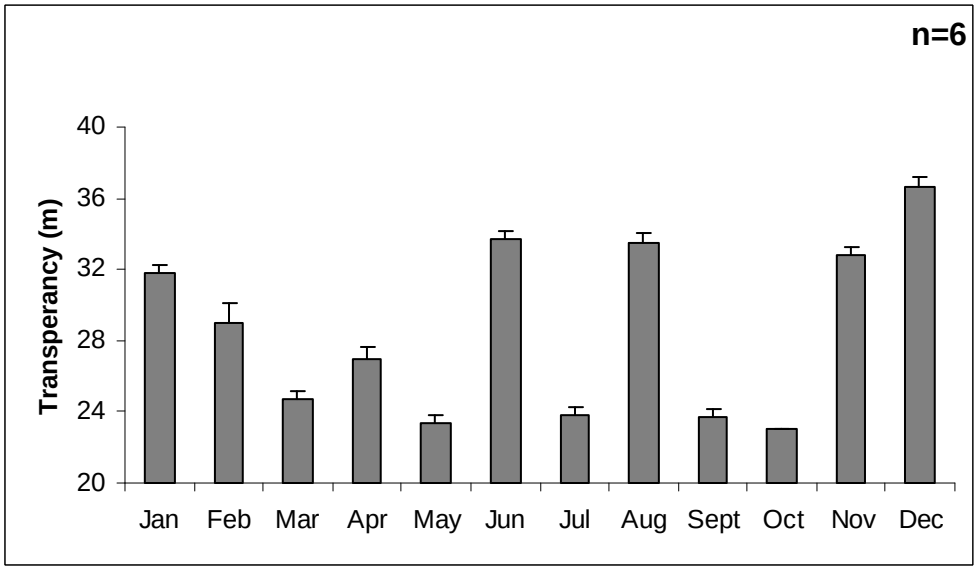


Fig. (10.3): Transparency measured using a 30 cm white Secchi Disc

Temperature

The mean water temperature at in front of the Industrial Complex is shown in Fig. (10.3). Water temperature shows a normal increase from June to September then drops gradually till February where the lowest values were recorded. The temporal variation in water temperature was significantly different. Besides, the temperature field in front of the Industrial Complex compares well with records in other coastal areas (Badran and foster, 2001). No incidents of abnormal temperatures have been recorded even in station due to cooling water on the temperature field in front of the Industrial Complex.

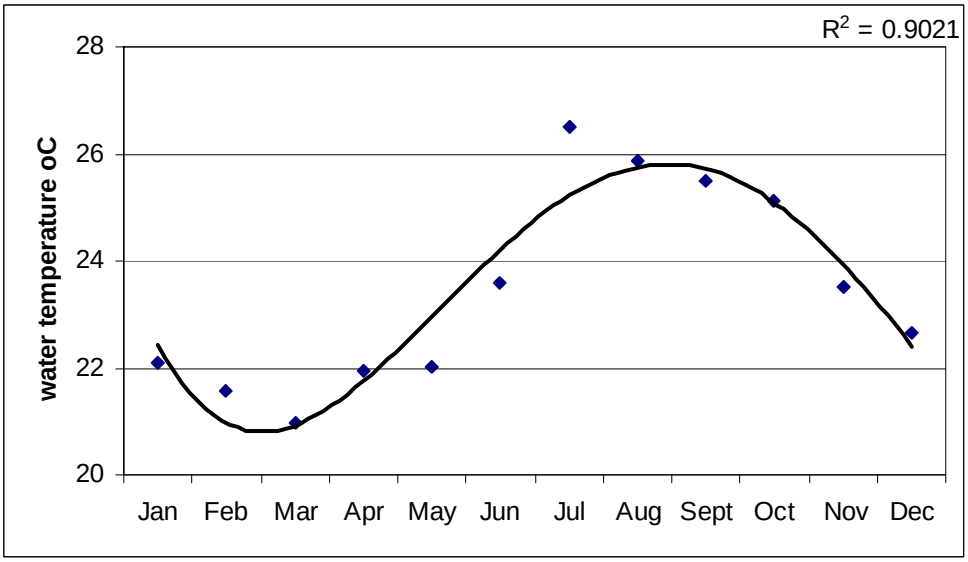


Fig. (10.4): Thermohaline structure of the coastal waters in front of the Industrial Complex

Salinity

Monthly average for six stations (n=6) of water salinity in front of the Industrial Complex is shown in Fig. (10.5). Salinity variations during the year were very low and mostly fall under instrumental noise. This is a typical behavior of waters of the Gulf Aqaba, where changes in salinity both with time and depth are extremely small. This is attributed to the lack of fresh water inputs like the precipitation and great depth of the Gulf as well as the efficient exchange with waters of the Red Sea.

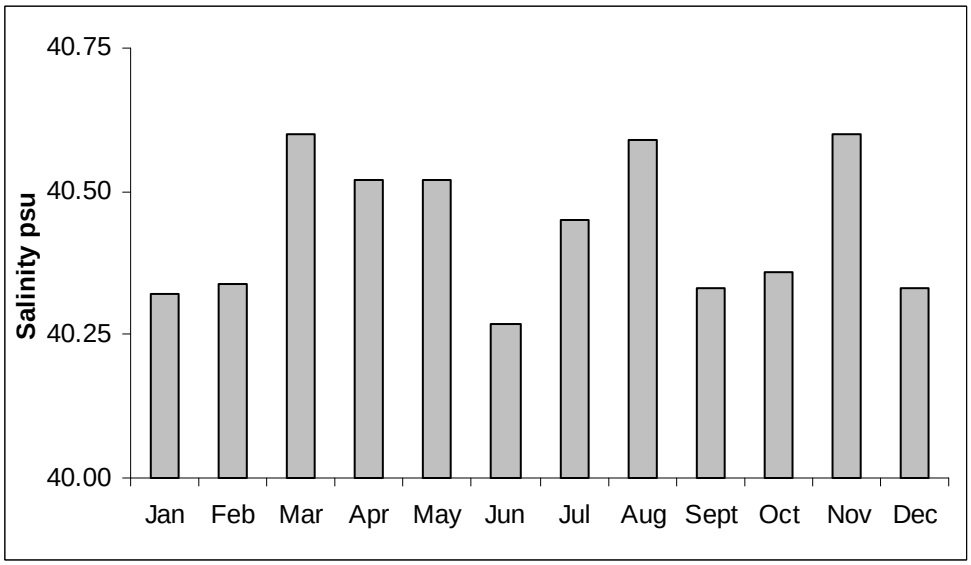


Fig. (10.5): Annual records of salinity of the coastal waters in front of the Industrial Complex on Gulf of Aqaba, Red Sea

pH

Records of monthly average pH (n=6) of the seawater in front of the Industrial Complex are shown in Fig. (10.6). pH also showed minor variations. This is typical not only for waters of the Gulf of Aqaba, but for all coral reef waters which are usually saturated with calcium carbonate and act as a buffer resisting any change in the pH.

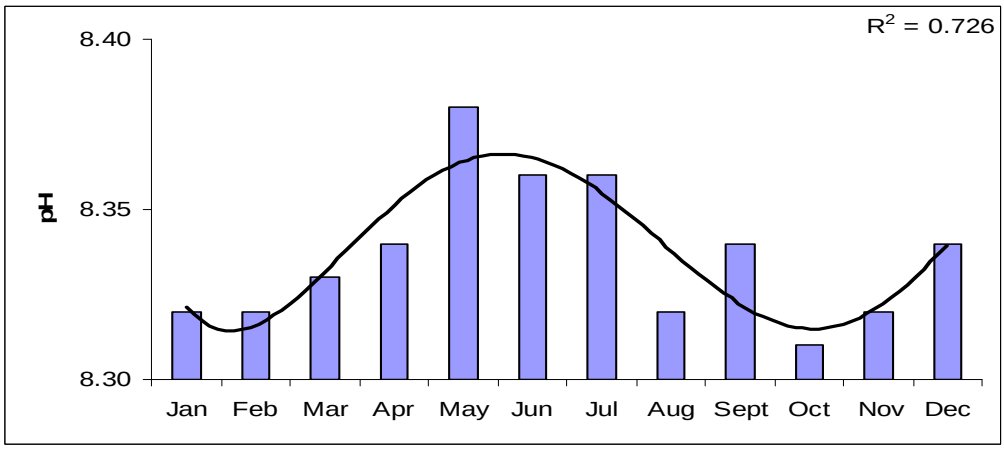


Fig. (10.6): Monthly readings of pH values for the coastal waters in front of the Industrial Complex on Gulf of Aqaba, Red Sea

Dissolve oxygen

Records of the monthly average dissolved oxygen concentration of the seawater in front of the Industrial Complex are shown in Fig. (10.7). Dissolved oxygen concentration in any seawater system is controlled by photosynthesis, respiration, decomposition, ventilation, temperature and salinity. Dissolved oxygen concentration shows a regular pattern opposite to that of temperature. The concentrations recorded are in fact the saturation concentrations Fig. (10.8). Waters of the Gulf of Aqaba are very well balanced in terms of respiration and photosynthesis and well ventilated due to the annual deep mixing. This leaves temperature and salinity as the two main factors controlling the dissolved oxygen concentration, because of the strong dependence of oxygen solubility on these two variables.

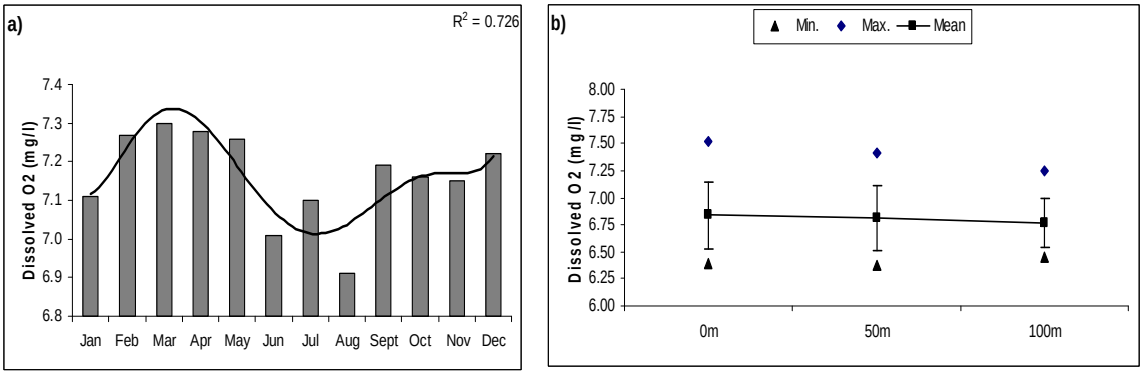


Fig. (10.7): Monthly average records of Dissolved O_2 (a) and mean O_2 values at three depths in front of the Industrial Complex (b)

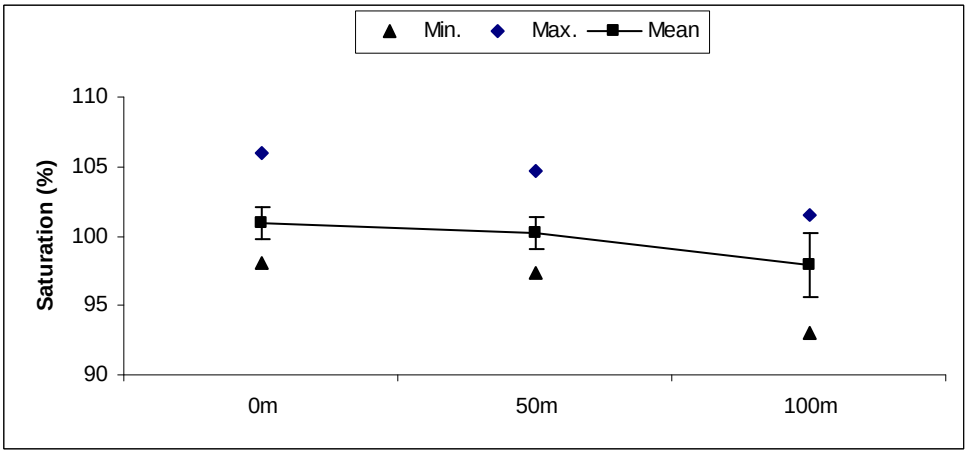


Fig. (10.8): The mean saturation level of O_2 concentration at three depths in front of the Industrial Complex

Ammonium, nitrate and nitrite

Records of the monthly average ammonia, nitrate and nitrite concentrations in the seawater in front of the Industrial Complex are shown in Fig. (10.9)

Ammonium concentrations fluctuated irregularly around 0.25 µM, with higher concentrations during winter months especially in January and February as a result of a mixing condition. Ammonium has high reactivity in the biogeochemical processes and the relatively high uncertainty in its analysis as compared to other environmental variables (Badran *et al.*, 1999; Richter *et al.*, 2001). Both nitrate and nitrite concentrations during the year showed a regular shift from summer low to relatively high early winter values. The typical behavior of these two nutrient species is that they vanish in summer and appear in winter. This is due to their rapid consumption by primary productivity during summer and the thermal stratification in the water column that prevents new

inputs to reach the euphotic zone from deeper waters. Nutrient concentrations build up in deep water during summer because the efficient decomposition of organic matter and the lack of primary productivity. In winter the water column is well mixed and whatever is consumed by primary productivity is substituted for or even exceeded by entrainment from deep waters. Comparison between different years shows very good similarity in both the magnitudes and the general annual patterns.

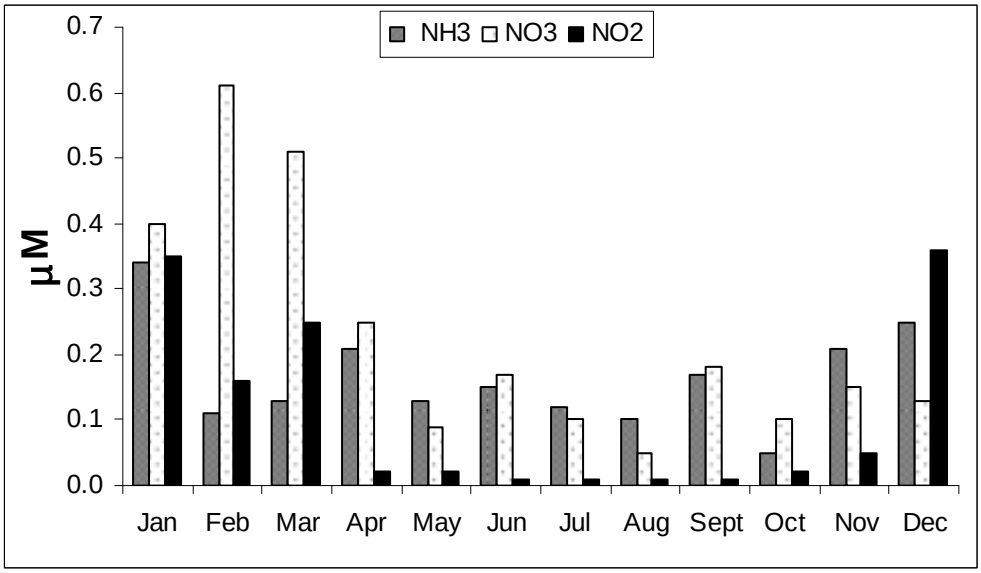


Fig. (10.9): Monthly averages of ammonia, nitrate and nitrite concentrations of seawater in front of the Industrial Complex

Phosphate and silicate

Records of the monthly average phosphate and silicate concentrations in the seawater in front of the Industrial Complex during one year period are shown in Fig. (10.10). Typical of oligotrophic waters, phosphate concentrations were low and higher during winter comparing to summer. However, seasonality in phosphate concentrations was not clear as for nitrate and nitrite. Irregularity of the pattern at the Industrial Complex site is attributed to intrusion of soluble phosphate. In fact, it is impossible to prevent phosphate to get into the seawater here. It can reach by wind, with cooling water and during shipment. However, a small amount of raw phosphate reaching the Aqaba seawater is not seriously dangerous. This is because phosphate rock is insoluble in seawater. Besides, even soluble phosphate can be only of minor significance, because it has been almost established that nitrogen rather than phosphorus is the primary productivity limiting nutrient (Badran and Foster, 1998; Badran, 2001). This means that anthropogenic phosphorus can be assimilated only if surplus nitrogen is available. Phosphate and

silicate, which have deep water reservoirs, have decreased considerably in the upper 50 m. Nitrite concentration has also decreased substantially and the characteristic subsurface nitrite maximum at 75-100 m has appeared. Similar conditions prevailed also in May and June, where low nutrient concentrations appeared in the upper water and relatively high concentrations below the thermocline. Worth mentioning is the silicate concentration minimum that appeared between 50 and 125 m during May. The nutrient story in July was similar to that of June; low in the upper water and high in the deep. Nitrite concentration subsurface maximum, still exhibited a broad peak between 100 to 200 m.

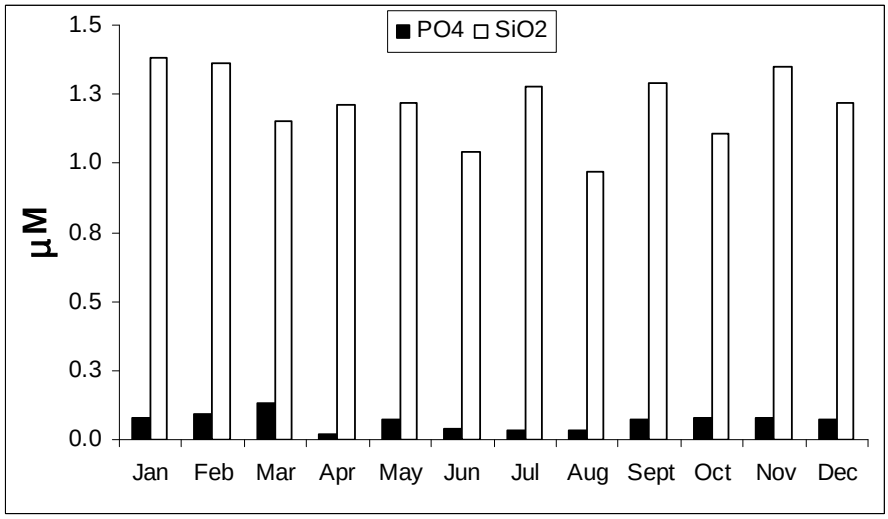


Fig. (10.10): Monthly records of reactive phosphorus and silicate during one year period in the coastal waters in front of the Industrial Complex on Gulf of Aqaba, Red Sea

Silicate concentrations in the euphotic zone during one year period fluctuates between (1.0-1.4 µM). These levels are similar to other stations along the Jordanian coast and this indicates that there are no significant changes in the basic characteristics of the coastal water in front of the fertilizers Industrial Complex. However, silicate concentration reported herein is higher than the concentrations in other oligotrophic waters, for example the Sargasso Sea (0.30 µM) reported and Bab el Mandab in the Red Sea (0.30 µM). This might be attributed to the desert enclosure of the Gulf of Aqaba and dissolution of silicate carried by the winds flowing from the desert.

Chlorophyll a

Records of the monthly average Chlorophyll *a* in the seawater in front of the Industrial Complex during the one year period are shown in Fig.

(10.11) Chlorophyll *a* repeatedly exhibited homogeneous values down to the depth of the thermo-haline (Pycnal) mixed layer. The increase of chlorophyll *a* concentration indicates elevated primary production and higher manifestation of nutrients into chlorophyll *a*.

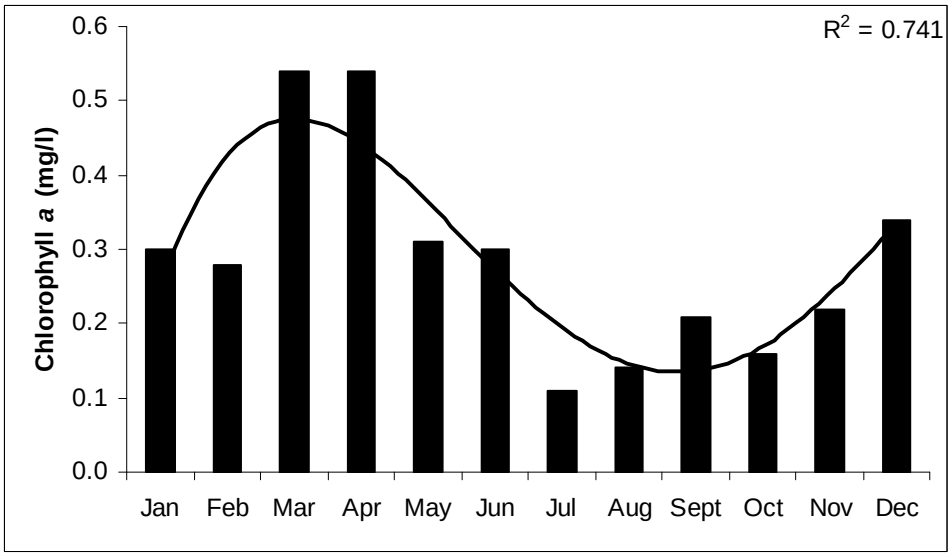


Fig. (10.11): Monthly records of chlorophyll a during one year period in the coastal waters in front of the Industrial Complex on Gulf of Aqaba, Red Sea

10.3.2 Sediment Quality

Bottom surface sediments in front of the Industrial Complex are typical coral reef sediments and consist mainly of fine to coarse sand. The upper layer (5cm section) of the bottom surface sediments is adequately oxygenated and the concentrations of organic carbon and organic nitrogen are moderately low, comparable with those of sediments from other parts of the Gulf of Aqaba. Ignition loss values are much higher than the organic carbon concentrations. This is attributed to calcium carbonate decomposition and oxidation of the possibly existing sulphur upon ignition. Trace metal concentrations measured exhibited a moderate temporal increase. The concentrations of heavy metal concentrations are in the normal range of similar sediments both from the Gulf of Aqaba and other coral reef environments.

<u>Physical properties of the sediment</u>

Color and odor

The color of the bottom surface sediments is shown in Fig. (10.12). Weights were given to the different sediment colors. White sediment has

been given 1, white-gray 1.5, gray 2, gray-black 2.5 and black 3. The tendency is that more whitish sediments were available at deeper water. However, no distinctive smell was detected for any sample at any depth in either month. This is an indication of well oxygenated sediments and a sign that the deviation from the white color is mainly due to the sediment mineral composition rather than accumulation of organic matter or that organic matter concentrations do not build up to high levels nor do they last for too long. The carbonate composition and the unconsolidated nature are the main factors behind such well oxygenated conditions.

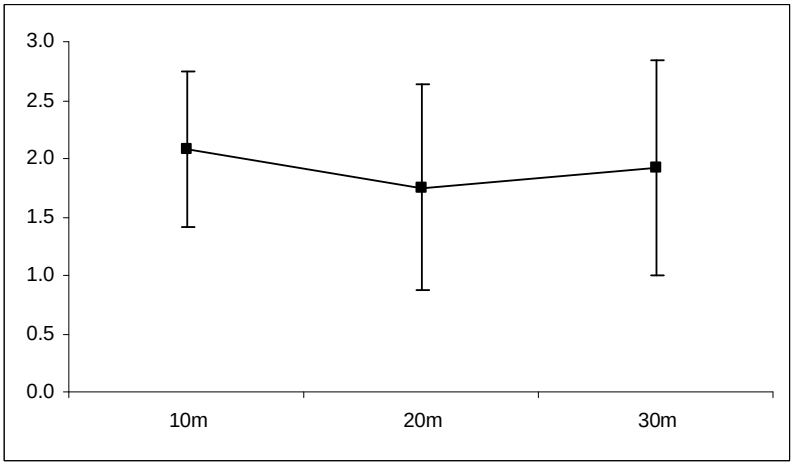


Fig. (10.12): Color code of bottom surface sediments at 10, 20 and 30 m depths (where 1 refers to white sediment, 1.5 = white-gray, 2 = gray, 2.5 = gray-black and 3 = black)

Grain size

Fig. (10.13) shows the cumulative percent of bottom surface sediment grain size, recorded according to the geometric scale of Wentworth, as mesh size ($-\log_2$ of the sieve porosity in mm). Sediments of the mesh size 1-4 (fine, medium and coarse sand) at most stations comprised around 70% for all depths. The silt and clay fractions (mesh size > 4; < 63 µm) were considerably low. Sediments at 10 m were clearly coarser than at higher depths, meanwhile the silt and clay fractions were a bit higher close to the cooling water pipe. This can be attributed to the flux of cooling water that removes the fine sediments from the immediate vicinity and redistributes them by the aid of induced currents. This is supported by the fact that the fine sediments have not been associated with anoxia, which indicates that they are recent deposits continuously reformed by currents and that their retention times are relatively short.

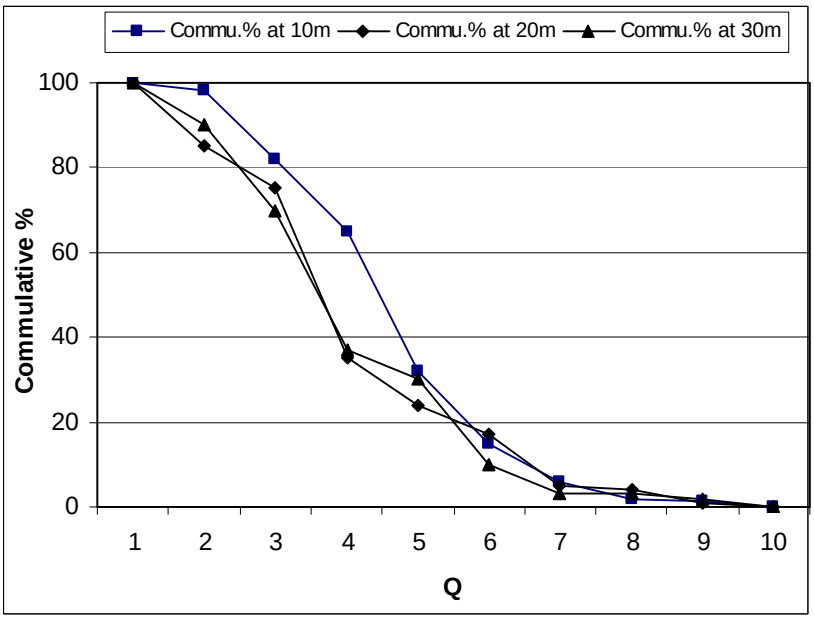


Fig. (10.13): Grain size distribution of the bottom surface sediments at 10, 20 and 30 m depths in front the Industrial Complex

Chemical properties of the sediment

Ignition loss

Fig. (10.14) shows the ignition loss values (g/kg) at three depths of the industrial site. No regular ignition loss pattern was shown with depth. Ignition loss is a simple and economic technique for estimation of total organic matter in sediment. Coral reef calcium carbonate sediment tends to lose weight upon ignition due to carbonate partial decomposition and conversion to calcium oxide or even being lost as carbon dioxide. Sulphur could also oxidized by heat. Hence the ignition loss might increase at stations composed of calcium carbonate fraction or sulphur in the bottom surface sediments. Generally, variations in the bottom surface sediment ignition loss values can also be attributed to external factors related to handling of the final product and raw material as well as to natural processes associated with current transport of bottom sediments and stationary re-suspension.

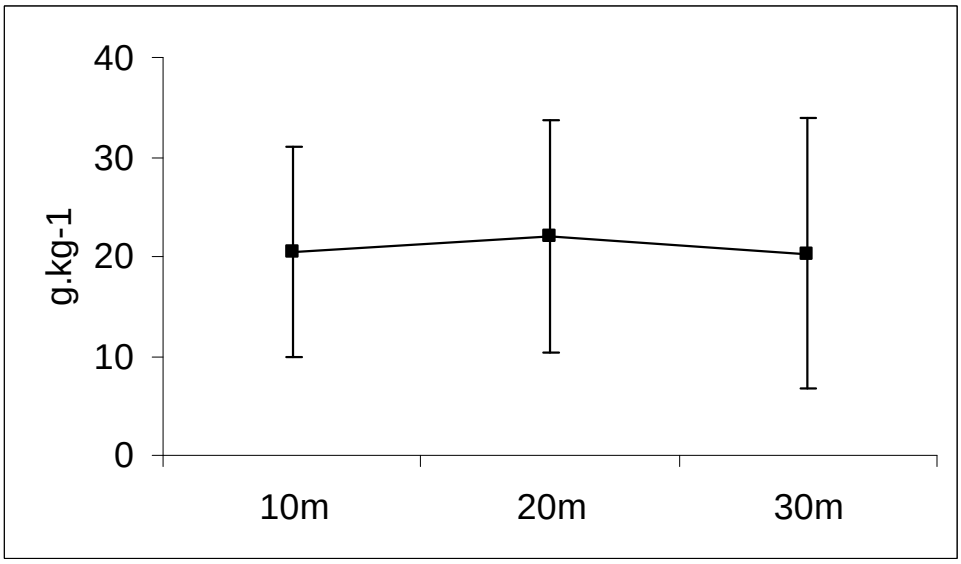


Fig. (10.14): Ignition loss (g/kg) of bottom surface sediment at 10, 20 and 30 m depths in front of the Industrial Complex

Organic carbon

Fig. (10.15) shows the organic carbon concentrations (g/kg) at the three different depths. No regular organic carbon concentration pattern was observed with depth. However, the mean values ranged between 1.46 and 2.01. At 20 m depth a slightly higher concentration than other depths but with no significant differences were observed. Yet organic carbon concentrations still comprise around 5%-10% of the ignition loss. In general, the high organic carbon concentrations occurred where and when the high ignition loss occurred.

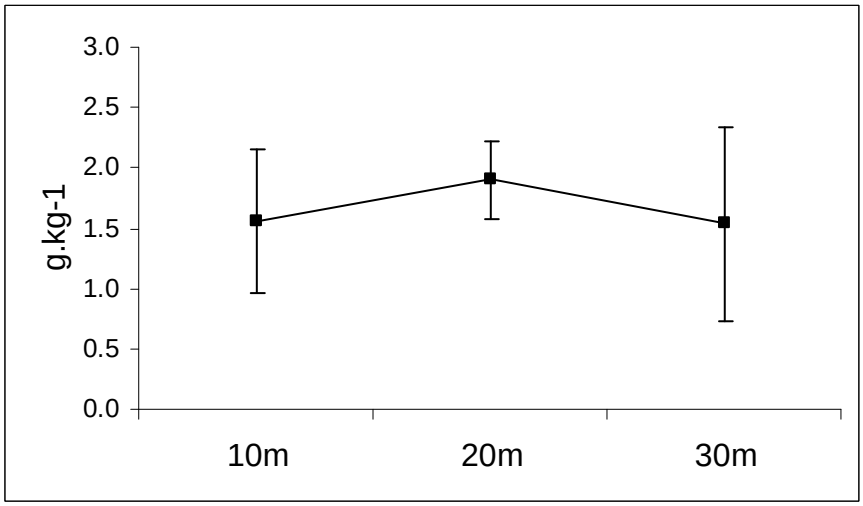


Fig. (10.15): Organic carbon content (g/kg) of bottom surface sediment at 10, 20 and 30 m depths in front of the Industrial Complex

Sulfides

Hydrogen sulfide concentration (mg/kg) is shown in Fig. (10.16). The Mean sulfide values were still relatively low and ranged between 0.25 and 0.39 mg/kg. No significant differences have been observed between the depths indicating well oxygenated bottom sediments.

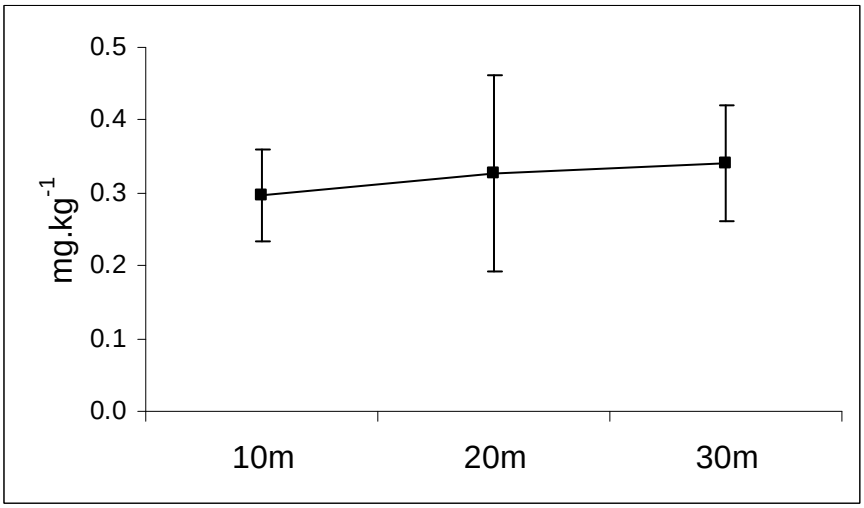


Fig. (10.16): Hydrogen sulfide concentrations of bottom surface sediment at 10, 20 and 30 m depths in front of the Industrial Complex

Total nitrogen

Fig. (10.17) shows the total nitrogen and phosphorus concentration (mg/kg). The results did not show any significant differences between different depths in all sampling sites. The lack of seasonal variations in total nitrogen concentrations do not help in identification of characteristic seasonal patterns since none regular seasonal patterns could be defined. A possible reason is that the half-life time of organic nitrogen in marine sediments, especially in warm environments is relatively low due to fast decomposition and rapid recycling (Rasheed *et al* 2002). Similar to organic nitrogen, total phosphorus concentrations exhibited a rather low seasonal variation. Comparison between records of the past years revealed that the highest concentrations were in mid spring both in range and magnitude. The highest concentration was recorded at 20 m depths.

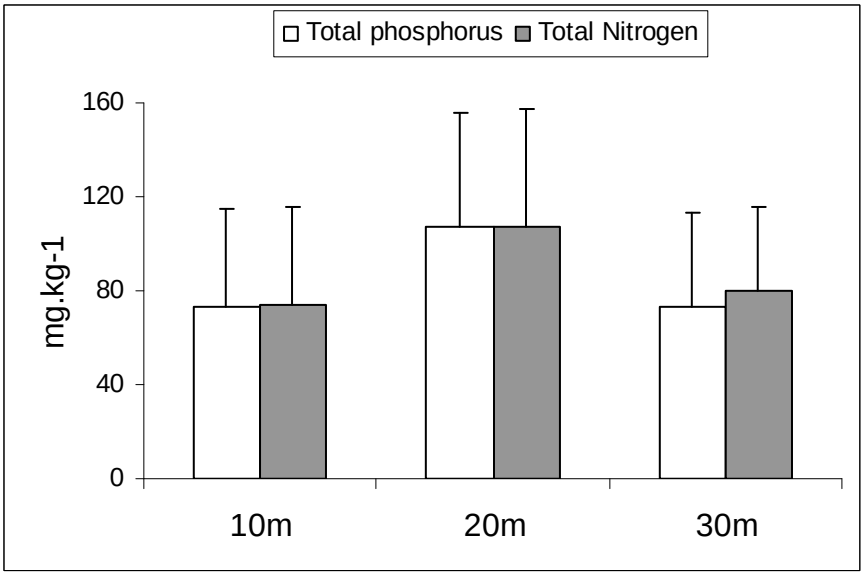


Fig.(10.17): Total nitrogen and Total phosphorus concentrations (mg/kg) of bottom surface sediment at 10, 20 and 30 m depths in front of the Industrial Complex

Trace metals

Concentrations of the trace metals cadmium, chromium, copper, lead and zinc in bottom surface sediments are shown in Fig.(10.18). Concentrations of cadmium and copper in addition to zinc were generally low. Concentrations of lead and chromium relative to the other metals were generally high. No regular patterns with either time or space could be noticed. Short time variability in minor and trace constituents of bottom surface sediments, which counteract persistence of regular patterns, is not uncommon. This is due to patchiness, instantaneous inputs especially in ports and industrial sites, rapid biogeochemical recycling and current and wave disturbances. Nevertheless heavy metals concentrations in front of the Industrial Complex are comparable to average concentrations recorded previously at different sites along the Jordanian coast (Abu-Hilal and Badran, 1991). Long term comparison of heavy metal concentrations revealed that there was a tendency to a slight increase in the concentrations, especially in the concentrations of cadmium and lead.

Heavy metal concentrations in the marine environment can be monitored in sediments water and biota. Sediment may help in identifying industrially affected areas and use of sediment cores may provide a historical record of the heavy metal burden. However, the concentration depends on many physical and chemical factors such as sedimentation rate and organic carbon content.

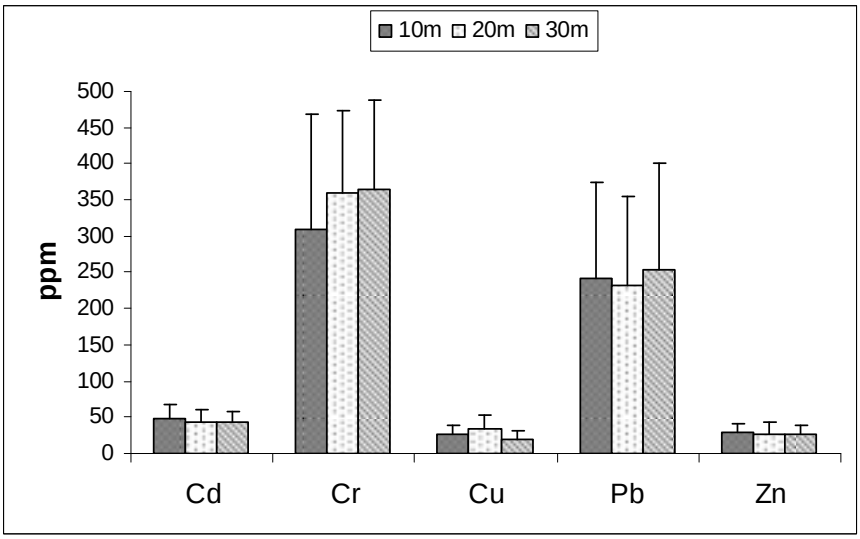


Fig. (10.18): Heavy metal concentrations (ppm) of bottom surface sediments at 10, 20 and 30 m depths during June 2001 and May 2002

10.3.3 Fish assemblages at the Industrial Complex

The number of species recorded was about 150 fish species all of which belonged to 29 families. The frequency of appearance of all investigated fish families indicated that two main families were the most frequently seen in the entire area (Fig. (10.19)). Both the pomacentridae and labridae exhibited the highest appearance at the both depths monitored (6 and 12 m). Minimum appearance however was seen in families that are mostly commercial fish since all these fish families are commonly of low abundance.

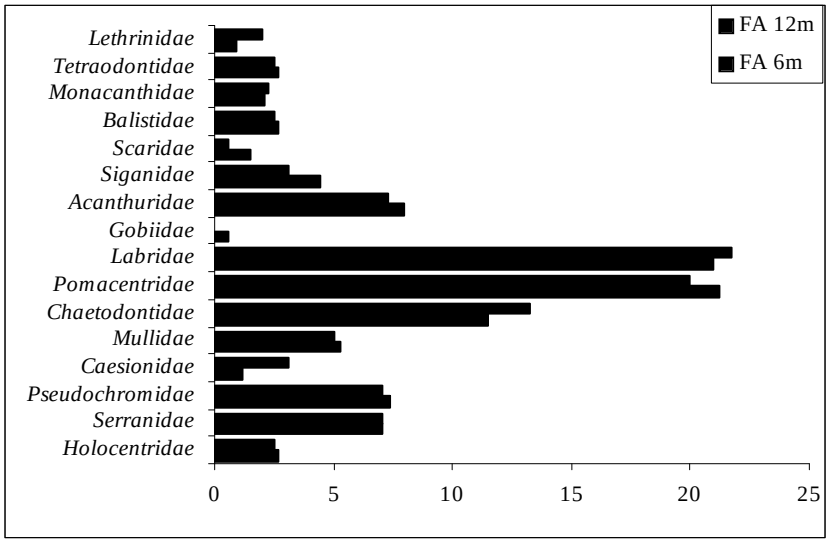


Fig. (10.19): Frequency of appearance of fish family at 6 and 12 m depths at the Industrial Complex

Similarly, the relative abundance at the two depths was consistent with the results on the frequency of appearance. (Fig. (10.20)). However, the relative abundance of pomacentridae was higher at both depths revealing and significant dominancy of this family at all zones of the studied area.

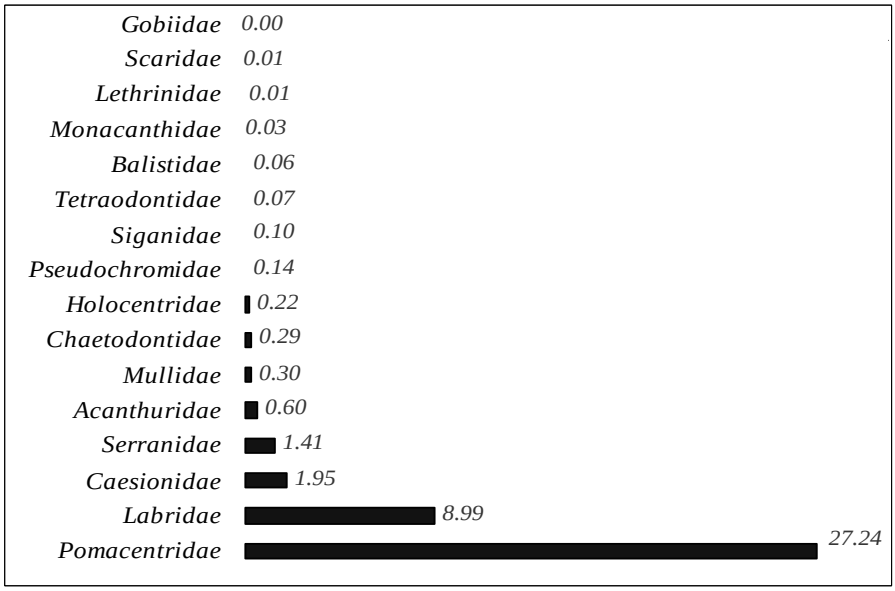


Fig. (10.20): Relative abundance per family as observed at the Industrial Complex

Species richness at the entire site revealed no significant difference between zones as well as between depths except that at the 6 m depth of Zone I. Richness values by zone and depth are shown in Fig. (10.21).

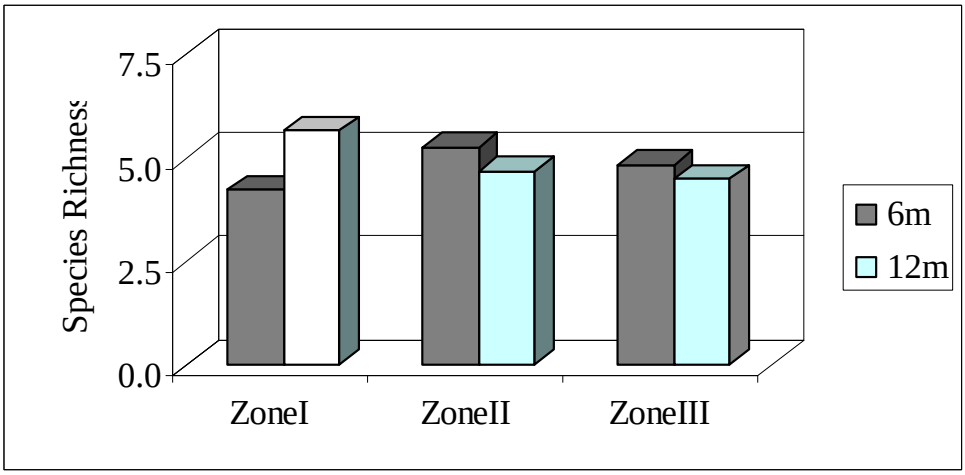


Fig. (10.21): Species richness at 6 and 12m depth in the three zones of the Industrial Complex

The dominant living habitats were certainly coral complex and to some extent seagrass and sandy beds. This study demonstrates the difference between the fish community assemblages in different zones relative to the extent of industrial activity impacts within each zone. Fishes were most abundant at the coral reef dominated sites at 12 m depth and less abundant at seagrass and sand dominated zones. The coral reef habitats exhibited the largest number of species.

The frequency of appearance of all species revealed that the zooplankton feeding fish were more frequent. These groups of fish are observed in large schools and usually inhabit the upper layer of water column associated with coral reef. All species that belongs to *pomacentridae* are plankton feeders and at the same time of less commercial value. Abundance and appearances of these fish in front of the Industrial Complex does not differ much from other sites along the entire coastline (Khalaf and Kozchius, 2003a). The frequency of appearance shows the percentage frequency of the family appearance. *Pomacentridae, Labridae, Chaetodontidae* and *Acanthoridae* are more common and can be seen frequently compared to the others. Whereas, *Letherinidae, Gobbiidae* and *Monacanthidae* were quite fewer in appearance among others. *Gobiidae were* only observed at shallow depth which usually inhabits the intertidal zone down to depth of 8 m. The reasonably higher frequency of appearance (50-98%) for many fish species could be an indication of good well being of the site. Deep water sites have shown higher species richness and abundance which might be due to the high productivity at this depth.

In conclusion, the analysis of the dominant taxa and fish community parameters revealed that *Labridae* and *Pomacentridae* dominated the ichthyofauna in terms of species richness and was the dominant family in terms of relative abundance. Finally, there was no major negative change in species composition, species richness and species distribution. The conditions are nearly similar to those observed in the other sites along the Jordanian coast.

10.3.4 Environmental quality of the benthic communities in front of Industrial Complex

Coral species at the site

Number of species of each genus was counted at the entire site (Fig. (10.22)).

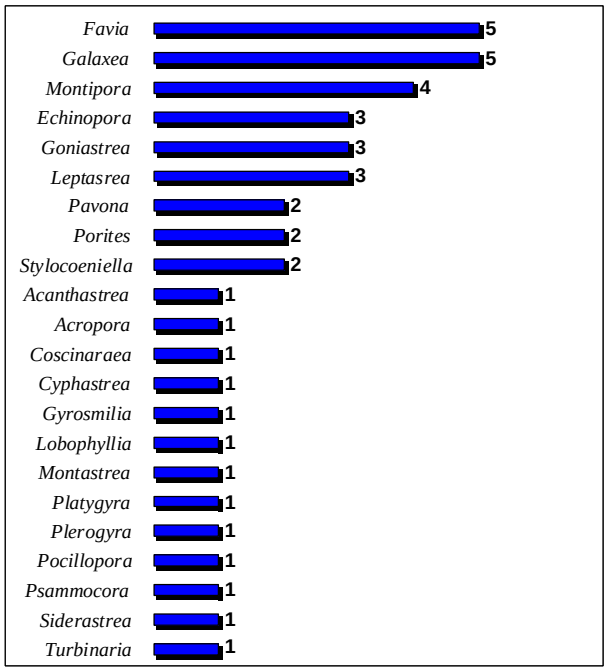


Fig.(10.22): Living hard coral genera and the number of species counted at the study site

A total of 42 hard coral species were recorded, among which Favia sps., Galaxea sps and Montipora sps were the most abundant. The bottom habitat is mainly rocky like other coral reef sites along the Jordanian coast of the Gulf of Aqaba. Some structural modifications were noticed at certain places of the study site mainly due to construction activities. It was therefore noticeable that hard coral abundance and cover were slightly perturbed.

Mean cover of benthos at the two depths in the entire site

The mean cover on coral and macro benthic invertebrates are presented in Fig. (10.23). The trend of cover profile was similar at both depths.

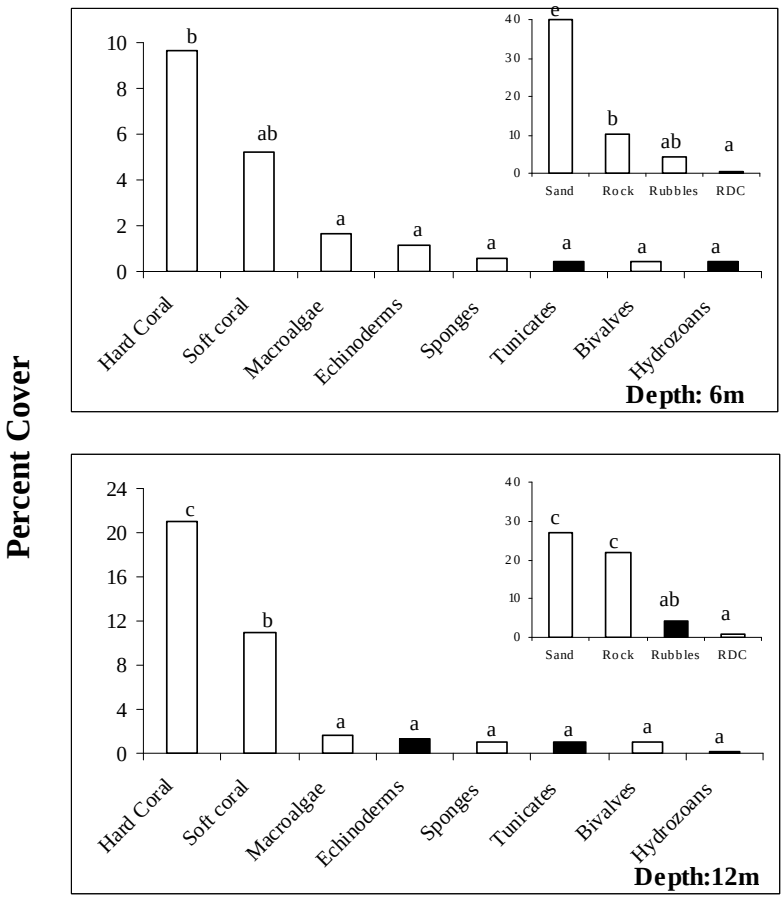


Fig. (10.23) Mean cover of hard and soft coral and the different macro invertebrate at two depths of three zones at the industrial site. Bars marked with different letters are significantly different at *P*<0.05

However, a significantly higher cover of hard and soft corals was observed at 12 m in comparison to that at 6 m. Similar profile was also noticed in the non-biotope substrata at the two depths with significantly higher cover at shallow water. However, there was no significant difference in covers of all investigated macro invertebrates between the two depths that both show considerably low covers 0.1-2%.

Mean cover of benthos at the three zones in the entire site

From the collective data of the three years study, all macro invertebrates investigated have shown very low cover that ranges between 0 - 3 % at the three zones (Fig. (10.24)). Hard coral was more abundant at Zone II and reach about 24%. However, the difference was insignificant (P<0.05) between the three zones. The soft coral was more abundant at Zone III and showed highly significant difference (P<0.01) compared to the other

two zones. The non-biotope substrata including the recently died corals (RDC) showed minimum cover in Zone I.

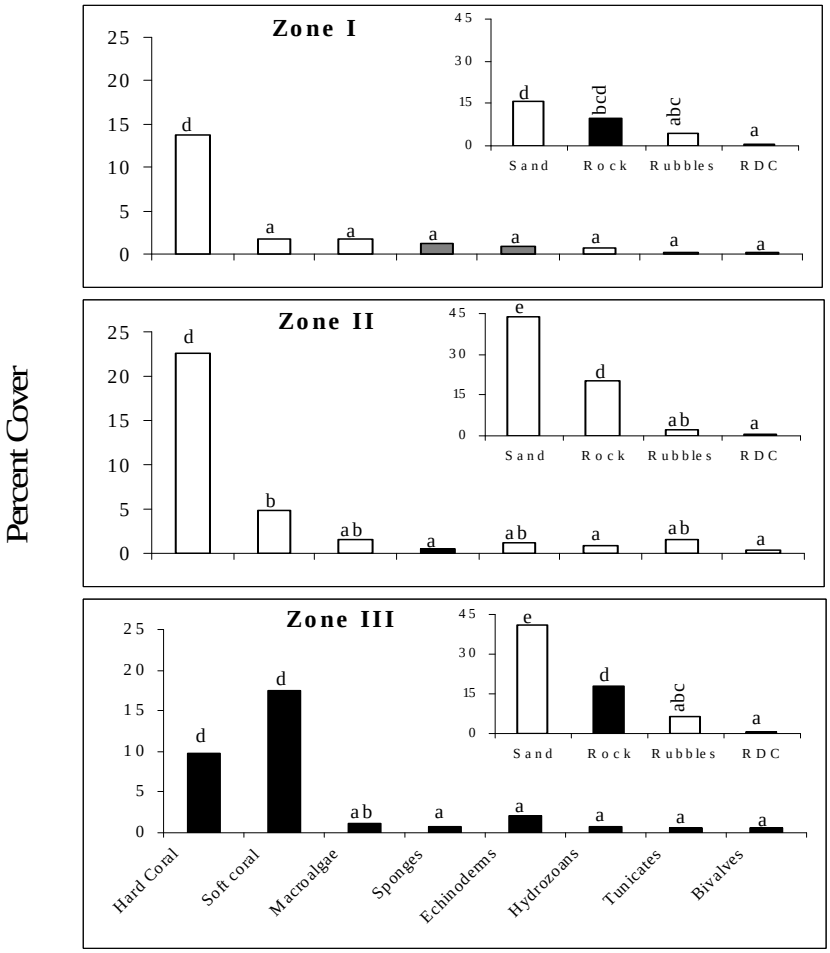


Fig. (10.24): Mean cover of hard coral, soft coral and other macro invertebrate at three zones at the industrial site. Small plots show the %cover of the non-living substrata at each zone. Bars marked with different letters are significantly different at *P*<0.05

An overall average of mean cover at the entire site of both depths showed that hard coral was the highest (about 15%) followed by the soft coral (8%). The macro benthic invertebrates were also very low in cover with a range between 0 - 3%. A similar profile was observed in the non-biotope substrata (Fig. (10.25)).

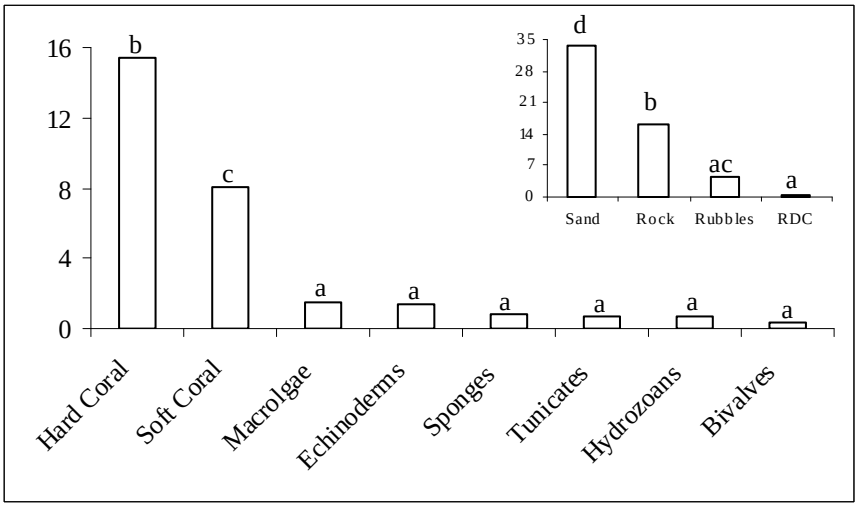


Fig. (10.25): Mean cover percent of the different investigated macro benthic fauna at the whole site of the Industrial Complex during three years period. Small figures show the %cover of the non-living substrata at each zone. Bars that bear different letters are significantly different at P<0.05

Cover relationship between hard and soft coral at the two depths

Exponential relation was plotted for the two items (Fig. (10.26)). The most obvious difference was in mean cover values of hard and soft corals at Zone II and Zone III at both depths. Highest mean cover values for both hard and soft coral were observed at Zone II at 12 and 6 m, respectively. The lowest mean cover values were observed at Zone III at the two examined depths (12 and 6 m).

Hard coral represent the most important component of the entire coral reef ecosystem along the coast of Gulf of Aqaba. Whereas, soft coral cover could fluctuate seasonally, its abundance in considerable amounts at a specific site might indicate certain perturbation due to anthropogenic factors. Hard coral cover did change slightly, but keeping the same trend with highest cover of 35%. The site is historically known as a well-developed coral reef area, but apparently the coral cover is considerably lower than at other sites such as the Tourist Camp, Marine Reserve and the Clinker Port along the Jordanian coast with coral cover that range from 50% to 65%. Coral cover at the Industrial Site is coral destruction during the port's construction.

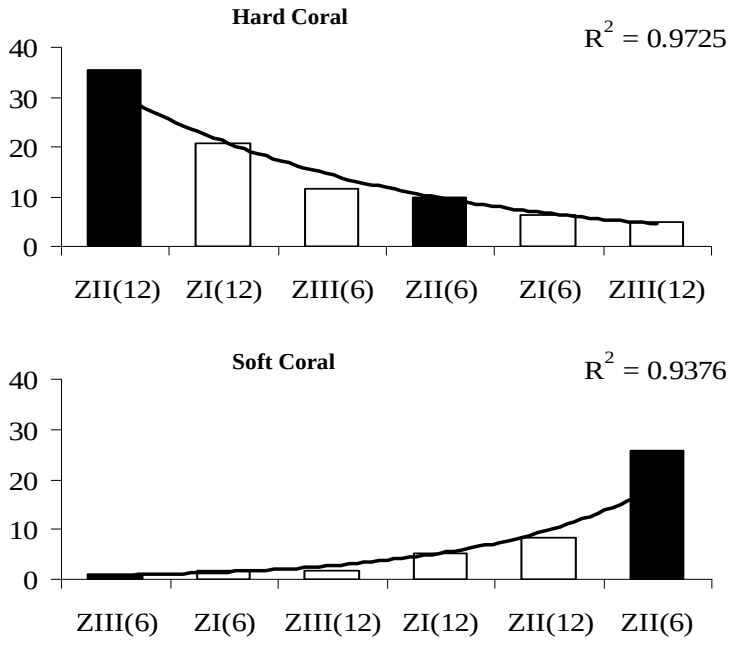


Fig. (10.26): Mean cover of hard corals (top) and soft coral (bottom) at two depths of the three zones. Stations are arranged in descending order with respect to hard corals and in ascending order with respect to soft corals

The abundance of coral competitors such as soft coral, corallimorpharians and algae was more significant in Zone III than on the more distant zones from the industrial jetty. It appears that there is a shift in the species abundance in favor of *Montipora sp.* The relative cover of the examined benthic organisms did not appear to have changed much.

The density of macro invertebrates like hydrozoans, sponges and bivalves, were surprisingly very low. Soft coral which compete with hard corals have taken the space of hard corals in very limited areas, for example Zone III. Parts of the dead coral skeleton have been overgrown out by soft corals, especially where the water current is relatively strong around the Industrial Jetty. Increase in fleshy algae at all zones was not very obvious. Reef fish density as well as the diversity, seemed to have decreased slightly in the entire area (Khalaf and Kochzius 2002a). Solid waste deposition at the shallow water of the Industrial Complex and the use of simple handling utilities are likely to result in threats to the structure and composition of coral reefs. The three zones at the industrial complex accommodate typical fringing reef habitat with considerably good coral cover reaching up to 35% at zone II. These values are very close to other known locations in Gulf of Aqaba (Fouda, 1998). Hard

coral seems impacted by port activity, especially those at shallow water and close to jetty area. Presence of disposals may negatively impact the coral health. Turbidity due to industrial activity might increase total suspended matter, decrease light availability and limit space for new larval settlement, at the same time it enhance mucus production by corals which is an energy consuming process (Te, 1992). The conditions at deep water (below 15 m) look better and not directly affected. In summary, coral degradation found in some parts at the Industrial Complex was highest in areas directly in contact with the port activity. Invertebrate counts including sea urchins, sponges, bivalves, tunicates and ascidians were relatively stable in spite of the increase in substrate cover for growth of fleshy algae. Macro invertebrates were few probably due to their ambient abundance.

10.4 Impact Evaluation

10.4.1 Phosphoric acid

Phosphoric acid is one of the most bulk transported basic chemicals. It is incompatible with strong caustics and most metals. It readily reacts with metals to form flammable hydrogen gas. The liquid can solidify at temperatures below 21°C. It is corrosive to ferrous metals and alloys. It is soluble in alcohol and hot water and can form three series of salts: primary phosphates, dibasic phosphates, and tribasic phosphates. It is a chelating agent and has a low vapor pressure at room temperature.

Behavior in the environment

When spilt into water, phosphoric acid is a strong acid which completely dissolves into phosphate ions and protons causing the release of heat. Its toxicity depends on the acidity of the substance and its effect on the pH (it is noxious for certain aquatic species whose survival requires a pH of at least 5.5). Phosphoric acid is harmful to aquatic life due to its acidity. However, it presents no danger of bioconcentration or bioamplification along the food chain. However, it pauses a danger on the water quality if large quantities infiltrate the ground and/or natural waters.

Given its high density, the acid is likely to sink if there is no agitation (Fig. (10.27)). In high concentrations, it leads to a significant decrease in pH, and therefore an acidification of the environment harmful for aquatic life. In the atmosphere, release of a gas cloud is not expected except in the area immediately surrounding the leak where acid vapors can be produced.

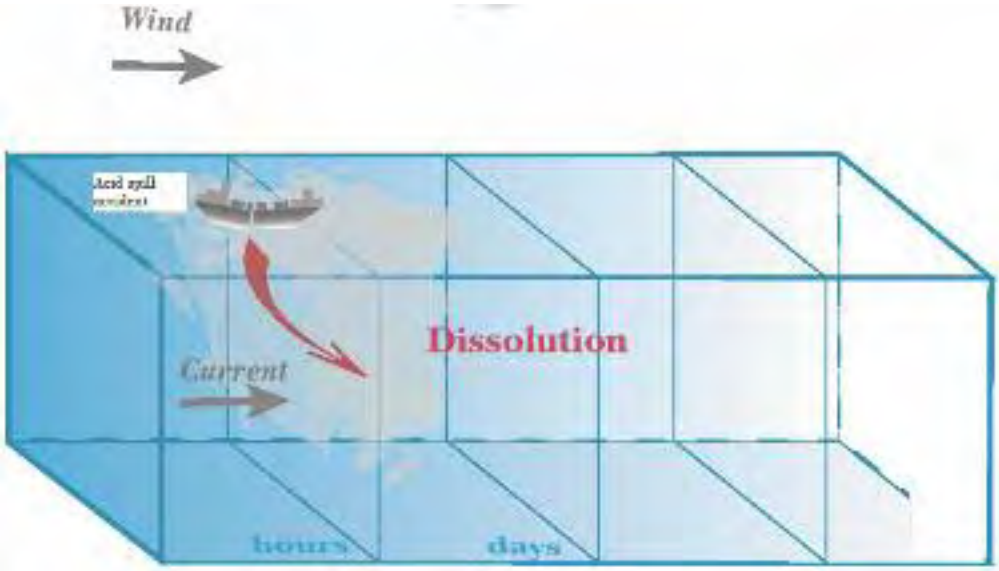


Fig.(10.27): Scenario of phosphoric acid spill in the sea and its possible dispersion by the effect of both wind and water current

Ecotoxicology

Phosphoric acid is not listed as a marine pollutant but could be harmful to fish, livestock and wildlife. It will be harmful to fish and other water organisms if pH drops below 5. This acid is highly soluble and will disperse with current (see Fig. (10.27)). Release to watercourses may cause effects down stream from the point of release. It can provide a source of phosphate nutrient which can promote algal growth in waterways. Rapid algal growth may result in eutrophication of waterways (oxygen depletion from decomposition of decaying plant matter), reducing the viability of waterways for other organisms. The pH and its fluctuation are very specific to the ecosystem in question. To estimate the effect of a phosphoric acid spill, the change in pH of the water shall be calculated or measured (continuous monitoring). Variation by one pH unit could affect flora and fauna. The average pH of water in Gulf of Aqaba can vary in seawater from 8 to 8.2 (stable pH with high buffering capacity) and in fresh water from 6 to 7.5.

Persistence in the environment

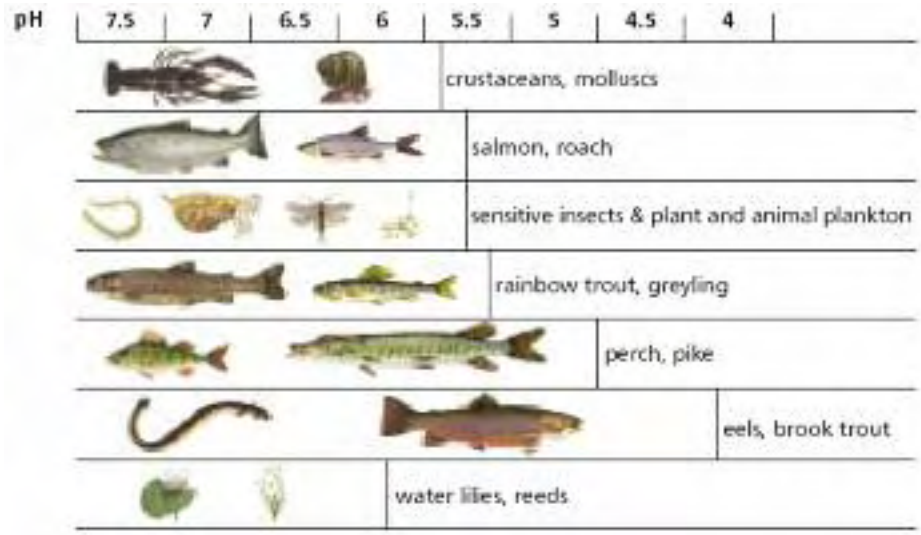
The risk presented by phosphoric acid on the environment is due to hydronium ions (pH effect). The effect of phosphoric acid therefore depends on the buffering capacity of the aquatic or terrestrial ecosystem. A pH of less than 5.5 is harmful for aquatic life. The effect of this ion is naturally reduced by dilution and in seawater by a buffering effect.

Risk for the environment

A high concentration of phosphoric acid in the water will increase the acidity of the water, which can be harmful for aquatic life. In seawater, some types of algae can survive at a pH of 6, but can not endure a decrease in pH to less than 5.5. Fresh water fish can not survive at a pH of less than 4.5. Marine organisms can not endure generally significant variations in pH.

Environmental fate

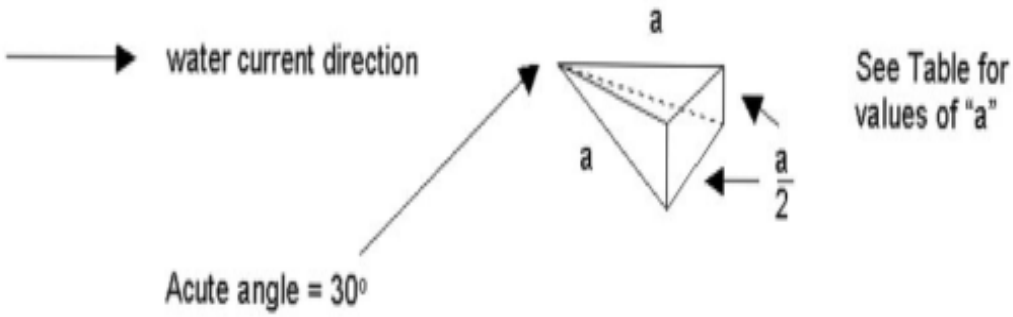
It was reported in the literature that while acidity of this material may be reduced readily in natural waters, the phosphate may persist indefinitely. The diagram below shows degrees of acidity of phosphoric acid tolerated by the fresh water environment



Is there a threat to users of the sea?

As a general rule, access to the casualty area shall be limited and activities in the area restricted. Restrictions shall be lifted once the area is declared safe. Detecting the extent of dispersion is done by a monitoring campaign involving a programme of marine life, water and sediment sampling and analyses. Analyses of dissolved chemicals in water can be done by different types of portable instruments, spectrometers, conductivity meters, fluorometers. In all cases, the background level of the uncontaminated sea-water must be known for comparison purposes.

The following diagram and table represent a simplified model that provides rough guidance on the spreading distances in the water column for an instantaneous release under steady slow surface current conditions:

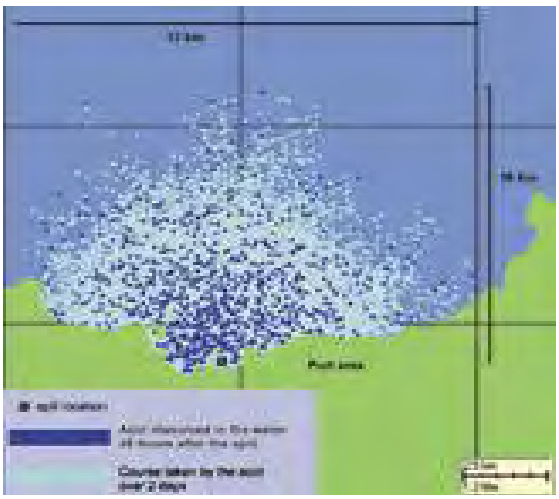


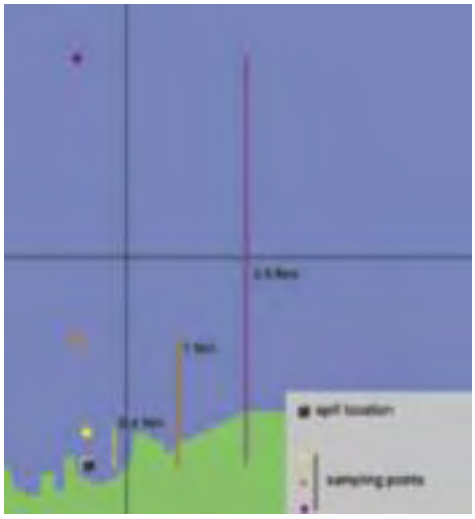
Release (tons)	Concentration (1 g/m^3)		Concentration (1 mg/m^3)	
	a metres	nautical miles	a metres	nautical miles
1	500	0.3	5,000	3
10	1,000	0.5	10,000	5
100	2,000	1	20,000	11
1,000	4,000	2	40,000	22

<u>Spill of phosphoric acid scenario at port</u>

Instantaneous spill of 100 tons of phosphoric acid were spilled on water surface under conditions of no wind and current speed of naught.

Behavior of phosphoric acid 48 hours after the release at the surface: dissolution in the water column (in dark blue) and course taken by the acid (in pale blue). 48 hours after the spill begins: Average and maximum concentrations at several sampling points





The area affected spreads 10 km north and 13 km from east to west. The acid sinks to the bottom and dissolves in the water column. The average concentrations of phosphoric acid 48 hours after the spill are around 0.035 g/l, which corresponds to a pH of 7.3. The pH can drop as low as 6.2.

Table (10.1): Analysis of concentrations and pH values

Distance from spill location to sampling point	Avg. Conc. (g/l)	pH	Max. Conc. (g/l)	pH
0.4 nautical miles (impacted 30 minutes after spill)	0.0175	5.5	0.08	1.8
1 nautical miles (impacted 9.5 hours after spill)	0.0008	7.5 (little variation)	0.08	1.8
3.6 nautical miles (impacted 15 hours after spill)	0.000025	8 (no variation)	0.08	1.8

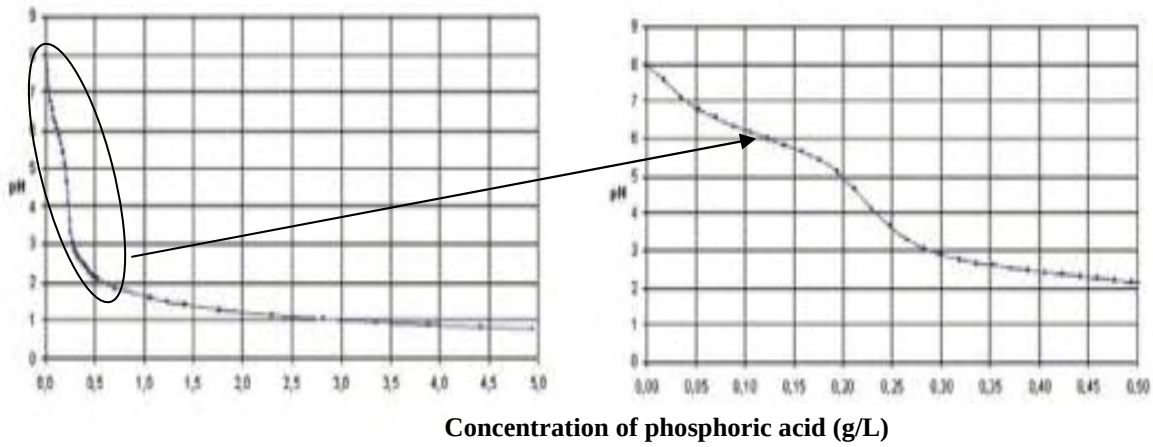


Fig. (10.28): pH values in the aquatic environment according to the concentration of phosphoric acid in the water

Soil adsorption and mobility

The exposure of soil to phosphoric aid will upset the pH of the soil and create a more acidic layer of soil. This decrease in pH often can exceed the buffering capacity of the surface layer of the soil depending upon the amount of spill. When spilled into soil, phosphoric acid will infiltrate downward, the rate being greater with lower concentration because of reduced viscosity. During transport through the soil, phosphoric acid will dissolve some of the soil material, in particular, carbonate-based materials. The acid will be neutralized to some degree with adsorption of

the proton and phosphate ions. However, significant amounts of acid will remain for transport down toward the groundwater table. Upon reaching the groundwater table, the acid will continue to move in the direction of groundwater flow. A contaminated plume will be produced with dilution and dispersion serving to reduce the acid concentration.

10.4.2 Fluosilicic acid

Fluosilicic acid (H_2SiF_6) with a concentration of 20-25% is obtained as a by-product. Fluosilicic acid is fuming colorless liquid with pungent odor. The substance decomposes by heat producing toxic fumes including hydrogen fluoride. The solution in water is a strong acid. It reacts violently with bases. It reacts with water or steam to produce toxic and corrosive fumes. It attacks glass, stoneware and many metals forming flammable gases.

Ecotoxicology and environmental information

Fluosilicic acid is toxic to aquatic organisms. Accidental spillage of fluosilicic acid may suddenly reduce pH levels in an aquatic environment. This substance may be hazardous in the environment and special attention shall be given to aquatic organisms in case of spill. However, no visible toxic effects have been observed on biological components such as plants and algae, although fluosilicic acid is moderately toxic to molluscs and fish. This acid contains phosphate and nitrogen compounds. When these chemicals get into natural water bodies -according to scientists- they fertilize explosions of opportunistic algae, which strangle other life as they compete for light and oxygen, until they essentially grow themselves to death. The acid is highly dependent on environmental conditions such as pH, temperature, oxidoreductive potential, mineral and organic content of the medium. Accidental spillage would suddenly reduce pH level due to the acidic properties and that local disastrous effects are possible.

Acid mobility in sediment or soil

The acid is adsorbed on minerals of soil constituents (the proton occurring in clay may assist with neutralization as well as may dissolve carbonate based materials). Some material may remain for transport down towards the water table reaching the ground water table. Remnants of the acid may continue to move, in the direction of the ground water flow.

10.4.3 Sulphur

Sulphur does not react rapidly in water or in air without initiators, but it is highly corrosive when it is wet due to the formulation of acids. Sulphur is a component of the natural environment. There is a natural cycle of oxidoreduction reactions that transform sulphur into organic and inorganic compounds. It is insoluble in water as well as in the majority of known organic solvents.

Exposure control / special protection

It is important to avoid the accumulation of powder in the air since it could cause an explosion. Control should be sensitive to the impact of a moderate mechanical explosion while the likelihood of explosion grows when there are small particles in the air exposed to static charge.

10.5 Mitigation Measures

10.5.1 Phosphoric acid

Response when spilled to sea

Phosphoric acid is likely to cause serious risk to the marine environment when spilled. Therefore, mitigation measures are essential in order to allow best handling, storage, loading and unloading processes of the phosphoric acid. So, all fittings shall be properly secured prior to energizing loading/unloading system. Care should be taken to avoid acid contact when disconnecting lines/hoses after unloading. The pipe from the storage yard to the jetty shall be inspected regularly.

Quantity of the acid that dissolves in water depends on salinity and temperature. When phosphoric acid comes into contact with the sea (rapidly dilute the acid concentrations and reduce heat production), the response action on the main cause (tanks, pipes, tankers) shall consider the precautions outlined below:

a. The accident area will be approached upwind (wind direction behind) equipped with personal protective equipment. The number of responders in the risk area shall be kept to a minimum.
b. In theory, the action of phosphoric acid could be neutralized in shallow waters and in limited quantities using soda bicarbonate. However, buffering capacity in seawater might help in neutralizing the acid. Furthermore, phosphoric acid was reported to sink into the shallow waters but did not spontaneously mix with the water.

Response actions in the event of spill into a water column

- Measure concentrations
- Regularly monitor the pH and water temperature
- Establish exclusion zones (fishing, water intakes)
- Ecological monitoring of water and sediment chemistry and benthos census

Tank container trucks

Phosphoric acid is transported in liquid form in stainless steel/rubber lined carbon steel tanks. Leak-floors shall be provided underneath vulnerable equipment to prevent contamination of the soil from acid leaks during transportation.

Response actions in case of land spill

- Isolate spill or leak area immediately for at least 25 to 50 m in all directions.
- Keep unauthorized personnel away.
- Contain large spills with dikes and transfer the material to appropriate containers for reclamation.
- Absorb remaining material or small spills with an inert material and then place in a chemical waste container.
- Neutralize washings with a base such as soda ash or lime. Flush residual spill area with large amounts of water.
- Approach release from upwind.
- Stop or control leak using special protective clothing.

10.5.2 Fluosilicic acid

Road transport

The number of locomotives or frequency of trips of trucks transferring fluosilicic acid (H_2SiF_6) will be 6 trucks/day (each truck hold 35 tone) through desert. Management of fluosilicic acid emergencies shall consider the following:

1) Tankers shall have bottom discharge nozzles with no provision of compressed air on the tanks utilized for unloading purposes.
2) Clean up personnel will need personal protection equipment and respiratory protection.
3) Source of water supply and eyewash facilities may also be needed for clean up personnel.

4) Bags of neutralizing agent or chemical absorbent will be required for spill.
5) A manual tool such as shovel may be required to scoop up neutralized acid/lime/soda ash residue.

10.5.3 Sulphur

Sulphur transportation

The number of locomotives or frequency of trips of trucks transferring sulphur through desert shall be 43 trucks/day and the quantity that will be transported from JPMC to Eshidiya is 1500 ton / day. Mitigation measures that will be implemented during transporation shall include:

- Dust emissions control by the use of water sprays in the event of a dry spell during uploading and downloading of trucks.
- Prevent wind blown sulphur from entering the environment by the use of proper sheltering of material during road transport.

Sulphur handling at the jetty

The following operational mitigation measures shall be implemented to alleviate potential environmental impacts of sulphur handling to the marine environment:

- Safety personnel will visually monitor and maintain the sulphur conveyance from the jetty to the storage yard.
- Conveyors shall be maintained and properly protected using suitable covers against any loss of powder product.
- Lost particles and dust dispersion on jetty platform shall be collected continuously and timely scheduled.
- Good house-keeping actions shall be followed during handling of the product at both the jetty and storage yard.
- Provision of automatic shut down systems in case of accidents and malfunctions.

10.5.4 Other mitigation measures

- All generated debris during construction activities shall de disposed to an authorized site after getting approval from ASEZA.
- It is recommended to continue conducting the monitoring program for the marine environment that could help in defining any points of divergence.
- ASEZA is responsible to monitor construction activities to confirm they are functioning as intended.

11. CUMULATIVE IMPACT ASSESSMENT

11.1 Introduction

This chapter presents the cumulative impact assessment as a result of the proposed project (sulphuric and phosphoric acid plants, and the storage tanks for the phosphoric acid) with the existence of other industrial activities of Indo-Jordan Chemicals Company (IJCC) and JPMC mines.

11.2 Cumulative Impact Assessment on the Ambient Air Quality

This section will focus on the cumulative impact of the proposed JIFCO project and the existing industries of JPMC and IJCC stack emissions on the ambient air quality.

The activities of the existing JPMC mine could cause mainly dust and SO_2 emissions, while IJCC has sulphuric acid and phosphoric acid plants, and so it will mainly emit SO_2, SO_3, HF and dust. The available data of each existing industry stacks and emissions are shown in Table (11.1).

Table (11.1): Data related to the stacks of the existing industries at Eshidiya industrial area

Source	North Coordinate	East Coordinate	Stack Height (m)	Total Volumetric Flow Rate (Nm^3/ hr)	Effluent Gases Temperature (°C)	Max. Concentration (mg/Nm^3)	
						SO_2	HF
IJCC: H_2SO_4 plant	925300	259960	50	139,170	60	1,175 (411.5 ppm)	
IJCC: H_3PO_4 plant	925348	260156	31.1	95,310	40		1.6 (1.8 ppm)
JPMC: Dryer	926700	259800	30	39,510	57	1,063 (372.2 ppm)	

Source: IJCC plant and JPMC

The SO_2 and HF pollutants were modeled at the weather cases B1, D4 and F2 (given it Table 11.2) at the prevailing wind direction of north and west as well as at the southern wind that could carry the plants emissions to the nearby employees-complex.

Figs. (11.1) to (11.18) show the maximum ground level concentration (C_{max}) and the distance at which it occurs (D_{max} where the reference point is JIFCO stack) for all modeling cases.

SO_2 Modeling Results

C_{max} ranged between 0.025 and 0.163 ppm for all modeling cases. This occurs at all atmospheric conditions tried in the model. SO_2 modeling results are summarized in Table (11.2) below.

The maximum one-hour ground level concentration (C_{max}) of SO_2 does not exceed the maximum allowable hourly limit of 0.300 ppm specified in the Jordanian Ambient Air Quality Standard, JS 1140/2006 for the case of B1 weather condition (Figs. (11.1) to (11.9)).

At weather condition of D4, there is a possibility that the cumulative emissions of proposed and existing industries at Eshidiya industrial area could reach the employees-complex, while the forecasted maximum concentration will be 0.094 ppm, which is well below the JS hourly limit.

Table (11.2): The model estimates of SO_2 maximum one hour ground level concentration from the emissions of JIFCO, JPMC and IJCC

Stability and wind speed	Wind direction	Max. gr. level conc. (C_{max}), ppm	Distance from final absorption stack at which C_{max} occurs (D_{max}) downwind (km)
B1	N	0.163	1.0
	W	0.142	1.0
	S	0.144	2.5
D4	N	0.073	3.0
	W	0.057	2.5
	S	0.094	3.5
F2	N	0.039	11.5
	W	0.025	31.0
	S	0.046	12.0

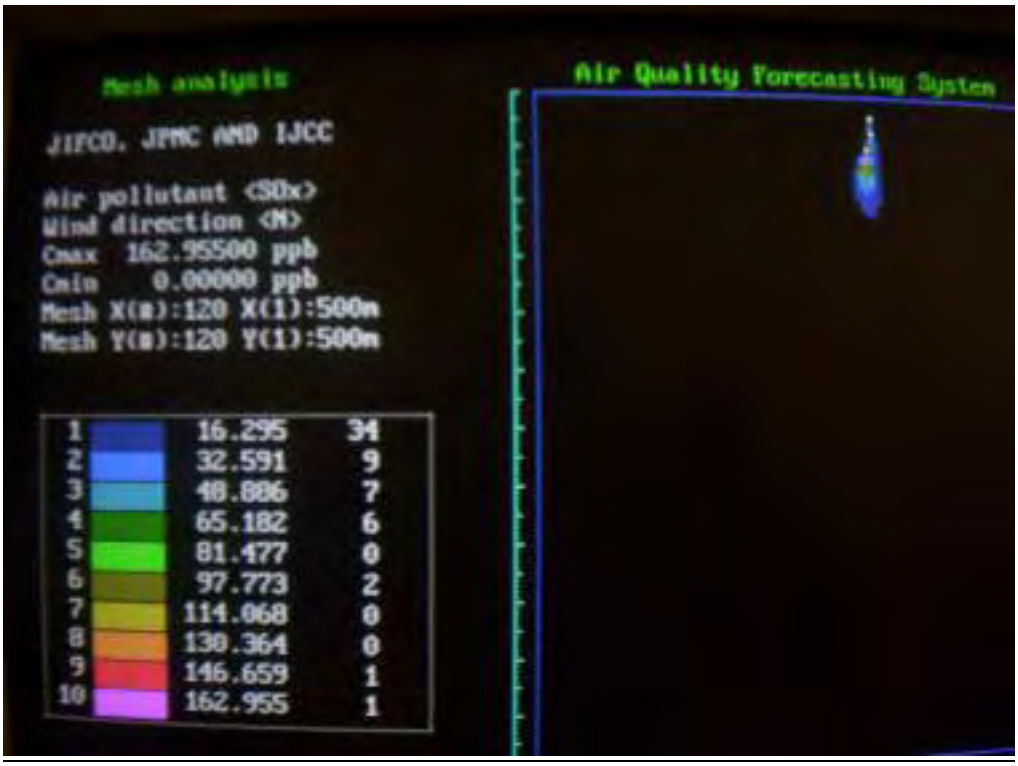


Fig. (11.1): One hour ground level concentrations of SO_2 estimated by modeling at stability class B, north wind and wind speed of 1 m/s (JIFCO, JPMC and IJCC)

Fig. (11.2): One hour ground level concentrations of SO_2 estimated by modeling at stability class B, west wind and wind speed of 1 m/s (JIFCO, JPMC and IJCC)

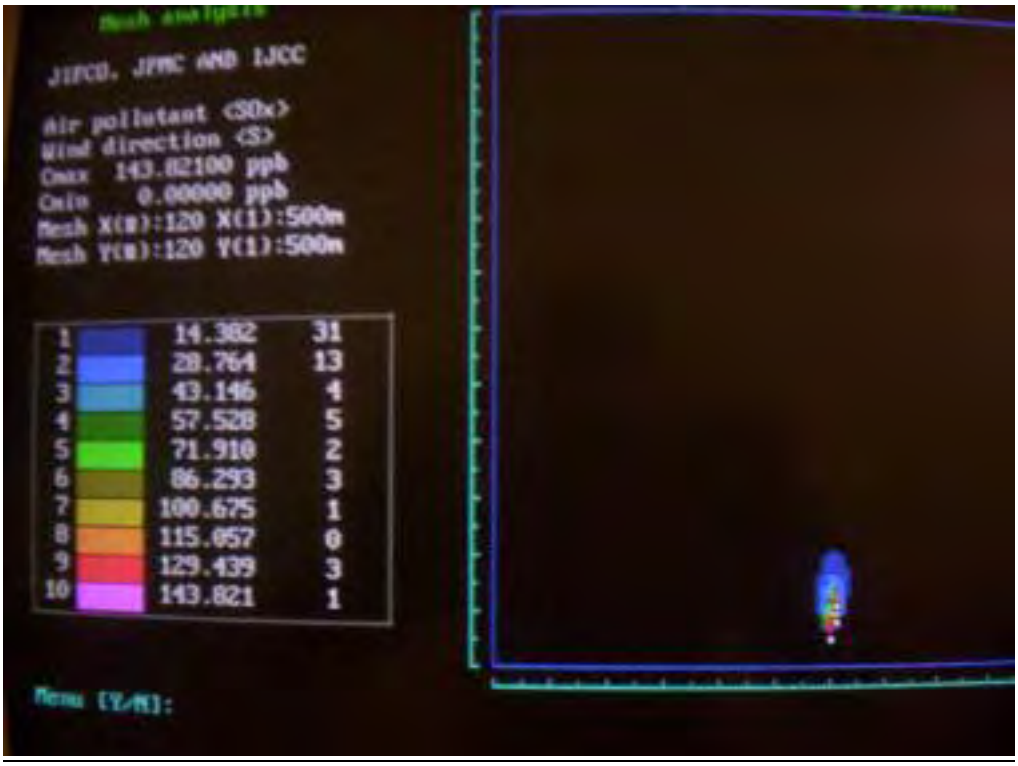


Fig. (11.3): One hour ground level concentrations of SO_2 estimated by modeling at stability class B, south wind and wind speed of 1 m/s (JIFCO, JPMC and IJCC)

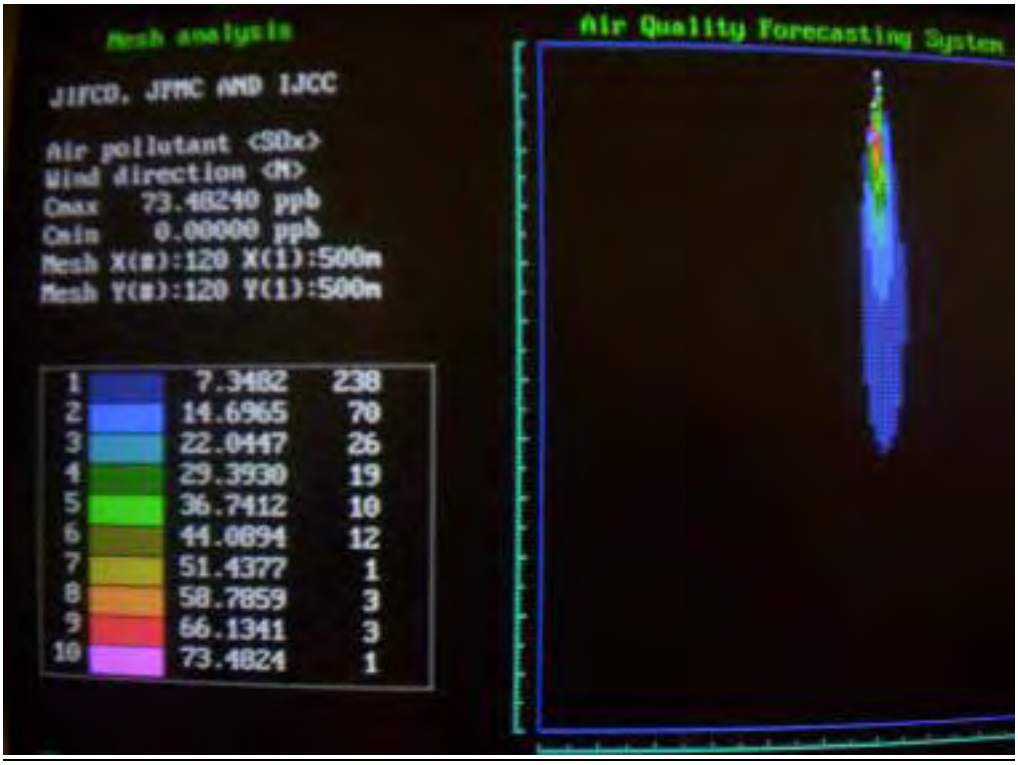


Fig. (11.4): One hour ground level concentrations of SO_2 estimated by modeling at stability class D, north wind and wind speed of 4 m/s (JIFCO, JPMC and IJCC)

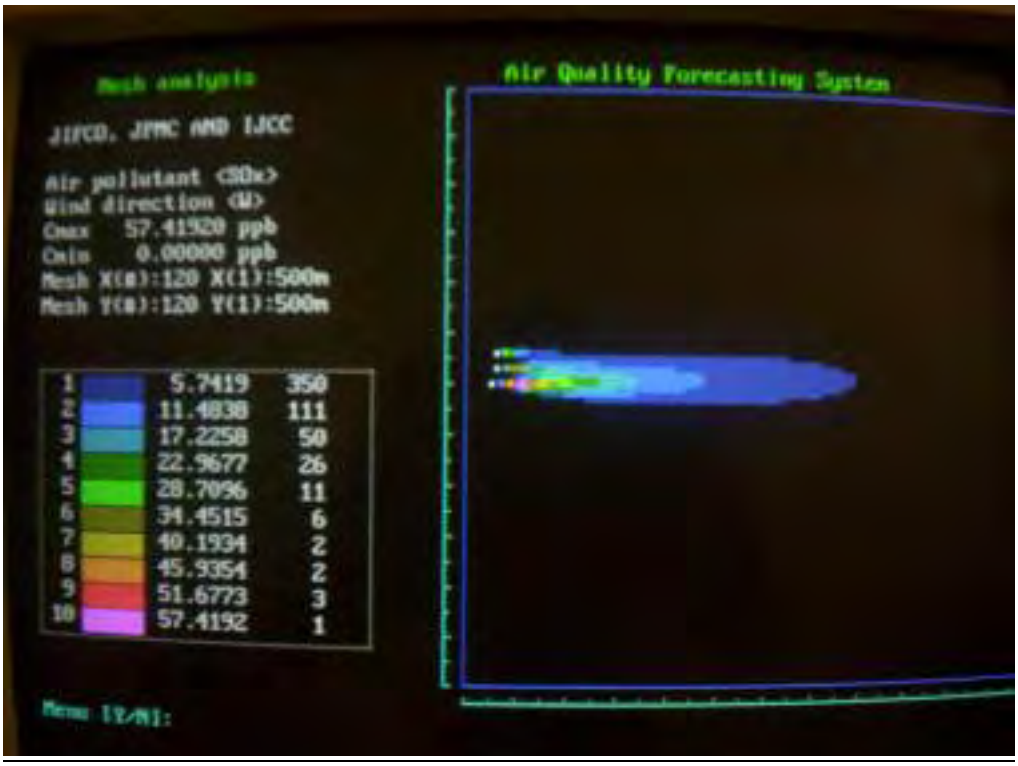


Fig. (11.5): One hour ground level concentrations of SO_2 estimated by modeling at stability class D, west wind and wind speed of 4 m/s (JIFCO, JPMC and IJCC)

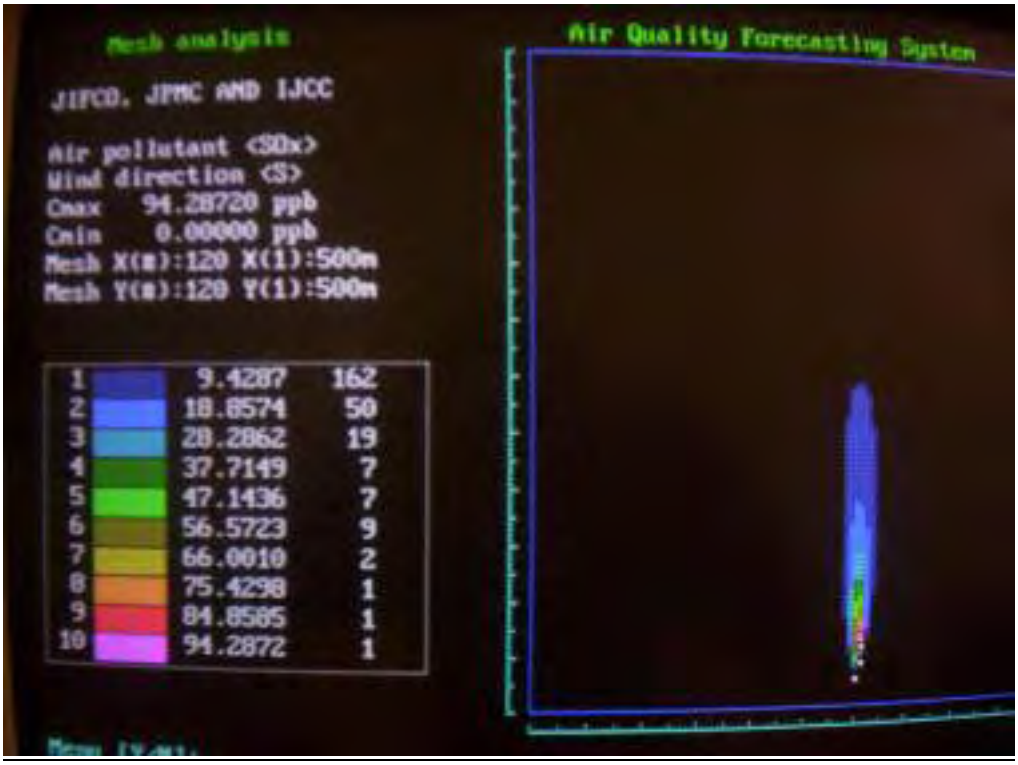


Fig. (11.6): One hour ground level concentrations of SO_2 estimated by modeling at stability class D, south wind and wind speed of 4 m/s (JIFCO, JPMC and IJCC)

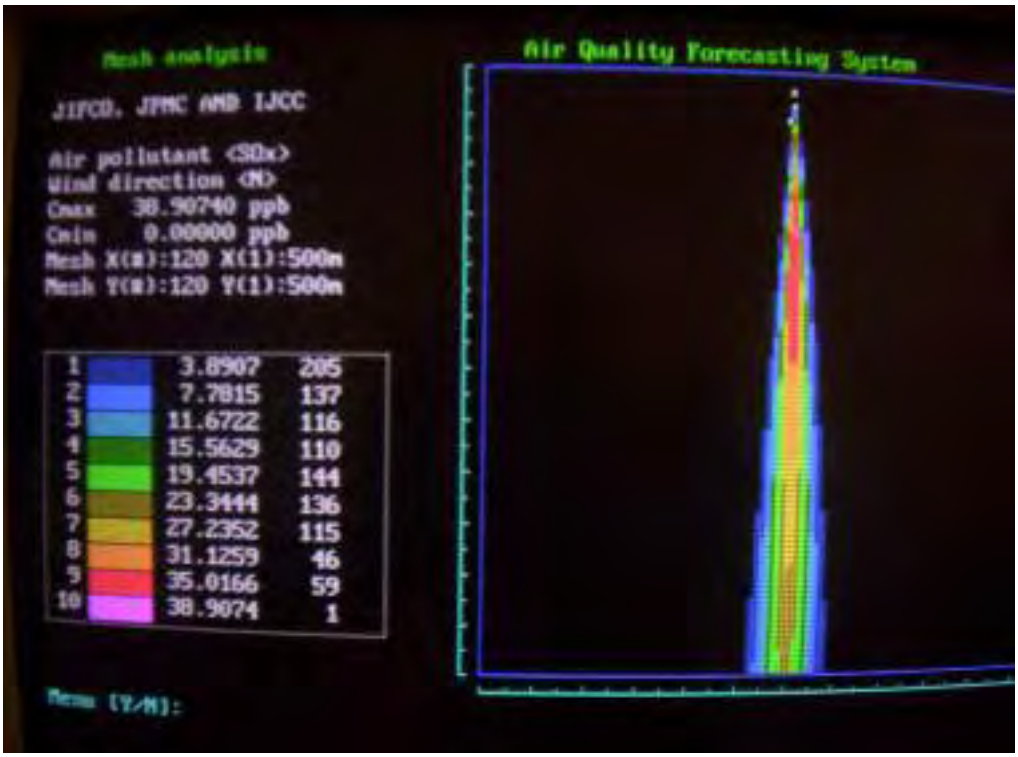


Fig. (11.7): One hour ground level concentrations of SO_2 estimated by modeling at stability class F, north wind and wind speed of 2 m/s (JIFCO, JPMC and IJCC)

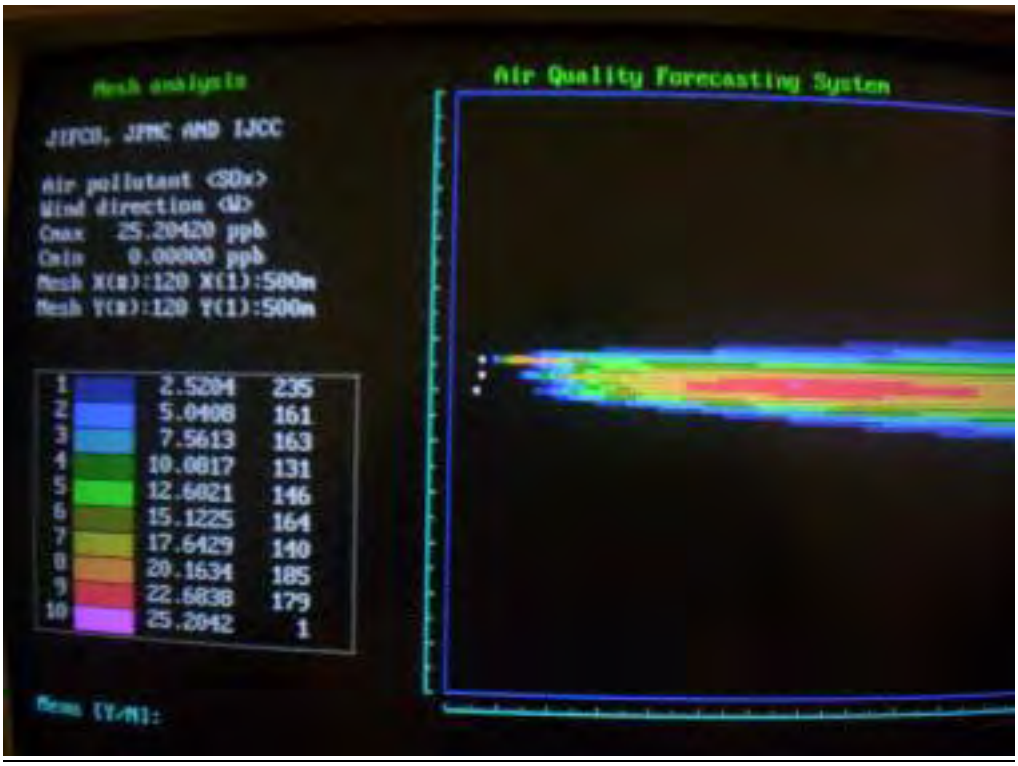


Fig. (11.8): One hour ground level concentrations of SO_2 estimated by modeling at stability class F, west wind and wind speed of 2 m/s (JIFCO, JPMC and IJCC)

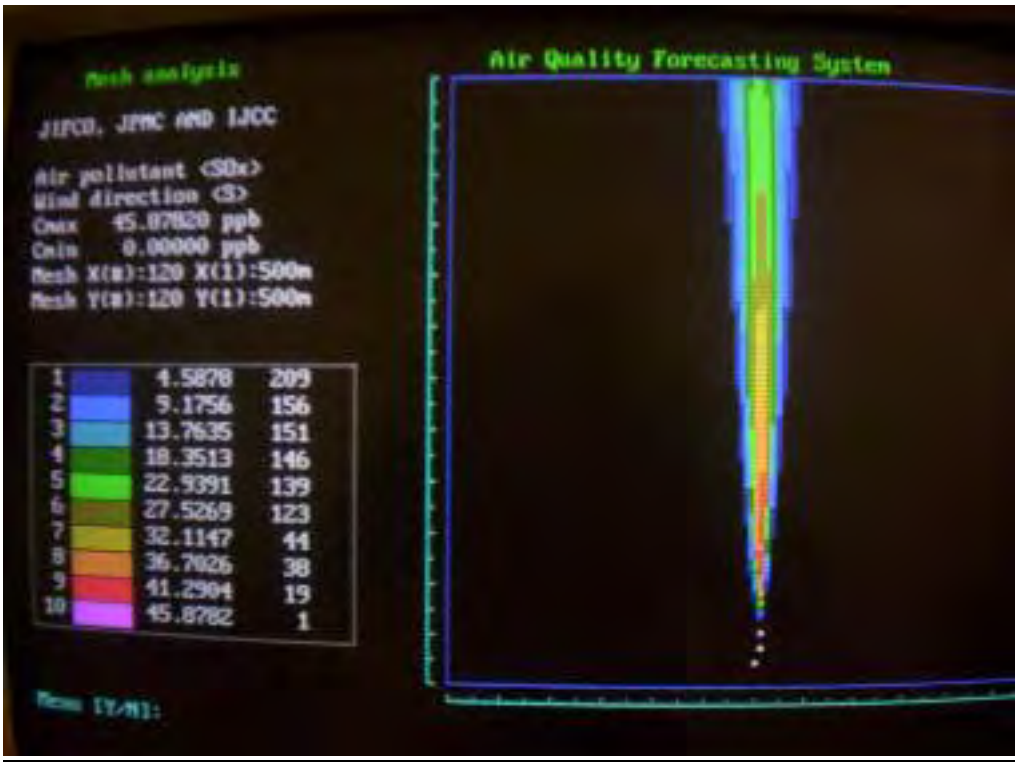


Fig. (11.9): One hour ground level concentrations of SO_2 estimated by modeling at stability class F, south wind and wind speed of 2 m/s (JIFCO, JPMC and IJCC)

<u>HF Modeling Results</u>

Cmax ranged between 0.039 and 1.3 µg/m^3 for all modeling cases. This occurs at all atmospheric tested in the model. HF modeling results are summarized in Table (11.3) below.

There is no maximum allowable hourly limit for HF specified in the Jordanian Ambient Air Quality Standard, JS 1140/2006 nor IFC regulations. The maximum concentration of 1.3 µg/m^3 will occur at western wind, while the maximum concentration at southern wind will be 1.1 µg/m^3 and will not reach the employees-complex.

Therefore, it does not seem that the proposed JIFCO activities in addition to the existing industries will affect the HF levels in the ambient air, see Figs. (11.10) to (11.18).

Table (11.3): The model estimates of HF maximum one hour ground level concentration

Stability and wind speed	Wind direction	Max. gr. level conc. (C_{max}), µg/m^3	Distance from H_3PO_4 plant stack at which C_{max} occurs (D_{max}) downwind (km)
B1	N	1.200	1.0
	W	1.300	0.8
	S	1.100	2.2
D4	N	1.200	2.0
	W	1.200	1.5
	S	0.719	2.9
F2	N	0.039	1.8
	W	0.039	1.6
	S	0.268	9 and 25.3

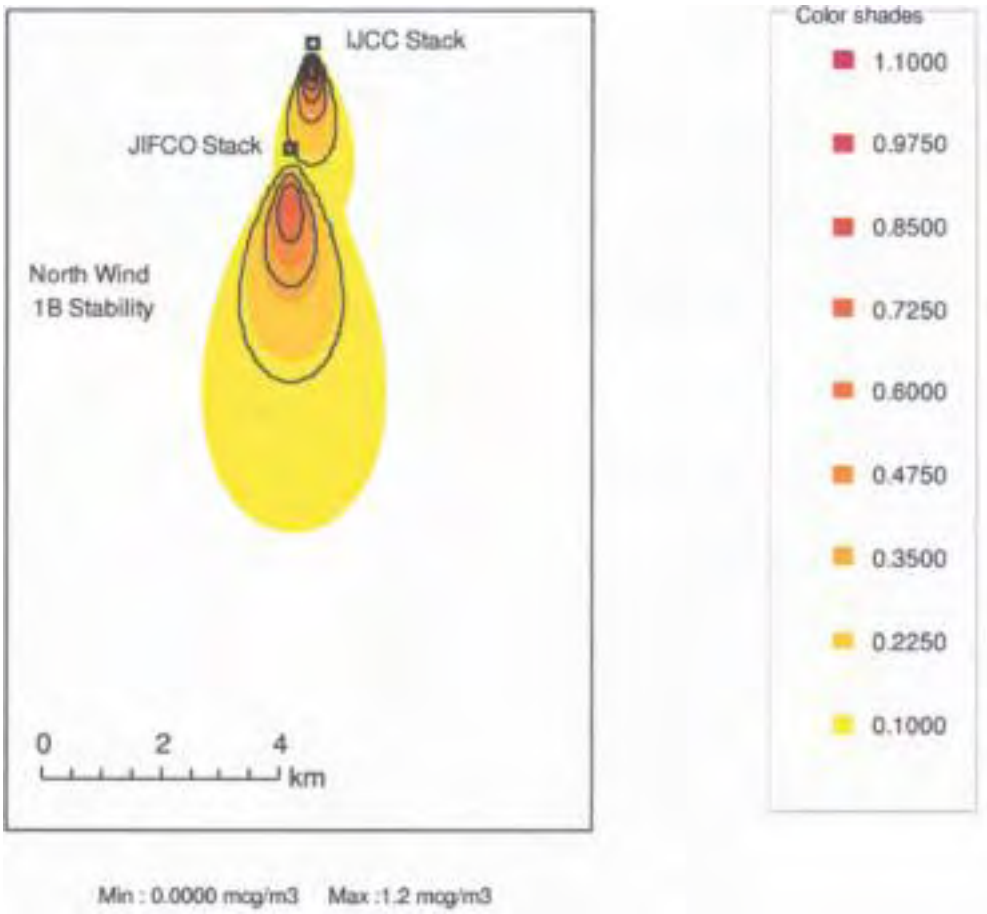


Fig. (11.10): One hour ground level concentrations of HF estimated by modeling at stability class B, north wind and wind speed of 1 m/s (JIFCO, JPMC and IJCC)

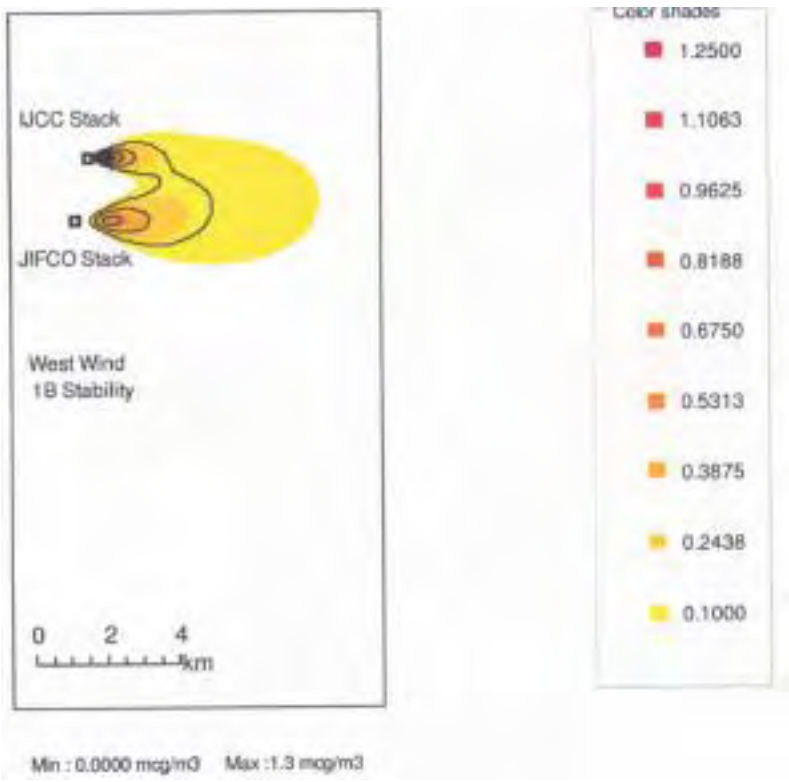


Fig. (11.11): One hour ground level concentrations of HF estimated by modeling at stability class B, west wind and wind speed of 1 m/s (JIFCO, JPMC and IJCC)

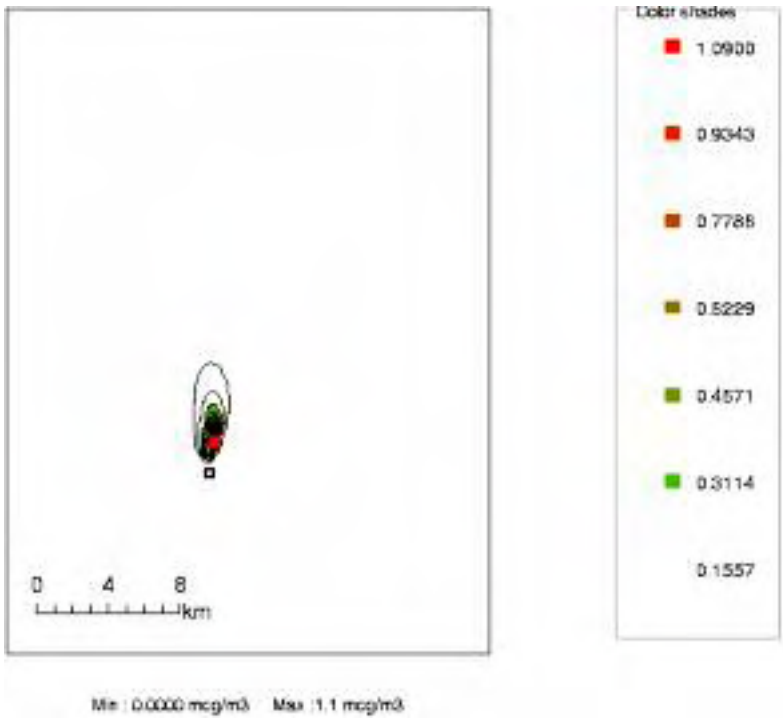


Fig. (11.12): One hour ground level concentrations of HF estimated by modeling at stability class B, south wind and wind speed of 1 m/s (JIFCO, JPMC and IJCC)

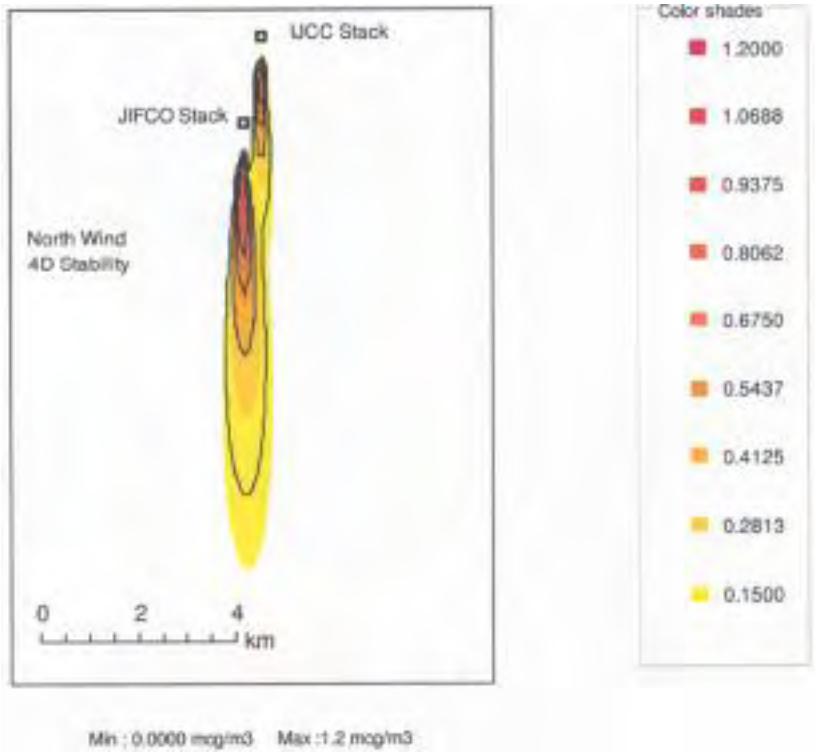


Fig. (11.13): One hour ground level concentrations of HF estimated by modeling at stability class D, north wind and wind speed of 4 m/s (JIFCO, JPMC and IJCC)

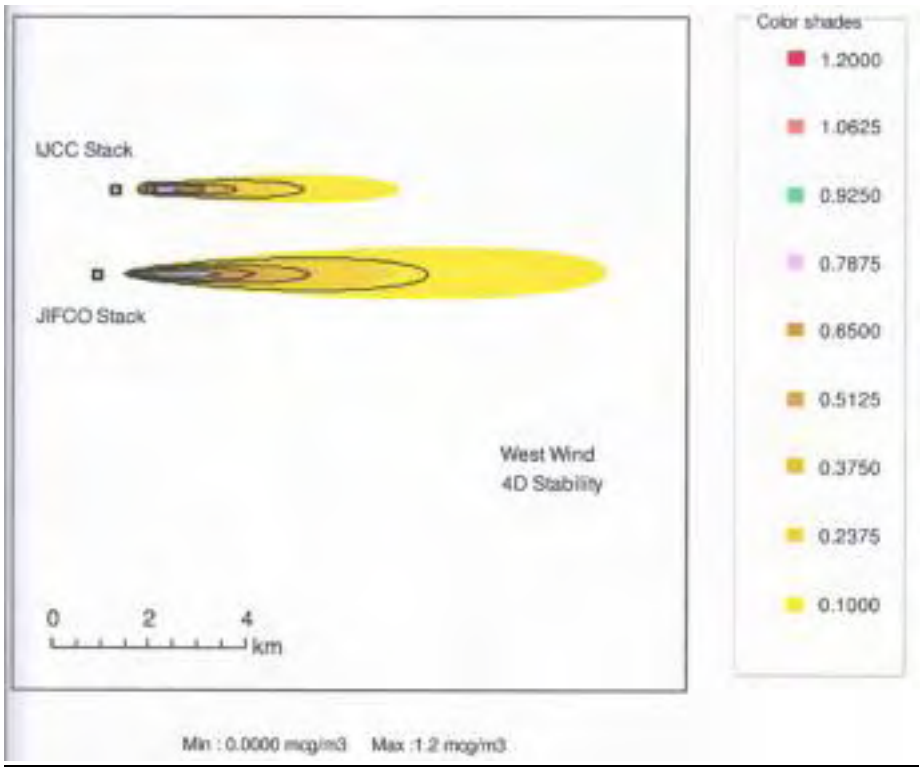


Fig. (11.14): One hour ground level concentrations of HF estimated by modeling at stability class D, west wind and wind speed of 4 m/s (JIFCO, JPMC and IJCC)

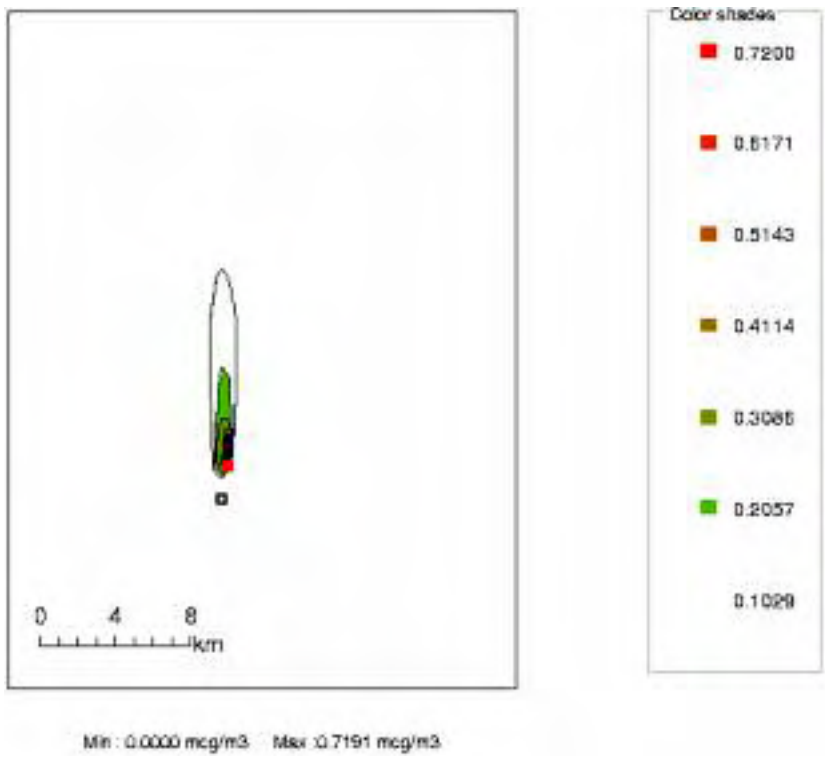


Fig. (11.15): One hour ground level concentrations of HF estimated by modeling at stability class D, south wind and wind speed of 4 m/s (JIFCO, JPMC and IJCC)

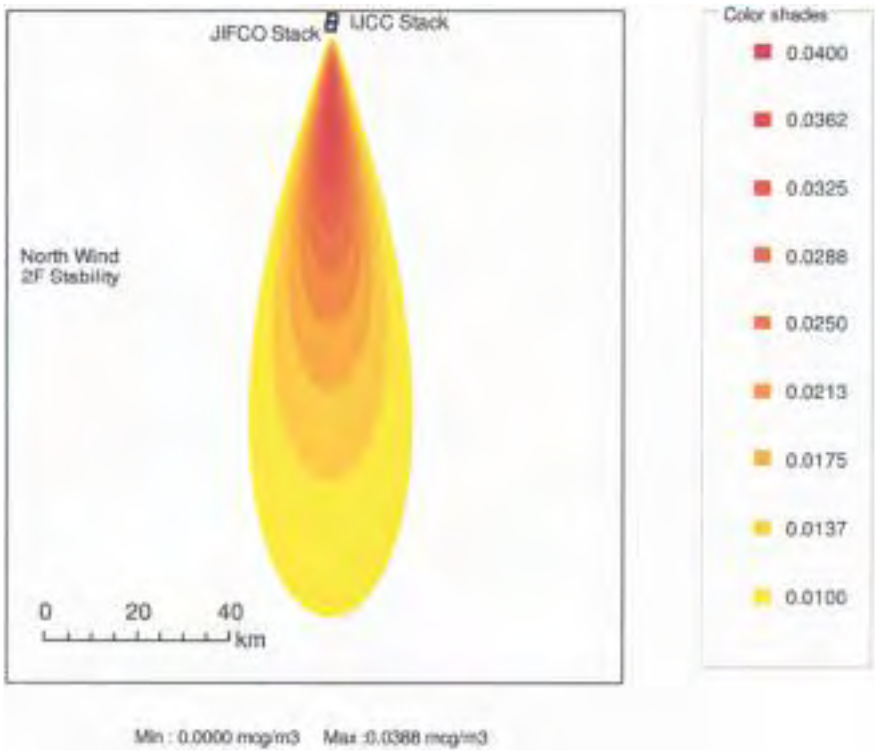


Fig. (11.16): One hour ground level concentrations of HF estimated by modeling at stability class F, north wind and wind speed of 2 m/s (JIFCO, JPMC and IJCC)

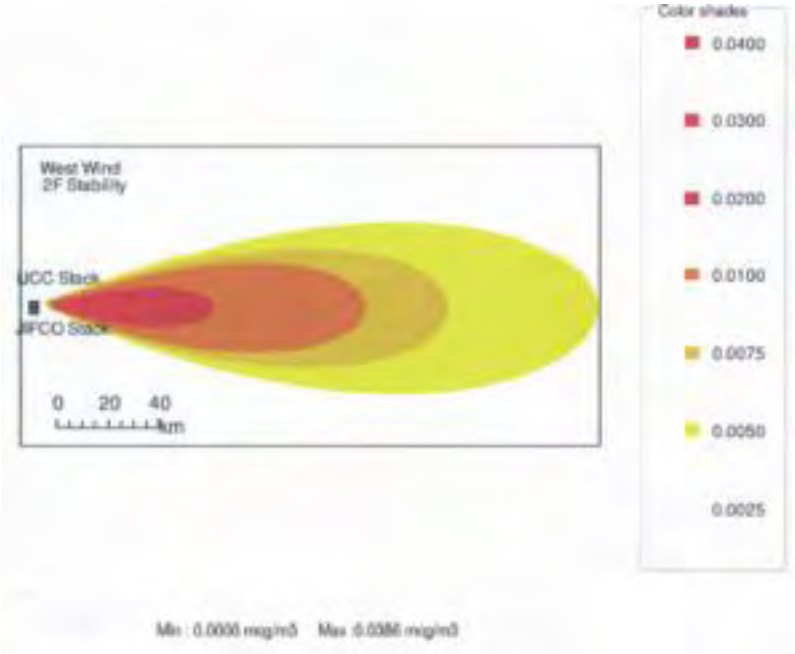


Fig. (11.17): One hour ground level concentrations of HF estimated by modeling at stability class F, west wind and wind speed of 2 m/s (JIFCO, JPMC and IJCC)

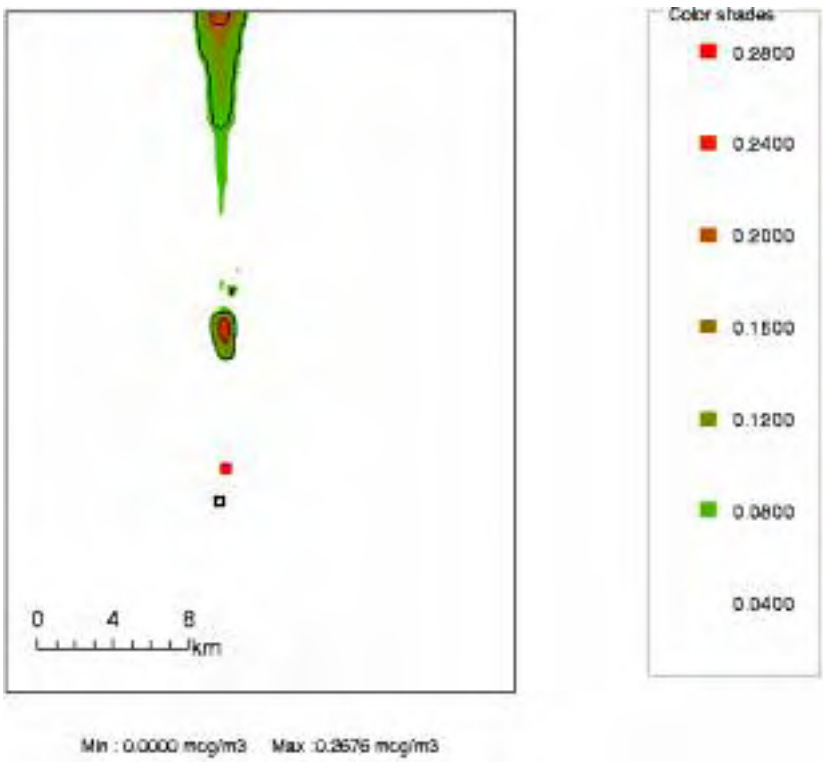


Fig. (11.18): One hour ground level concentrations of HF estimated by modeling at stability class F, south wind and wind speed of 2 m/s (JIFCO, JPMC and IJCC)

As a results of the modeling for SO_2 and HF for the proposed project with the existing activities (JPMC and IJCC), it is clear that there is not any cumulative impacts from the new project

11.3 Cumulative Impact Assessment of Transportation

During the operation phase product, by-product (fluosilicic acid) and raw materials (sulphur) will be transported via the desert highway. Table (11.19) shows the total number of trucks that will be used for transportation.

Table (11.19): Total numbers of trucks that will used for transportation

Material	Number of Trucks (trucks/day)	Number of Trucks (trucks/year)
Phosphoric acid	81	25,677
Sulphur	45	14,265
Fluosilicic acid	6	1,902
Total	132	41,844

Table (11.20) shows the number of vehicles that are crossing Amman - Aqaba desert highway.

Table (11.20): Number of vehicles crosses the desert highway during the year 2005

Main Roads Name	No. of Vehicles Per Day Passing Through the Road of Each Site
Amman- Aqaba Desert Highway	5,100 To Aqaba 5,073 To Ma'an

Referring to Table (11.20) the number of vehicles passed through the desert highway in 2005 were 5,100 and 5,073 vehicles per day for both sides. The transportation of product and raw material will increase the daily number of vehicles passing through desert highway by 2.6% for each side. Thus, it is expected that a slight increase in traffic flow will take place during the operation period. The negative impact of traffic congestion will be limited, providing that proper measures will be adopted.

11.4 Cumulative Impact of Increase in Pumping Water from Eshidiya Area

The groundwater demand in Eshidiya area for industrial uses is growing rapidly. The total abstraction of the groundwater from the year of 1989 until 2006 reached about of 117 MCM with an average of about 6.5 MCM/yr. This amount is used by JPMC and IJCC. This demand might be increased within the coming few years in order to satisfy the water needs of the various industries being developed in that area.

Howard Humphreys study in 1986, estimated the total aquifer yield in Eshidiya wellfield zone is about 580 MCM and the recharge to the aquifer is approximately 3.5 MCM/yr, of which 2.1 MCM/yr is derived from the Western Highlands by lateral flow, and 1.4 MCM/yr from indirect recharge in the southern escarpment.

In addition, a study of Al Naser, H in 1999 was conducted as a part of the Environmental Impact Assessment Study of Hydro – Agri Jordan Fertilizer (HAJ) Project to investigate the impact of the increasing pumping from the aquifer in Eshideya area to cover the industrial demand on groundwater availability and life time in advance. Al Naser developed a lumped parameter model to Amman – Wadi Sir Aquifer System (B2/A7) of the Eshidiya area to calculate the storage volume of the aquifer after the abstraction by JPMC, Indo-Jordan Chemical (IJC) Company, and Hydro-Agri Jordan Fertilizer Company uses. Al Naser's study concluded that the majority of the present abstraction will be derived from the aquifer storage while the leakage and recharge are not significant to sustain the abstractions. The study results showed that the water in the aquifer will run out by the year of 2037 if the total abstraction reaches to 12.5 MCM/yr.

Regarding the proposed project, water requirement of the JIFCO project in Eshidiya is about 6.0 MCM/year and therefore the total abstraction of water by all industries in this area will be 12.5 MCM/year at the end of the year 2011 (year of starting the operation of JIFCO project). Considering the water consumption at the rate of 12.5 MCM/year, the Amman-Wadi Sir aquifer will run out by the year 2037 because the abstraction rate is over the safe yield. Hence it is proposed that JIFCO shall exploit water from the deeper Kurnub/ Disi aquifer at Eshidiya, which is a nonrenewable one, by drilling about 4 new boreholes in addition to the existing one, each pumping about 200 m^3/hr. This will

reduce depletion of the Amman-Wadi Sir aquifer and will last for many more years.

A study has been made by JPMC through the consultant Scott Wilson Kirkpatrick & Co. Ltd in the year 1999/ 2000 by deep exploratory drilling of ground water resources in Eshidiya region, concluded a conservative estimate of production from the deep aquifer would be in the region of 6 to 10 MCM per year.

The company shall use the excess amount of the treated domestic wastewater from project as well as study in future the possibility to reuse the treated domestic wastewater from Ma'an municipal treatment unit and the planned treatment unit of Ma'an industrial zone.

12. ENVIRONMENAL AND SOCIAL ACTION PLAN

12.1 Introduction

The study of the environmental and social impact assessment of the Jordan India Fertilizer Company (JIFCO) Project - to produce phosphoric acid in Eshidiya/Ma'an governorate and store it in Aqaba governorate for export purposes by ships - has identified a number of potential impacts that are likely to arise during construction, operation and decommissioning phases of the proposed project. The study has examined both the positive and negative effects of each stage of the plant.

The negative impacts require further actions to eliminate or offset damage to the environment. These actions are called mitigation measures which are based on improved construction methods, management practices and procedures, pollution control technology, monitoring and reporting.

12.2 Purpose of Environmental and Social Action Plan

The environmental and social action plan (ESAP) serves as the base for the environmental and social monitoring and management programs to be implemented over the course of the project. It is a tool for management.

The purpose of the ESAP is to identify the set of mitigation measures to eliminate or reduce the potential adverse impacts of the project on the environment and societies as low as reasonably practicable, and to ensure that the mitigation measures are implemented effectively and on time. The local society shall have social and economic benefits from the project.

12.3 Standards Adopted in Developing the ESAP

The following standards and guidelines were used in the preparation of the ESAP:

Jordanian Laws, Regulations and Standards: All Jordanian environmental, labor and social regulations, standards and requirements as described in Chapter 2 of this environmental and social impact assessment study were used in the ESAP preparation.

International Finance Corporation (IFC) Guidelines and Requirements: The relevant guidelines and requirements of the IFC as identified in Chapter (2) of this ESIA study were also used to prepare the ESAP.

12.4 The Environmental and Social Action Plan

This section presents the major possible environmental and social impacts resulting from the proposed project with the required mitigation measures (action plans). For each action plan a completion date is assigned by the company itself (i.e. Jordan India Fertilizer Company).

12.4.1 Development of HAZOP

Hazard and Operability Analysis (HAZOP) is a systematic method for examining complex facilities or processes to find actual or potentially hazardous procedures and operations so that they may be eliminated or mitigated. HAZOP study will be performed by engineering consultant together with JIFCO engineers.

The study will be undertaken during the design phase of the project. Different effects shall be regarded, such as Environmental protection, industrial safety, process security and quality.

12.4.2 Development of occupational health and safety plan and emergency response plan

The company will prepare a comprehensive occupational health and safety plan (OHSP), which includes the applicable comprehensive occupational health and safety programs, guidance, operational plans and procedures, and the associated technical and monitoring manuals for all the phases of the project as well as it will adopt well recognized guides to implement its program.

All activities that impose unreasonable risks on workers health or safety shall be addressed and mitigated in the occupational health and safety system for either elimination or reduction of the risk to an acceptable level and according to established standards and regulations.

The occupational health and safety plan will include:

- Occupational health and safety plan objectives.
- Standards referred to.
- Occupational health and safety management system.

- Management commitments (including responsibilities of company staff).
- Resource management (including training for the employees).
- Realization of product.
- Measurements, analysis and improvement.
- Control of occupational health and safety management system (including identifying the accidents and documentation procedure, prevent / mitigate the risk, emergency response plan, etc).

The emergency response plan (ERP) will also be prepared by the company. The plan will deal with any emergency conditions. This plan shall be well implemented and reviewed by the management staff frequently. The employees shall be trained on all issues related to the emergency response plan. Also, the drivers shall be part of the plan and well trained.

12.4.3 Responsibility

JIFCO is responsible for implementing all mitigation measures mentioned in the action plan on time. If JIFCO signs contract(s) with other companies for certain issues such as transportation of product, all relevant mitigation measures shall be mentioned clearly in the contract. So, JIFCO shall check and monitor if the mitigation measures are implemented; it is the responsibility of JIFCO to ensure its implementation.

The following table shows the environmental and social action items for the JIFCO project during different phases.

Table (12.1): Environmental and social action plan

No.	Issue	Proposed Action	Completion Date
1.	Hazard and Operability Analysis (HAZOP)	Prepare HAZOP	Before plant start-up
2.	Occupational Health and Safety Plan (OHS)	Prepare an OHS plan	Before start of construction
3.	Emergency Response Plan (ERP)	Prepare ERP	Before start of construction
4.	Grievance Mechanism	Prepare a clear grievance mechanism	Before start of construction
5.	Mitigation measures regarding water resources	Implement all mitigation measures related to all water resources issues	During construction and operation
6.	Mitigation measures regarding biodiversity	Implement all mitigation measures related to all biodiversity issues	During construction and operation

No.	Issue	Proposed Action	Completion Date
7.	Mitigation measures regarding public health	Implement all mitigation measures related to all public health issues	During construction and operation
8.	Mitigation measures regarding archeology	Implement all mitigation measures related to all archeology issues.	During construction
9.	Mitigation measures regarding socio-economic conditions	Implement all mitigation measures related to all socio-economic issues	During construction and operation
10.	Mitigation measures regarding occupational health and safety	Implement all mitigation measures related to all occupational health and safety issues	During construction and operation
11.	Mitigation measures regarding marine environment	Implement all mitigation measures related to all marine environment	During operation
12.	Domestic wastewater generated from workers and labor camp during operation phase	Construct an activated sludge wastewater treatment plant	Before plant start-up
13.	Fluosilicic acid	Record all quantities produced or sold to JPMC in Aqaba	During operation
14.	Disposal of the spent catalyst (vanadium pentoxide)	Record the amount of vanadium pentoxide purchased and the amount used	During operation
		Send all of spent catalyst (vanadium pentoxide) back to the supplier	During operation
15.	Gypsum disposal	Construct and compact the disposal area in a proper way and contained by dikes in all sided	Before start-up of the plant
16.	Safety hazards during transportation on public roads	Comply with the Jordanian Regulation for Hazardous Material Transportation by road.	During operation
17.	Guard pond	Compact the ground of the guard pond and use a proper lining material such as high density polyethylene (HDPE)	Before start-up of the plant
18.	Storage tanks in Aqaba located in medium to high risk seismic zone	Follow the regulations and design codes of the Ministry of Public Works and Housing against earthquakes	During design and construction
19.	Drilling bore wells for water	Get license from Jordan Water Authority, Ministry of Water and Irrigation	Before start of construction
20.	Water consumption	Report to the Ministry of Water and Irrigation	During operation
21.	Local employment	Record the number of people from local communities trained and employed by the company	During construction and operation

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Environmental and Social Impact Assessment (ESIA) Study

Jordan India Fertilizer Company (JIFCO)

VOLUME (II)

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

Submitted to:

Jordan Phosphate Mines Company (JPMC)

Submitted by:

The Royal Scientific Society (RSS)

Environmental Research Centre (ERC)

June, 2008

TABLE OF CONTENTS

1. INTRODUCTION

An environmental management plan (EMP) including mitigation measures and a monitoring program (MP) is presented in this document. The EMP outlines the environmental impact management procedures that shall be taken by the Jordan India Fertilizer Company (JIFCO) to protect the environment during all phases of the project.

2. ENVIRONMENTAL MANAGEMENT PLAN (EMP)

2.1 Introduction

The environmental management plan document outlines the necessary mitigation measures identified in the ESIA study. Responsibilities for proper environmental management are outlined.

2.2 Responsibilities

The responsibility for the EMP within the JIFCO will be with the JIFCO Project Manager, who may choose to delegate responsibility within the organization. This responsibility includes implementing the mitigation measures and monitoring the performance of these measures, establishing environmental policy, executing the monitoring programs and controlling the operation of all environmental protection activities.

2.3 Permitting Requirements

Table (1) summarizes the permits needed for the project in accordance to their timing.

2.4 Proposed Mitigation Measures

The environmental management plan covers the issues related to the following environmental components:

- Water resources.
- Biodiversity.
- Public health.
- Archeology.
- Socio-economic conditions.
- Occupational health and safety.
- Marine environment.

Table (1): Summary of permitting requirements of major relevant regulatory authorities

Authority	Responsibility
Ministry of Environment	• Permitting prior to construction (ESIA report is required). • Inspection during operation.
Aqaba Special Economic Zone Authority	• Permitting prior to construction in Aqaba zone (ESIA report is required). • Inspection during operation.
Ministry of Labor	• Permitting prior to operation (after occupational health and safety measures). • Inspection during operation.
Water Authority of Jordan	• Supplying water needs during project phases. • Water quality monitoring during project life.
Ministry of Health	• Inspection during operation.
Department of Antiquities	• Permitting in case of existence of archaeological remains.
Civil Defense	• Approval for construction plans. • Permitting prior to operation.
Ministry of Housing and Public Works	• Inspection of the heavy trucks loads during operation

2.4.1 Water resources

Following are the necessary mitigation measures:

<u>Disposal of the industrial wastewater</u>

- The guard pond shall be designed and lined by using high density polyethylene material in a proper method to prevent any possible occurrence of the infiltration of the industrial wastewater into the groundwater table. The lining material shall be inspected regularly.
- The phosphoric acid storage tanks in Aqaba area shall be designed according to the local and international codes against the seismic hazard. In addition, the tank should be provided with a properly lined containment area capable of holding the largest tank volume and 10% of its volume. During the operation phase, emergency handling and cleaning program in case of accidents shall be included in the design of the site facility. The storage tanks should be inspected on a regular basis.
- It is recommended to establish a monitoring program to monitor infiltration through soil sampling through shallow boreholes located downstream of the guard pond and the gypsum staking area.

Disposal of waste oil and leakage of oil storage tanks

- Fuel oil/diesel storage tank should be designed according to international standard codes. In addition, the tank should be provided with a properly lined containment area capable of holding the tank volume.
- The waste oil generated from the spillage, leakage of oil storage tanks, and the spent lubricating oil of equipment and vehicles should be collected in special containers and transported in a safe manner to Jordan Petroleum Refinery Company or sold to the licensed collector of used oil.

Handling and disposal of domestic wastewater

- During the construction phase, the domestic wastewater should be collected in an impermeable reinforced (sealed) tank and should be disposed to the nearest municipal wastewater treatment plant using licensed vacuum tanks and following the appropriate environmental regulations.
- During the operation phase, the treated domestic wastewater resulting from the treatment unit shall be complying with the regulations before it can be used for irrigation.
- The dismantling of the domestic wastewater treatment unit during the decommissioning phase should be done in an environmentally safe manner. The wastewater should be emptied before by using vacuum vehicles. The wastewater should be disposed to the nearest domestic treatment unit.

Impact of the industrial solid wastes

- The spent vanadium pentoxide catalyst (V_2O_5) should be sealed in steel or plastic drums and stocked in designated area and then it shall be returned to the supplier.
- The floor of the gypsum stacking area shall be constructed and compacted in a proper way using proper material to obtain the soil permeability not larger than $1x10^{-6}$ m/sec. The stacking area shall be contained by dike in all sides to prevent seepage of the wastes out the containment area.

Impact of the surface runoff

During the construction phase, the company shall consider constructing gabions along the side of the wadi near to the storage tanks in Aqaba to minimize the flood impact on the tanks. The company shall also work on protecting the drainage pattern of this wadi from the construction activities.

Considering an alternative water resources

Further studies shall be commenced by all industries in Eshidiya area to find alternative resources to compensate for the deficit between the available and required quantities. The company should use the excess amount of the treated domestic wastewater from the project as well as to study in future the possibility to reuse the treated domestic wastewater from Ma'an municipal treatment unit and the planned treatment unit of Ma'an industrial zone. The company shall comply with the rules of the Ministry of Water and Irrigation regarding water resources protection zones.

2.4.2 Biodiversity

Following are the recommended mitigation measures to be implemented to reduce the negative impacts:

Construction Phase

Flora

- Disposal of debris on flora: The proposed sites for the plants and the storage tanks are suffering from very high levels of deterioration and the expected accumulative impact of the debris disposal is minimal and reversible.

  Mitigation Measure

  Disposal of debris should avoid the shallow depressions in the area that have some vegetation cover.

- Direct damage of the flora at both sites of the project: As observed and studied during the baseline; both proposed sites of the project have very low species flora diversity as well as the absence of any critical or conservation important plant species. Therefore, the expected impact is considered insignificant and dose not threatens the absence of similar species in the surrounding area.

  Mitigation Measure

  At the proposed site for the plants, construction should avoid shallow depressions that have vegetation as much as possible.

- Collecting wood by workers: This impact on the vegetation is of low magnitude level due to the lack of woods in both sites, but some shrubs might be used by workers in the construction.

  Mitigation Measure
  To prohibit workers from collecting wood.

- Habitats destruction: Due to random access dirt road to the construction site, it is expected to have a low magnitude impact on the vegetation that found in the site.

  Mitigation Measure
  To limit construction activities within the plants site.

- Solid and liquid wastes: This impact might be significant of medium level especially on the surrounding area to the proposed sites of the project like the wadi systems. Hazard liquid wastes from machineries used in the construction might affect the seasonal wetlands formed in the flood seasons.

  Mitigation Measure
  To collect all wastes in sealed containers and to be disposed properly according to the regulations of the Ministry of Environment.

Fauna

- Disposal of debris on fauna: This impact is very limited to insignificant level due to the high disturbance levels in the project sites that made the fauna diversity restrict mainly to the micro levels of small reptiles and rodents that are not considered critical or conservation important species.

  Mitigation Measure
  Disposal should avoid the shallow depressions in the area that have some vegetation cover that might have rodents or reptiles borrows.

- Direct damage of the fauna at both sites of the project: The kind of expected damage is restricted to the disturbance during the construction phase. The proposed sites have low fauna diversity. However, this impact may be of more significance at night time and during the migration seasons of birds during spring and autumn.

  Mitigation Measure
  Any killed mammal or rodent species should be reported to the Ministry of Environment for recording its status.

- Animals and birds hunting by workers: This impact is of low magnitude level due to the low abundance of game species in the proposed sites of the project.

  Mitigation Measure
  To prohibit workers from hunting.

- Accidental killing of animals and birds: Accidents of animal killing due to the movements of the vehicle and machineries is expected especially during the night time. This impact is of low magnitude level.

  Mitigation Measure
  To report any accident and inform the Ministry of Environment.

- Solid and liquid wastes: Domestic wastes might attract some animals species to the site which might initially threat the workers in the site and also threat the animals if it contaminated with hazard wastes produced by the construction activities. This impact is of medium magnitude level.

  Mitigation Measure
  To collect all wastes in sealed containers and to be disposed properly according to the regulations of the Ministry of Environment.

Operational Phase

Flora

- Disposal of gypsum and possibilities of reuse: The proposed area for the gypsum disposal has very low vegetation coverage of shrubs that are on no conservation importance in away make this impact negligible. In addition to that, the gypsum disposed will have moisture that will harden the residues when its dry in a way minimize the weathering impact on the vegetation cover surrounding the project site.

  Mitigation Measure
  Restrict gypsum disposal in the proposed site only.

- Soil contamination due to disposal of used oil: This impact has significant levels on the soil although the vegetation cover is very poor in the project area and the surroundings. The extent of this impact can last beyond the project life where the soil will not be able to support regeneration of plant species after the project in the area.

  Mitigation Measure
  All disposed oil should be collected and management according to the regulations of the Ministry of Environment.

Fauna

- Guard pond impact on the migratory birds: The project area is on the fly way of the migratory birds especially the raptors which can be attracted to the pond that will have harmful liquid (acid). The impact of this pond on the migratory birds is very significant.

  Mitigation Measure

  Guard pond should not be in direct interaction (contact) with migratory birds. Therefore, strict mitigation measures should be placed such as covering the pond with pale color mesh (sand color) in order to avoid having birds attracted to the pond. The pond should also be fenced to protect the wild animals from falling in it.

- Disposal of gypsum and the possibility of reuse: This impact is very limited to the micro level habitats of reptiles and rodents, as the disposal of gypsum might cover the borrow areas that are mainly restricted to the areas of vegetation cover. This impact is of low significance since there is no conservation important reptile or rodent species found in the area, and the proposed area for gypsum disposal is almost empty of vegetation cover.

  Mitigation Measure

  Avoid disposal in depression areas with vegetation cover as much as possible.

- Hunting by workers: This impact is expected to be of low magnitude level due to the mild interaction of workers during the operational phase with the surrounding environment during night time.

  Mitigation Measure

  To prohibit workers from hunting.

- Accidental killing: Due to the heavy transportation activities, road killing for animals is expected especially during the night time due to the nocturnal activities for the animals in the area. This impact is of low magnitude level.

  Mitigation Measure

  To report any accident and inform the Ministry of Environment.

Decommissioning Phase

Flora

- Random disassembling: This impact is limited to destruction of habitats at the surrounding area during the decommissioning activities by using it as temporary storage or parking sites for machineries.

  Mitigation Measure
  Disassembling should be restricted within the project boundaries.

Fauna

- Random disassembling: This impact limited to the disturbance that may occur in the area during this phase which may affect fauna species, especially if these activities take place during the night time or during the migration seasons of birds.

  Mitigation Measure
  Disassembling should be restricted within the project boundaries and during day time as much as possible.

2.4.3 Public health

Air pollution

Construction Phase

- Dust resulting from the construction activities should be minimized as much as possible. Following are some examples that could be taken: water slightly all active construction areas to reduce dust generation, cover all trucks hauling soil, sand, and other loose materials, cover stockpiled soils, sand and cement, and try to remove them promptly and strictly limit truck speed on unpaved roads.
- In addition, it is recommended to apply some other measures such as turning off the vehicles and machinery when not used for extended periods, scheduling the deliveries of the construction materials during off-peak hours and using the minimum number of vehicles.
- To reduce vehicular emissions to limits within national and international standards, it is necessary to regularly monitor these emissions, test the opacity and conduct periodical maintenance of vehicles and machinery that will be used in all phases.

Operation Phase

- The suitable type of de-dusting system that is reliable and of high efficiency shall be installed in all dust emission points such as the phosphate rock discharge point to the ball mill.
- It is important, not only to install de-dusting systems such as cyclones and bag filters i.e. at the stack of phosphate rock ball mill, but also apply regular maintenance and check of the performance of the installed dust protection equipments. In addition, this will ensure meeting the dust emission concentration to the Jordanian Standards limit of 50 mg/Nm^3. For example, the regular maintenance and performance check of the bag filters should be done at least once every six months and spare bag filters should always be available at the company.
- To reduce the dust emission from material storage areas, the phosphate rock and sulphur stockyards walls should be high enough and built against the prevailing wind direction. This means that the outdoor phase of the stockyards wall should be against the northern and western winds. Moreover, during material transportation, conveyor belts in enclosed galleries (covered conveyor belts) are necessary to carry all materials that can cause pollution such as sulphur granules.
- Cover well all the trucks that will haul the sulphur granules from Aqaba to Eshidiya to prevent the sulphur spillage during transportation and the possibility of grinding it by the vehicles. The company shall import the granular sulphur not the fine one.
- The installation of on-line continuous SO_2 gas analyzer at the sulphuric acid final absorption stack will be so helpful to assist the plant control on air quality and the efficiency of the SO_2 to SO_3 converter. By this system, appropriate corrective action i.e. in case of vanadium oxide malfunction can be taken in earlier times.
- During the operation phase, on-line continuous monitoring of dust emissions from the ball mill stack is also recommended.
- The radioactivity of phosphoric acid and phospho-gypsurn should be measured from time to another in order to take the required actions in case of high level of radioactivity and to have baseline data for the existing situation.
- To reduce the possible dispersion of phosphate rock and sulphur dust by wind, good housekeeping measures such as frequently cleaning/sweeping the plant grounds could be applied.
- Build green belt around the area of the proposed project to provide a barrier between the project site and the surrounding area. The green belt helps to capture the fugitive emissions generated in the project activities.
- The unplanned stoppages should be prevented as possible, since they could generate more air pollution emissions than at the normal operation,

such as the emissions of SO_2, CO and NOx from the start-up boiler and more SO_2 emissions from the sulphuric acid plant.

- The loading of sulphur and phosphate rock from the trucks to the stores shall be managed well to avoid dust emissions, such as applying the most appropriate angle of loading.
- Apply water spray on the gypsum stacks during the southern windy days to reduce the generation of dust.
- The sulphuric acid absorption unit as well as the hydrogen fluoride scrubbing unit should have sufficient capacities to handle the sudden load increase of gaseous pollutants (SO_3 and HF).

Noise

- Equipment and vehicles shall be maintained in line with manufacturer's recommendations to meet relevant standards.
- Vehicles and machines shall be used responsibly, e.g. machines will not be left idling for long periods if they are not in use.
- During the operation phase, the heavy equipment shall be selected, properly operated for the right purpose, inspected and maintained regularly to keep them up to the established standard to reduce their potential generated noise.
- During the operation phase, strict speed limits and safety signs shall be posted along the roads. Drivers shall be trained on defensive driving to reduce potential increase in noise, accidents and dust emissions.
- During the operation phase, a periodical maintenance to all transportation and heavy vehicles shall be done. The vehicles shall be replaced after the mentioned operational life time.
- During operation phase regular checks on the effectiveness of operational systems and noise should be done.

Wastes

- All types of wastes (domestic and hazardous) resulting from construction, operation and decommissioning activities at both sites shall be managed in an environmentally safe manner and according to related regulations. All domestic solid wastes to be disposed of shall be collected in compatible closed containers and then transferred to the authorized waste disposal site with prior coordination with the relevant authorities or the company shall contract a private company to manage this issue. All hazardous waste (oils and others) shall be collected and managed according to the regulation of hazardous waste management and handling issued by the Ministry of Environment. Waste oils shall be

collected and sent to the Jordan Petroleum Refinery Company or sold to a licensed collector of the used oil. The management of used oils shall be according to the regulations of management and handling of used oil issued by the Ministry of Environment.

- The spent catalyst (vanadium pentoxide) shall be sent back to the supplier.
- Gypsum will be piled in a prepared adjacent area east of the plant area.
- Sulphur filter cake will be pilled in the gypsum disposal area.
- During the construction phase, toilettes shall be available to be used by the workers. The generated domestic wastewater shall be collected in a container or sealed pit and transported to the nearest wastewater treatment plant. Certain control system shall be in place to ensure collection and transportation of the wastewater in an environmental safe manner.
- Domestic wastewater generated by workers during operation phase will be treated in an activated sludge treatment plant which will be constructed in Eshidiya site. The treated wastewater will be used to irrigate the green belt which will be planted around the Eshidiya site. The excess sludge produced shall be disposed of according to the local standards.
- For Aqaba site, the company shall establish a treatment unit or a sealed pit to handle the domestic wastewater generated during construction and operation phase in order to ensure zero discharge. Approval from local authority (ASEZA) is necessary.
- The quantity of produced by-product (fluosilicic acid) shall be registed and the amount send to JPMC shall be also registed. If there is any surplus amount, the related authorities such as Ministry of Environment shall be informed.

<u>Additional Required Mitigation Measures for Other Issues</u>

Safety measures are the most important factors that shall be implemented so as to reduce the probability of accidents impact on public and the surrounding environment. These measures include, but not limited to, the following:

- During all phases of the project, environmental, occupational health and safety, operation and monitoring plans shall be established according to the applicable standards and regulations to protect workers, public health and environment.
- An emergency response plan shall be prepared for all emergency cases, such as earthquakes, leak from phosphoric acid storage tanks in Aqaba

or from the pipeline connecting the storage tanks with the jetty. The pipeline shall be protected against collisions.

- The storage tanks in Aqaba and Eshidiya shall be constructed according to the international codes and standards and in coordination with the civil defense to apply its regulations.
- The vehicles drivers shall have good skills in driving transport trucks and well trained to handle with any oil or chemical spillage. There shall be limits for trip duration to avoid drivers' overtiredness. Also, the vehicles shall be frequently maintained to avoid any spillage of such materials. The transport vehicles shall be placarded.
- Wind breakers shall be constructed around the site to reduce dust dispersion especially from the storage areas of sulphur and phosphate.
- The potential of reuse of gypsum (e.g. in cement industry, leveling the roads) and the rehabilitation of the mining sites in Eshidiya shall be explored by the company during the operation phase and revised frequently with the related institutions.
- Before and during decommissioning phase of any site, prior coordination with relevant authorities shall be established to define site rehabilitation requirements according to the applicable established codes, standards, and regulations at the time.
- During the decommissioning phase, strict decommissioning operation plan shall be established to include environmental and occupational health and safety procedures according to established codes, standards, and regulations that are applicable at the time of decommissioning to protect health and environment.

2.4.4 Archeology

- During the construction phase, it is essential to provide strict instructions to the contractor to pause construction work and excavations in case of discovering any antiquities or archeological items. Such discoveries should be reported to the Director of Department of Antiquities or to the nearest Public Security Center. The Department of Antiquities may in such cases recommend certain measures to protect the found items.

2.4.5 Socio-economic conditions

Following are the mitigation measure to minimize the negative impacts and to enhance the positive ones.

- Employment

- The project is expected to create temporary jobs for both skilled and non-skilled employees during construction and operation phase. So, it is highly recommended that JIFCO give a priority for local community (Al-Jafer and Ma'an area). This can be done in cooperation with the labor directorate in Ma'an governorate.
- In order to make the local employment more successful, it is recommended that JIFCO arranges with the vocational training center in Ma'an governorate to build and upgrade the capacity of the potential local workers, having basic qualification, on the skills jobs needed by the project.
- The company shall follow the Jordanian/ International regulations regarding child labor.
- The employment procedure should be established according to an approved criterion (such as the qualification is one of the main criteria).
- In case of project decommissioning, it is recommended to help terminated employees to find new jobs and to pay them fair compensation.

• Business prosperity
  - The company should get supplies, food, spare parts (if available having requisite quality and competitive price) from local stores during both construction and operation phases.
  - The company should give priority for local contractor to provide employees with suitable transportation and other services on competitive rates basis.
  - The company should contribute to social development of local communities (especially remotes ones) that are close to the project site.

• Traffic congestion and accident

  To reduce the risk of accidents and traffic jams to a minimum along the roads, the following mitigation measures should be adopted:
  - Strict instructions should be issued for drivers not to overload trucks transferring materials.
  - During construction phase, transportation of material to the project site (where congested public access crossings are used) should be avoided during the Rush hours.
  - During the operation phase, strict speed limits and safety signs shall be posted along the roads and drivers shall be trained on defensive driving to reduce potential increase in accidents.

- During construction activities, warning and traffic signs shall be posted so as to prevent accidents.
- High qualified and trained drivers should be chosen and directed to follow Jordanian traffic regulations.
- Well maintained appropriate trucks to transport products should be used.
- The trips of truck transporting the product should be organized to avoid the probability of traffic congestion caused by the use of large number of trucks at the same time.

- Earthquake impact

  Due to the location of the storage tank in high risk seismic zone, it is obligatory to take into consideration the regulation and design codes of the Ministry of Public Works and Housing against earthquakes.

- Visual impact

  In order to minimize the negative visual impact, the following mitigation measures should be followed:
  - Manage and dispose the excess soil, debris and all types of waste resulting from construction activity and decommissioning phases to a proper dump site specified by the local municipalities.
  - Plant selected trees appropriate for the area to improve the scenery of the site.
  - Reuse or recycle of the disassembled machines.

- Hazardous materials transportation

  JIFCO should follow the Ministry of Transport regulations for year 2003 regarding hazardous materials transportation. Following are those regulations:
  - Truck driver should be trained to handle hazardous materials in proper way.
  - Trucks should design in such a way that no leakage or damage of hazardous materials should happen or end up in an explosion while moving.
  - A printed label on the trucks is necessary to identify the nature of hazardous material.
  - Information about the hazardous materials should be given to the truck driver.
  - It is prohibited to park the hazardous material trucks inside the residential area.

- Trucks should be equipped by all the means of security (such as having fire extinguishers) and should be regularly checked.

- Grievance mechanism

  In order to minimize potential negative impact from the project activity and to maximize positive impacts, the company should establish a grievance mechanism as part of the management system to ensure that proper consultation, disclosure and community engagement is included throughout the project life continuously.

  A policy or process for addressing complaints cannot be effective if no one knows about it. Company's grievance procedures should be documented, publicized and should be clear to the relevant stakeholder groups. Also, the mechanism should be simple and the people should know where to go and whom to talk to as well as to understand the process for handling this issue. As a general rule, the grievance mechanism should not be complicated to use.

  Not all grievances can be handled in the same manner. Some serious problems require immediate interventions by senior managers. A simple problem could be solved by the JIFCO community liaison officer.

2.4.6 Occupational health and safety

Following are the mitigation measure to minimize the negative impacts and to enhance the positive ones.

- The company shall adopt the following points in order to have a comprehensive occupational health and safety policy:
  - Abide by the relevant laws and regulations and design.
  - Raise the sense of environmental protection and organize an environmental protecting construction.
  - Use qualified materials and dispose wastes in sorts.
  - The disposal of domestic wastewater shall be according to the related regulations.
  - Minimize noise generation to the permissible values.
  - The serious complain of environment would be nil.
  - The death accident would be nil, severe injury rate would be as low as possible.
  - Guarantee the health of the staff in case of occupational disease.
  - Prevent fire and exploding accidents.

All activities that impose unreasonable risks on workers health or safety shall be addressed and mitigated in the occupational health and safety system for either elimination or reduction the risk to an acceptable level and according to established standards and regulations.

The occupational health and safety plan that shall be prepared and available will include:

- Occupational health and safety plan objectives.
- Standards referred to.
- Occupational health and safety management system.
- Management commitments (including responsibilities of company staff).
- Resource management (including training for the employees).
- Realization of product.
- Measurements, analysis and improvement.
- Control of occupational health and safety management system (including identifying the accidents and documentation procedure, prevent / mitigate the risk, emergency response plan, etc).

- The employees shall be provided by the company with information regarding their rights under national labor and employment law.
- The working conditions shall comply with the national law.
- The company shall enable means for workers to express their grievances and protect their rights regarding working conditions. The grievance mechanism shall be provided by the company for the workers. Also, the company shall not discourage workers from forming or joining workers organizations of their choosing which will not contradict the local laws and regulations.
- An emergency response plan shall be prepared by the company to deal with fire, accidents, spillage and any other abnormal conditions. This plan shall be well implemented and reviewed by the management staff frequently. The employees shall be trained on all issues related to the emergency response plan. Also, the drivers shall be part of the plan and well trained.
- The company should coordinate and involve the concerned authorities in planning and implementing the emergency response plan.
- Hazard and Operability Analysis (HAZOP) will be prepared to be ready before the operation of the plant.
- All workers shall have a medical inspection before starting to work in the project.

- The workers shall be provided with all the related issues concerning occupational health and safety.
- Control staff of the company shall visit the work areas frequently to check and be sure that all the occupational health and safety measures are applied.
- Periodic medical inspection shall be done for all workers. If the company proposes to use the existing medical clinic of JPMC, it shall be upgraded to meet the IFC requirements.
- During construction phase, the ground shall be sprayed with water, if required, in order to reduce the dust from vehicle movements and to enable the vehicles drivers to see the workers around. Also on-site trained flag people wearing high-visibility vests shall direct traffic during construction activities. Vehicles shall be outfitted with audible back-up alarms.
- During construction activities, good house-keeping practices should be implemented, such as placing loose construction materials or debris in areas away from foot paths.
- The need for manual transfer of heavy loads should be minimized by good planning of site layout. Lifting devices appropriate to the load shall be used and well maintained.
- Control zones and safety monitoring systems shall be used to warn workers of their proximity to fall hazard zones, as well as securing, marking and labeling covers for openings in floors, roofs or walking surfaces.
- During construction and operation phases, all areas where the equivalent sound level (noise) exceeds 85 dB(A), warning signs will be posted indicating hearing protection is required. Workers will be instructed directly by occupational health and safety responsible person to use the personal hearing-protection equipment. Periodic medical hearing checks should be performed on workers exposed to high noise levels.
- All employees shall have the necessary personal protecting and safety equipment such as dust masks, safety slip retardant shoes, helmet and hearing protection equipment during different phases of the project, which provides additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems. The personal protective equipment shall be maintained frequently and replaced by new ones after the end of its life time.
- Catering with warm and healthy diet for workers (i.e. high carbohydrates fraction and low meat fraction) shall be provided to all workers during construction phase. Cold fresh water shall be available during both construction and operation phases for all employees all the time.

- During construction activities, a medical support including first aid clinic and ambulance shall be made available.
- During operation phase, eye-wash stations and emergency showers shall be provided close to all workstations where immediate flushing with water is the recommended first-aid response.
- Toilettes shall be available to be used by the workers during the construction phase. The generated domestic wastewater shall be collected in tanks and then transported to the nearest wastewater treatment plant in a safe manner. Certain control system shall be in place to ensure transportation of wastewater to the treatment plant.
- During operation phase, the domestic wastewater from the workers will be treated properly using activated sludge technology. The treated wastewater that will be used for irrigation purposes shall comply with the Jordanian standards.
- During construction and operation phases, adequate lavatory facilities shall be available. Toilette facilities shall be provided with adequate supply of hot and cold running water, soap and hand drying devices. Water provided for lavatory facilities shall meet drinking water quality standards.
- Domestic solid waste generated by workers during construction phase shall be collected in closed bags and disposed in a safe manner in closed domestic solid waste containers. The same can be said to solid waste generated from the personnel during operation phase.
- The residence of the workers shall be constructed in a healthy way and provided with all necessary utilities and services.
- Granulated sulphur should be used and not pulverized (fine) one.
- The storage tanks shall be constructed according to the international standards including all the necessary auxiliary tools and equipments related to safety concerns such as vents and alarm systems.
- The company shall apply appropriate measures to maintain air quality within the considered regulations. Air quality control shall be measured and controlled frequently by the company or by a contractor.
- Passages to emergency exits shall be unobstructed at all times. Exits shall be clearly marked to be visible in total darkness. There shall be enough exits at least two for each work area.
- The workplace shall be designed to prevent the start of fires through the implementation of the related codes applicable to industrial settings. Specific worker training in fire prevention or suppression shall be provided.
- Workplaces shall receive natural light as much as possible and supplemented with sufficient artificial illumination. Also, emergency

light shall be activated automatically in case of failure of the artificial light source.

- Safe passageways for pedestrians shall be constructed in the complex. Access ways shall be there for all equipment and installations requiring servicing. Railings shall be installed on stairs, fixed ladders, platforms, permanent and interim floor openings and ramps. All openings shall be sealed by gates or removable chains.
- Unauthorized access to dangerous areas shall be prevented by appropriate measures and signage of hazardous areas, installations, materials, safety measures and emergency exits shall be according to international standards and well known to workers.
- All vessels and pipes containing hazardous materials shall be labeled with the content according to national and international standards, also for piping systems with the direction of flow. Also the workers shall be trained how to use the available information such as Materials Safety Data Sheets (MSDS).
- According to Jordanian regulations, asbestos containing materials shall be avoided in construction of the project.

2.4.7 Marine environment

Phosphoric acid

Response when spilled to sea

Phosphoric acid is likely to cause serious risk to the marine environment when spilled. Therefore, mitigation measures are essential in order to allow best handling, storage, loading and unloading processes of the phosphoric acid. So, all fittings shall be properly secured prior to energizing loading/unloading system. Care should be taken to avoid acid contact when disconnecting lines/hoses after unloading. The pipe from the storage yard to the jetty shall be inspected regularly.

Quantity of the acid that dissolves in water depends on salinity and temperature. When phosphoric acid comes into contact with the sea (rapidly dilute the acid concentrations and reduce heat production), the response action on the main cause (tanks, pipes, tankers) shall consider the precautions outlined below:

a. The accident area will be approached upwind (wind direction behind) equipped with personal protective equipment. The number of responders in the risk area shall be kept to a minimum.

b. In theory, the action of phosphoric acid could be neutralized in shallow waters and in limited quantities using soda bicarbonate. However, buffering capacity in seawater might help in neutralizing the acid. Furthermore, phosphoric acid was reported to sink into the shallow waters but did not spontaneously mix with the water.

Response actions in the event of spill into a water column

- Measure concentrations
- Regularly monitor the pH and water temperature
- Establish exclusion zones (fishing, water intakes)
- Ecological monitoring of water and sediment chemistry and benthos census

Tank container trucks

Phosphoric acid is transported in liquid form in stainless steel/rubber lined carbon steel tanks. Leak-floors shall be provided underneath vulnerable equipment to prevent contamination of the soil from acid leaks during transportation.

Response actions in case of land spill

- Isolate spill or leak area immediately for at least 25 to 50 m in all directions.
- Keep unauthorized personnel away.
- Contain large spills with dikes and transfer the material to appropriate containers for reclamation.
- Absorb remaining material or small spills with an inert material and then place in a chemical waste container.
- Neutralize washings with a base such as soda ash or lime. Flush residual spill area with large amounts of water.
- Approach release from upwind.
- Stop or control leak using special protective clothing.

<u>Fluosilicic acid</u>

Road transport

The number of locomotives or frequency of trips of trucks transferring fluosilicic acid (H_2SiF_6) will be 6 trucks/day (each truck hold 35 tone) through desert. Management of fluosilicic acid emergencies shall consider the following:

- Tankers shall have bottom discharge nozzles with no provision of compressed air on the tanks utilized for unloading purposes.
- Clean up personnel will need personal protection equipment and respiratory protection.
- Source of water supply and eyewash facilities may also be needed for clean up personnel.
- Bags of neutralizing agent or chemical absorbent will be required for spill.
- A manual tool such as shovel may be required to scoop up neutralized acid/lime/soda ash residue.

Sulphur

Sulphur transportation

The number of locomotives or frequency of trips of trucks transferring sulphur through desert shall be 43 trucks/day and the quantity that will be transported from JPMC to Eshidiya is 1500 ton / day. Mitigation measures that will be implemented during transportation shall include:

- Dust emissions control by the use of water sprays in the event of a dry spell during uploading and downloading of trucks.
- Prevent wind blown sulphur from entering the environment by the use of proper sheltering of material during road transport.

Accidental release

Mitigation measures that will be implemented during accidental release:

- Remove all sources of ignition.
- Evacuate and ventilate the area of spills.
- Wear self-contained breathing apparatus, rubber boots and heavy rubber gloves.
- Wear disposable coveralls and discard them after use.
- Clean up spills in a manner that does not disperse dust into the air and place in closed containers.
- Use non-sparking tools and equipments.
- Reduce dust and prevent scattering by moistening with water.

Sulphur handling at the jetty

The following operational mitigation measures shall be implemented to alleviate potential environmental impacts of sulphur handling to the marine environment:

- Safety personnel will visually monitor and maintain the sulphur conveyance from the jetty to the storage yard.

- Conveyors shall be maintained and properly protected using suitable covers against any loss of powder product.
- Lost particles and dust dispersion on jetty platform shall be collected continuously and timely scheduled.
- Good house-keeping actions shall be followed during handling of the product at both the jetty and storage yard.
- Provision of automatic shut down systems in case of accidents and malfunctions.

Other mitigation measures

- All generated debris during construction activities shall de disposed to an authorized site after getting approval from ASEZA.
- It is recommended to continue conducting the monitoring program for the marine environment that could help in defining any points of divergence.
- ASEZA is responsible to monitor construction activities to confirm they are functioning as intended.

2.4.8 Training

Trained operators are the key to safe and environmentally sound project activities. Appropriate training programs should be established and implemented for the project employees as relevant to their duties and responsibilities including all activities taken place in the project.

All project employees should undergo professional training on occupational health and safety and on managing environmental issues relevant to their duties and practices.

Procedures should be developed to monitor the effectiveness of the training programs.

3. MONITORING PROGRAM (MP)

Environmental monitoring is an important part of the ESIA study. It is used for protecting and conserving valued environmental components (VECs) and to assess the effectiveness of the mitigation measures.

JIFCO is responsible for ensuring the implementation of the monitoring program. Regulatory authorities such as the Ministry of Environment (MoEnv), Aqaba Special Economic Zone Authority (AESZA), Water Authority of Jordan and Ministry of Health have the mandate to check / inspect that the program is fully and adequately implemented.

3.1 Objectives

The main objectives of the monitoring program with respect to the project activities are as follows:

- To ensure compliance with regulatory authorities requirements.
- To assess effectiveness of the proposed mitigation measures in the ESIA.
- To assure that the objectives of EMP are met.

3.2 Monitoring Targets

To fulfill the above-mentioned objectives, the monitoring program shall cover issues related to valued environmental components as shown in the following sections.

3.3 Water Resources

Desired targets

- The quality of the drinking water shall meet the Jordanian standard for drinking water JS: 286/2001 and IFC regulations.

- The quality of treated domestic wastewater shall meet the Jordanian standard for treated domestic wastewater JS: 893/2006 and IFC regulations.

- Regulations regarding monitoring groundwater (No. 26 for 1977).

Parameters to be measured

- Drinking water: All relevant parameters shown in Table (2) shall be analyzed.

- Treated domestic wastewater: All relevant parameters shown in Table (3) shall be analyzed.

- Groundwater (well):
  The following parameters should be measured:
  PO_4, F, K, pH, EC, TDS, Mg, Na, SO_4, Fe, Mn.

Method of measurement

- Field instruments shall be used to test the following parameters (pH and EC). For completion of other analysis, samples should be sent to specialized water analysis laboratories or JIFCO's own laboratory.

Time frame

- Frequency: As shown in Table (2) and Table (3) for drinking water and treated domestic wastewater respectively.

- Groundwater analysis should be done at least once a year.

Table (2): Monitored parameters for drinking water

Parameters	Sample Collection and Analysis Frequency	WHO Maximum Levels (WBG/IFC Units)	Jordan Maximum Levels (Jordan Units) JS: 286/2001
pH	Daily	6.5 - 8.0	6.5-8.5
Total residual chlorine	Daily	5 mg/l	0.2-1 mg/l
Total hardness (as $CaCO_3$)	Annual	500 mg/l	300-500 mg/l
Sulfate (SO_4)	Annual	400 mg/l	200-500 mg/l
Total dissolved solids	Annual	1000 mg/l	500-1500 mg/l
Arsenic	Annual	0.01 mg/l	0.01 mg/l
Chromium (total)	Annual	0.05 mg/l	0.05 mg/l
Lead	Annual	0.01 mg/l	0.01 mg/l
Benzene	Annual	0.01 mg/l	0.01 mg/l
E. Coli or thermotolerant Fecal coliform bacteria Most Probable Number (MPN) or plate count (PC)	Weekly	<1 Per 100ml	<1.1 MPN/100 ml

Table (3): Monitored parameters for treated domestic wastewater

Parameters	Sample Collection and Analysis Frequency	WBG/IFC Maximum Levels (WBG/IFC Units)	Jordan Maximum Levels (Jordan Units) JS: 893/2006 (for irrigation purposes)
pH	Daily	6-9	6-9
Biochemical oxygen demand (BOD_5)	Weekly	30 mg/l	300 mg/l
Chemical oxygen demand (COD)	Weekly	125 mg/l	500 mg/l
Oil and grease	Weekly	10 mg/l	8 mg/l
Total suspended solids (TSS)	Weekly	30 mg/l	300 mg/l
Total dissolved solids (TDS)		1000 mg/l	1500 mg/l
Cadmium	Monthly	0.1 mg/l	0.01 mg/l
Fluoride	Monthly	20 mg/l	2 mg/l
Phosphorus	Monthly	5 mg/l	30 (as PO4) mg/l
Nitrogen (total)	Monthly	15 mg/l	100 mg/l
Total coliform bacteria, Most Probable Number (MPN) or plate count (PC)	Monthly	≤400 Per 100ml	- -
Temperature increase	Monthly	3°C	
NO_3	Weekly		70 mg/l

3.4 Public Health

3.4.1 Air pollution

Desired target

- Air emissions shall not exceed the limits given in the Jordanian Standards (JS: 1189/2006) and IFC regulations for stack emissions.
- The ambient concentration shall not exceed the Jordanian Ambient Air Quality Standards (JS: 1140/2006) and IFC regulations.

Parameters to be measured

- All relevant gaseous pollutants and particulate emissions from the stacks shall be monitored as shown in Table (4).
- All relevant gaseous pollutants and particulate matter concentrations in the ambient air shall be monitored as shown in Table (5).

Method of measurement

- Online and intermittent stack emission sampling will be conducted to demonstrate compliance with the national standards and IFC regulations.
- Isokinetic dust sampling will be used to measure particulate concentration in stacks to demonstrate compliance with the national standards and IFC regulations.
- Gravimetric by using high volume sampler will be used to measure inhalable particulate matter (PM10 and PM2.5) concentrations in ambient air.
- The ambient air monitoring will be conducted down wind of JIFCO (south to southeast of JIFCO)

Time frame

Stack (intermittent measurement)

- Measurement period: short time measurement during 1 day.
- Frequency: As shown in Table (4).

Ambient

- Measurement period: during 1 week (24 hrs continuous)
- Frequency: As shown in Table (4).

Table (4): Monitored parameters for stack emission

Parameters	Collection Frequency	WBG/IFC Maximum Levels (WBG/IFC Units)		Jordan Maximum Levels (Jordan Units) JS: 1189/2006	
PM	Quarterly	50	mg/Nm^3	50	mg/Nm^3
Nitrogen oxides (as NO_2)	Quarterly	200	mg/Nm^3	200* 1500**	mg/Nm^3
Sulfur dioxide (SO_2)	Quarterly	2,000	mg/Nm^3	6500	mg/Nm^3
For sulfuric acid plant, SO_2	Quarterly	450 2	ppm kg/t acid	1500	mg/Nm^3
For sulfuric acid plant, SO_3	Quarterly	60 0.075	mg/Nm^3 kg/t acid	150	mg/Nm^3
Fluorides (gaseous) as HF	Quarterly	5	mg/Nm^3	15	mg/Nm^3
F_2	Quarterly	-	-	5	mg/Nm3

* : If the combustion temperature is less than 1200 °C.

** : If the combustion temperature is more than 1200 °C.

Table (5): Monitored parameters for ambient air emission

Parameters	Collection Frequency	WBG/IFC Maximum Levels (WBG/IFC Units)	Jordan Maximum Levels (Jordan Units) JS: 1140/2006
Particulate matter (PM10)			
1-year		70	70
24-hour	Quarterly	150 μg/Nm^3	120 μg/Nm^3
Particulate matter (PM2.5)			
1-year		35	15
24-hour	Quarterly	75 μg/Nm^3	65 μg/Nm^3
Nitrogen dioxide			
1-year		40	0.05 ppm
1-hour	Quarterly	200 μg/Nm^3	0.21 ppm
Sulfur dioxide			
24-hour		125	0.14 ppm
10-minute	Quarterly	500 μg/Nm^3	-
Ozone			ppm
8-hour daily maximum	Quarterly	160 μg/Nm^3	0.08
Hydrogen sulfide			
24-hour health effect		150 μg/Nm^3	0.01 ppm
30-min sensory effect	Quarterly	7 μg/Nm^3	-
Fluorides	Quarterly	1 μg/Nm^3	-
P_2O_5			
24 hours	Quarterly	- -	100 μg/Nm^3
yearly		- -	40 μg/Nm^3

3.4.2 Noise

Desired target

- Noise levels shall not exceed the values given in the Jordanian Noise Regulations for 2003 and IFC regulations.

Method of measurement

- Sound level meter will be used during day and night time periods at the measured site that was selected for background noise levels measurements (labor camp). Also, noise measurement shall be conducted at the borders of JIFCO.

Parameter to be measured

- Noise: Day and night equivalent sound pressure level (LAeq).

Time frame

- Measurement period: 24 hours for labor camp and short term measurements at the borders of the project site during day time.
- Frequency: Quarterly.

3.5 Occupational Health

Desired target

- Workplace air quality parameters shall not exceed the values given in the Jordanian Regulations (Regulation 943/1998) and IFC regulations.

Parameter to be measured

- SO_2, HF, PM, Temp., Noise

Method of measurement

- Electrochemical cells will be used for short term measurements of SO_2, HF.
- Light scattering or gravimetric will be used for short term measurement of PM.
- Sound level meter will be used for measurement of noise in working areas.

Time frame

- Measurement period: 24 hours (short term measurements).
- Frequency: Quarterly.

Table (6): Monitored parameters for workplace

Workplace Monitoring Parameter	Sample Collection and Analysis Frequency	WBG/IFC Maximum Threshold Limit Value (TLV-TWA)[1]	Jordan Regulatory Limits and Units Regulation 943/1998
Workplace Respirable Air Concentrations			
SO_X (SO_2)		13 mg/m^3	5.2 mg/m^3 (2ppm)
HF*			2.6 mg/N m^3 (3 ppm)
Workplace Noise	Quarterly	80 dB(A)	85 dB(A)
Heat Exposure, continuous work	Quarterly		
Moderate work load (walking, standing, use of hand tools)		27.5 ^oC	

The above monitoring programs and time frames should be subject to revisions and updates as necessary depending on the monitoring results.

3.6 Follow Up Procedure

In addition to the above procedures, follow up procedures shall be in place to ensure implementation of all mitigation measures stated in this document.

[1] TLV-TWA (Threshold Limit Value-Time Weighted Average): The time-weighted average concentration for a conventional 8-hour workday and a 40-hour workweek, to which nearly all workers may be exposed, day after day, without adverse effect.

Environmental and Social Impact Assessment

Jordan India Fertilizer Company (JIFCO)

REVIEWING SESSION REPORT

Submitted to:

Jordan Phosphate Mines Company (JPMC)

Submitted by:

Royal Scientific Society / Environmental Research Centre

July, 2008

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1. Introduction

A reviewing session for the Environmental and Social Impact Assessment (ESIA) study for Jordan India Fertilizer Company (JIFCO) was held in Aqaba (Aqaba Gulf Hotel) on June 22, 2008. Copies of the draft ESIA report were sent to Ministry of Environment (MoEnv) and to Aqaba Special Economic Zone Authority (ASEZA) prior to the session.

The main objective of the reviewing session was to ensure that the ESIA study addressed adequately all issues and concerns raised by the general public and concerned authorities during consultations and the scoping session that was held in Aqaba on February 12, 2008. In addition, the reviewing session was also held to share the findings of the ESIA study with the concerned authorities and public, and to ensure that the recommended mitigation measures and monitoring plans are seen appropriate to ensure sound environmental management of the project activities during its construction, operation and decommissioning phases.

The arrangements for the reviewing session were undertaken in close coordination with ASEZA and MoEnv. ASEZA invited the concerned parties and authorities in Aqaba region. MoEnv is responsible to give the final permit of the project after approval of the ESIA report from its EIA committee while ASEZA is also responsible to give its permit on project activities taken place at Aqaba region.

The reviewing session was patronized by Dr. Salim Al-Moghrabi, representative of ASEZA and Mr. Izzat Abu Hamra, representative of MoEnv. Representatives of Jordan India Fertilizer Company (JIFCO), Mr. Faysal Doudin, Mr. Santosh Chandrasekharanpillai and Mr. Navin Nath also attended the session. A list of all participants in the reviewing session are shown in Annex (1).

2. Activities Undertaken in the Reviewing Session

The following activities took place during the reviewing session:

- Opening session: Opening speeches and remarks were given by Dr. Salim Al-Moghrabi and Mr. Izzat Abu Hamra. Mr. Faysal Doudin of JIFCO emphasized during his speech the commitment of his company to implement all the results of the ESIA study.

- Presentation of ESIA study results: Presentations of results of the ESIA study were given by Mr. Mohammad Mosa from RSS study team and of the marine environment was given by Dr. Mohammad Alzibdah. The presentations covered the whole ESIA study and as follows:

  - The different stages and activities conducted during the ESIA study.
  - Project description.

- Results of the different component studies:
  - Air quality.
  - Noise.
  - Water resources.
  - Socio-economic conditions.
  - Biodiversity.
  - Archeology.
  - Marine environment (detailed results and baseline data).

- Environmental management plan including mitigation measures and monitoring plans.

- Work session: A work session was facilitated by RSS team. A panel comprised representatives of ASEZA, MoEnv, JIFCO and RSS team. Each participant was asked to write down his/her notes and comments and to pass

it to RSS team in addition to the oral comments and questions. After collection of all filled forms, each comment was discussed with the participants in details. Most of the points raised were clarified, answered and agreed to be closed with MoEnv and ASEZA.

The issues and notes raised during the session as well as the answers are shown in Annex (2), while the comments of MoEnv and ASEZA and the relative replies are shown in Annex (3) and Annex (4) respectively. Additionally, RSS ESIA team and Mr. Santoush from JIFCO held a short meet with the representatives of MoEnv and ASEZA to discuss in detail the comments.

Annex (1)

List of the reviewing session participants

Table (1): Participant Names of Reviewing Session

Name	Company
Eng. Ezzat Abu Hamra	Ministry of Environment
Dr. Saleem Al-Mughrabi	Aqaba Special Economic Zone Authority (ASEZA)
Ayman Al-Sukhon	ASEZA
Eng. Khaled Abu Aesheh	ASEZA
Ra'ed Abdulraheem Damra	ASEZA
Eng. Suha Al-Farahat	ASEZA
Eng. Bayan Al-Refa'i	ASEZA
Eng. Hayah Ahmad Al-Athameen	ASEZA
Eng. Ayman Al-Kouz	ASEZA
Dr. Ayman Sulaiman	ASEZA
Eng. Moh'd Al-Kabareeti	ASEZA
Ibrahim Al-Sheeshani	Intelligence Directorate / Aqaba
Samer Kraishan	Intelligence Directorate / Aqaba
Eng. Dema Hadadeen	Public Works Directorate / Aqaba
Moh'd Abdelmahdi Al-Fa'ouri	Environmental Rangers
Eng. Abdulwahhab Al-Shoyyab	Royal Society for Marine Conservation
Eng. Belal Yousef Al-Khalafat	Marine Authority of Jordan
Eng. Moh'd Hasan Amr	Central Electricity Generation Company
Eng. Belal Sulaiman Al-Nsour	Fertilizers and Chemicals Industries (KEMAPCO)
Eng. Zeyad Al-Ta'ani	Aqaba Water Company
Eng. Abed Salameh	Jordan Phosphate Mines Company
Eng. Moh'd Abdulkahreem Khader	Civil Defense Directorate / Aqaba

Table (1): Participant Names of Reviewing Session

Name	Company
Eng. Khal ed Moh'd Al-Da'ajah	Royal Marine Force
Fawzi Moh'd Saleem Al-Hakeem	Electricity Distribution Company
Eng. Ra'edah Al-Azzeh	Ministry of Health/ Aqaba Health Directorate
Rasha Mahmoud Al-Dmour	Environmental Rangers
Khaldoun Al-Momani	Aqaba Governorate
Yazeed Oran	Labor Directorate / Aqaba
Eng. Amenah Bayaydah	Arab Potash Company
Dr. Moh'd Al-Zebdeh	Marine Science Station
Eng. Moh'd Al-Hjouj	Jordan Phosphate Mines Company
Eng. Faysal Dodien	Jordan Phosphate Mines Company
Navin Nath	Jordan India Fertilizer Company
Eng. C. Santosh	Jordan India Fertilizer Company
Dr. Bassam Hayek	Royal Scientific Society
Eng. Moh'd Mosa	Royal Scientific Society
Eng. Jehan Haddad	Royal Scientific Society
Eng. Najeeb Ateyat	Royal Scientific Society

Annex (2)

Comments during the reviewing session and the replies

Aqaba Civil Defense Directorate / Eng. Moh'd Abdulkahreem

1. It is necessary to take into consideration all of the safety and protection requirements for the project facilities of both sites, and the detailed diagrams shall be submitted to the Civil Defense Directorate to study and determine the safety and protection requirements of the processing methods.
   - JIFCO will be committed with civil defense requirements through all project phases. Also, it is known (it is mentioned in the report in Chapter II, page 4) that approval of civil defense of the project diagrams is a must prior to getting the final approval.

2. Prepare emergency plans of the expected accidents (materials spills in the storage tanks and during the transportation) and do the trainings for the workers.
   - JIFCO will be committed for preparing all emergency plans related to the project activities and preparing training plans for all workers before starting the operation phase. Also, it is mentioned in Chapter VI in the report some of safety procedures and how to deal with spilled materials during transportation.

Aqaba Special Economic Zone Authority/ Mr. Ra'ed Damra

1. What are the suggestions to solve the disposed gypsum?
   - It is mentioned in the report that it is required to investigate the possibility to reuse the disposed gypsum in the cement manufacturing and in rehabilitation of phosphate rocks mines.

2. How is to control the problems that are resulting from the sulphur transportation.
   - JIFCO will make a contract with a special company (licensed) for transporting the sulphur, whereby the company will be responsible for safe transportation of sulphur, avoiding spills on the road be occurred and to treat any spills on road if it happens. However, JIFCO is still responsible with all environment and safety measures that were mentioned in the environmental management plan related to the transportation. Also, JIFCO will import the granular sulphur not the fine one.

3. What are the measures that will be adopted by the company to reduce the environmental impact of transportation of fluosilicic acid.
   - All measures related to the transportation of fluosilicic acid are mentioned in the report in Chapters VI and X. The company confirmed full commitment to the safe transportation.

4. It is not mentioned in the report the subject of the soil stability in the storage tanks area in Aqaba.
   - The soil stability of the storage tanks in Aqaba will be investigated prior to the design of the foundations of the storage tanks and before the start of the infrastructure works.

5. What are the solutions to dispose the gypsum remains in the storage tanks in Aqaba?
   - An agitator will be installed in each tank to mix the stored material to avoid any precipitation of the gypsum inside tanks. In case of existence of gypsum inside the tanks, JIFCO will collect it and dispose into gypsum disposal area of JPMC.

Royal Society for Marine Conservation/ Eng. Abdulwahhab Al-Shoyyab

1. It is noticed that the spills of sulphur in the sea from the ships impact on the marine environment and the cleaning remains of the deck is dumped into the sea?
   - This issue is discussed in the report (chapter X).

2. It is recommended to prepare a proper emergency plan during the cleaning of pipes that are carrying the phosphoric acid to prevent any spill accidents in the future.
   - JIFCO will prepare all emergency plans related to the project activities and prepare training plans for the workers prior to start the operation phase. Also, it is ensured in the study report (chapter X) to conduct a routine inspection on the pipes.

Aqaba Water Company/ Eng. Zeyad Al- Ta'ani

1. The domestic wastewater shall be reused into the process to save much amount of drinking water.
   - It is mentioned in the study report in chapter IV the necessity to reuse the treated wastewater for irrigation water (trees on the plant borders). Also, it is recommended to investigate the possibility to reuse the treated domestic wastewater from domestic wastewater plant in Ma'an Governorate and from Ma'an Industrial Zone into the plant process. This shall be investigated in the future, when such reclaimed water become available.

2. The issue of sulphur spills shall be investigated?
   - JIFCO will make a contract with a special company for transporting the sulphur where the company is responsible of not allowing for any spills of sulphur on the road and to treat any spill on road if it happens. However, JIFCO is still responsible for all environment and safety measures that were mentioned in the environmental management plan related to the transportation. Also, JIFCO will import the granular sulphur not the fine one.

3. An alarm system for the sea water shall be installed in the southern shore as a precaution for any chemical spills to reach sea?
   - ASEZA will install two alarm systems in the north and south parts of the gulf for general monitoring and will be funded by private sector. Additionally, a monitoring program for the marine environment is now

running by ASEZA in cooperation with the Marine Science Station in Aqaba.

Marine Authority of Jordan/ Eng. Belal Al-Khalafat

1. What is the treatment method of the gaseous emissions?
   - JIFCO will comply with IFC guidelines and Jordanian Standards (JS: 1189/2006) for the stack gaseous emissions (such as installing scrubbing system of the gaseous emission from phosphoric acid plant). In addition, a dispersion modeling of pollutants to predict the concentrations of the gaseous emissions in the ambient air that are generated from the company and the surrounding companies in Eshidiya area was done. It is concluded from the results of the modeling, that there is no expected impact of gaseous emission on the residential areas. Also, the company will conduct a periodic maintenance to the vehicles that will be used for the project.

2. What is the method of handling of the spilled sulphur and how to avoid any more spills of sulphur in the industrial port in Aqaba zone during next two years before commissioning the new handling system?
   - JIFCO will comply with all the measures mentioned in the environmental management plan to avoid any spills to the sea water.

3. It is necessary to take the most precautionary measures during sulphur transportation through vehicles and have warning signs on them to avoid any accidents.
   - JIFCO will prepare whole emergency plans related to transporting of sulphur through vehicles. In addition, JIFCO will contract with special company for transporting the sulphur where the company is responsible of not allowing for any spills of sulphur on the road be occurred and to treat any spills on road if it happens. However, JIFCO is still responsible for all environment and safety measures that was mentioned in Chapter VI.

4. It is necessary to all workers in the company to have a proper training to deal with the chemical substances.
   - JIFCO will prepare all emergency plans related to the project and prepare training for all workers as mentioned in Chapters VI and IX of the study report.

5. Prepare awareness to the workers who deal with transferring the phosphoric acid through the pipeline between storage tanks and the port to prevent any expected spills on the sea water.
   - JIFCO will prepare all emergency plans related to the project and prepare training for all workers prior to starting the operation phase as mentioned.

Central Electricity Generation Company/Eng. Moh'd Amr

1. Regarding to the standby boiler: What is fuel type to be used in the project, what are the concentrations of the stacks emissions, what is the control system adopted?
   - It is not expected that there is an impact of the gaseous emissions from the standby boiler stack on the ambient air on the residential area as shown in results of the dispersion modeling of the pollutants, while the standby boiler will be operated for limited days during start-up. The fuel type will be diesel. Also, JIFCO will comply with IFC guidelines and Jordanian standard (JS:1189/2006).

2. Why treated wastewater is not adopted as source of needed water for the project?
   - It is mentioned in the study report the necessity to reuse treated wastewater for irrigation water (trees on the plant borders) in Chapter IV. Also, it is recommended for JIFCO to investigate the possibility to reuse the treated domestic wastewater from domestic wastewater plant in Ma'an Governorate and from Ma'an Industrial Zone into the plant process.

3. Who guarantee that used V_2O_5 will be sent back to the supplier. If this case is not achieved, is there any possibility to treat this material and dispose it in Jordan through Ministry of Environment?
   - JIFCO will store this material in special and sealed containers to send it back to the supplier, and the company will select the supplier that has an ability to receive the material back and to treat it.

4. What grantees that the used oil will be sent back to the refinery and will be disposed in a proper way.
   - The company will contract special licensed contractors, and the company will record the amounts regularly.

5. Why the study did not mention any suggestion of disposal of the gypsum instead of dumping in the disignated area of JPMC?
   - In the study report, many suggestions were mentioned, such as to investigate the reuse in cement manufacturing and in the rehabilitation of the phosphate rocks mines.

6. Are there clear and quick plans to be used to face the accidents of phosphoric acid from ships?
   - JIFCO will prepare all emergency plans related to the project and prepare training for all workers prior to starting the operation phase and ensure to monitor the pipeline routinely.

7. What are the company plans in the awareness of the drivers on the risks that might be faced due to spillage of the substances on the road?

- JIFCO will make a contract with a special company for transporting the substances where the company is responsible of not allowing for any spills on the road to be occurred and to treat any spill on road if it happens. However, JIFCO is still responsible for all environment and safety measures that were mentioned in the environmental management plan related to the transportation.

8. Has the extent of the spillage impact of phosphoric acid on the marine environment been studied by using modeling or simulation?
   - The extent of the impact of phosphoric acid spills on the sea water was studied and also the measures that shall be taken to face the spill problem were mentioned in chapter X.

Aqaba Special Economic Special Zone Authority/ Eng. Suha Al-Farahat

1. The company shall coordinate with Investment Directorate in ASEZA for submitting required papers for getting approval before staring construction phase.
   - JIFCO will coordinate with Investment Directorate prior to commencing the construction phase.

Aqaba Public Works Directorate/Eng. Dema Hadadeen

1. The company shall be committed to meet the regulations for the permissible axial loads of the vehicles during transportation.
   - It is mentioned in the report that the company shall comply with the permissible axial loads as mentioned in Chapter VIII .

2. The drivers shall be well trained in case of spills accidents on the roads.
   - JIFCO will prepare all emergency plans related to the project and prepare training for all workers prior to starting the operation phase as mentioned in Chapters VI and IX of the study report.

3. The transportation of the substance shall be avoided during peak periods.
   - It is recommended to the company to avoid transportation of the substances during peak periods as mentioned in Chapter VIII in the study report.

Aqaba Intelligence Directorate/Mr. Ibrahim Sheeshani

1. Investigate the possibility to install underground tanks for storing phosphoric acid in Aqaba?
   - Phosphoric acid is strong acid but is not explosive or flammable, hence, it is not necessary for the acid to be stored in underground tanks. Based on the international guidelines, JIFCO will construct a containment area which will handle 110% of largest volume. If the spill is occurred, the spilled acid will be pumped directly to any of storage tanks.

2. It is recommended for the company to aid in the environment fund?
   - JPMC is conducting a monitoring program of marine environment along southern coast of the Aqaba Gulf in six points, and the company is ready to develop this program if required.

Fertilizers and Chemicals Industries (KEMAPCO)/ Eng. Belal Al-Nsour

1. What is mechanism of dealing with spilled sulphur in the sea and how it can be avoided in the future?
   - JIFCO will be commitment to comply with the mitigation measures to prevent any spills of sulphur in the sea water as mentioned in the study report in Chapter X, page 37.

Electricity Distribution Company/ Eng. Fawzi Al-Hakeem

1. What is the impact of using Disi water by the project on the Transfer Disi water to Amman Project?
   - JIFCO will coordinate with the Ministry of Water and Irrigation regarding this issue and it is recommended to reduce the consumption of water as much as possible. Disi project has allocation for industrial uses as well as domestic.

Others

1. The company has to take care of some of local schools.
   - JIFCO will cooperate with relevant organizations to public society development according to the company capabilities.

2. The company has to do social activities for disabled people.
   - JIFCO will cooperate with the relevant organizations serving this sector of the society according to the company's capabilities.

3. The company has to employ from local community.
   - Yes; this issue was mentioned in the study report in Chapter VIII.

4. The company has to do public services according the local society future needs.
   - JIFCO will cooperate with the relevant organizations for society development according to the company's capabilities.

Annex (3)

Comments of MoEnv and the replies

1. There are some differences between Arabic and English summaries
   - The two summaries were modified.

2. In page (I/25), the amount of catalyst (V_2O_5) has not been estimated and the mitigation measures to handle this material by workers have not been mentioned.
   - The annual quantity of catalyst (V_2O_5) to be used in the process is estimated at around 900'000 liters and the annual amount of spent catalyst is estimated at around 9'000 liter (1% of the catalyst). The spent catalyst will be kept in the sealed container and properly stored at a designated place till it is sent back to the origin supplier. While loading and unloading of the catalyst, the workers will use the personal protective equipments like dust, mask, gloves and protective clothing.

3. What is the impact of the solid wastes that result from the neutralization of fluosilicic acid with lime and the impact of sulphur impurities that will be sent into the gypsum dumping site on the quality of the gypsum if it will reused
   - The neutralization of off-grade fluosilicic acid is very rare since as a first priority the off-grade fluosilicic acid will be recycled back to the process. The produced materials from the neutralization, if any, will be sent to the designated area within the gypsum dumping site and it will be in the wet form. Also, sulphur impurities which contain mainly hydrocarbon substances are proposed to be segregated from the gypsum taking into consideration that the generated quantity is very negligible.

4. In page (II/3) the directorate that is responsible for reviewing EIA study is EIA division which is belongs Licensing and Guiding Directorate.
   - The modification is done in page (II/3)

5. The presentation of the impact of the issues and concerns in Table (3.3) is not accurate where the impact is occurred from the activity itself not from the absence a part of project elements as mentioned in this table.
   - The evaluation of environmental issues and concerns that are mentioned in this table is based on the opinion of the participants in the scoping session that was held in Aqaba in 12/2/2008 and the team wrote all concerns and issues as mentioned in this session.

6. In page (IV/9) it is not clear how the value of CN is estimated?
   - The value of CN is not estimated but it is taken from the reference (Davis, M., and Cornwell, D., 1991, Introduction to Environmental Engineering, McGraw Hill) depending on the geological characteristics of the surface soil of the project site.

7. In page (IV/25), the table number is (4.6) not (4.7).
   - The modification of the table number is done

8. In page (VI/2) and in the summary, is the location of ambient air monitoring site in the northwest border of the project site right according to the wind direction?
   - The monitoring program was conducted at the northwest border of the proposed JIFCO project site where it is downwind the existing industrial activities since the prevailing winds most of time in Eshidiya area are calm and northwest direction (according to data of Jordan Meteorological Department of Al-Jafer area and the one-month wind speed and direction monitoring). Therefore, the site is selected due it is affected by the emissions of the existing industries only. Also, the study recommends to JIFCO to conduct a monitoring program during the operation phase at a south side of the project borders where it is affected by the emissions of both of JIFCO plant and the existing industries.

9. In page (VI/54), the study doesn't clarify the measures that will be taken by JIFCO after conducting the radioactivity measurements of the phosphoric acid or phospho-gypsum.
   - It is not expected to obtain high impact from the radioactive elements on the workers and the surrounding residential areas as referring to the Environmental Impact Study of Hydro-Agri Jordan Project, 1999. On the other hand, the study recommends to conduct a measurement from time to another and propose the proper mitigation measure in case of increasing the radioactivity levels such as prevention of dust by spraying water from time to another and not allowing the workers to be close to the gypsum dumping site for not exposed to radon gas.

10. It is noticed in Table (6.3) in page (VI/5) that five measurements on HF levels which 30 minutes period each sample were conducted using instrument of detection limit is 0.05 ppm. It is preferred to conduct these measurements over 24 hours per sample not 30 minutes according to WHO guidelines to better compare with the standard. In addition, the detection limit of the instrument used in the measurement is higher than the standard detection limit of WHO (0.0011 ppm). So the measurement of HF is not acceptable.
    - The area where HF measurements were conducted represents work environment (the existing industries in Eshidiya area) not public environment (surrounding residential areas), hence when comparing the detection limit of the instrument (> 0.05 ppm) with the standard limit of HF in the work environment (3 ppm, as short term exposure limit), it is found that measured HF concentration is considered much lower. Based on the modeling program to predict HF dispersion from Indi-Jordan Co. and JIFCO (during operation phase), the maximum HF concentrations will be reached to 1.1 $\mu g/m^3$ at a distance of 2.2 km from JIFCO plant borders. Therefore, it is not expected to have impact on residential areas in Al-Jafer where it is far around 45 km from the northern side of JIFCO plant (Upwind direction) or employee residential complex which is 3.2 km far from the northern side of JIFCO plant.

11. The concentrations of P_2O_5 has not been measured by RSS although it is important and there is standard limit in Jordanian standards.
    - Referring to the studies conducted by RSS in Abiyad and Sultani areas through continuous three years program (inareas that would be affected by the emissions of phosphate rocks mining), it is found that no exceedance of P_2O_5 concentration has been recorded. In addition, P_2O_5 measurement in the project site was not included in the terms of references that are approved by the Ministry of Environment. Hence, it may be possible to conduct P_2O_5 measurement in the project site during the operation phase.

12. There is no daily and yearly assessment of SO_2 emission.
    - The probability of recording the weather conditions such as the 100% occurrence of one wind direction, stability conditions, etc. that could cause the highest concentrations of pollutants at ambient air is higher at one hour rather than during 24 hours. Hence, it is better to assess the activities of JIFCO project at one hour.

      Referring to the results of the modeling program that was undertaken and shown in table below, the impact of JIFCO plant will be not significant on long distance beyond plant borders on the surrounding residential area of Al-Jafer area which is located around 45 km upwind direction. But if the employee's residential complex is taken as residential area which is located around 3.2 km, it is not expected also to be affected by the plant emissions during 24 hours due to the south direction of the wind in this area (see figures below). Also, maximum hour concentrations that were recorded during the weather conditions of F2, D4 and B1 area are 0.043, 0.05 and 0.0 ppm respectively.

Stability and wind speed	**Max. gr. level conc. (C_{max}), ppm**	**Distance from final absorption stack at which C_{max} occurs (D_{max}) downwind (km)**
B1	0.142	1.5
D4	0.056	3.0
F2	0.017	24.0

13. There is no daily and yearly annual assessment of NO_2 emission.
    - The assessment of one hour concentration of NOx from JIFCO plant is done by the modeling program by taking into consideration that NOx concentration measured in the ambient air is the highest concentration of NO_2. It is concluded from the table shown below that there is no possibility of NO_2 exceedance of the daily and annual average values beyond the limits of Jordanian Standard and WHO standard.

Stability and wind speed	Max. gr. level conc. (C_{max}), ppm	Distance from start up boiler stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.004	1.0
D4	0.002	2.3
F2	0.001	16.0

14. There is no 8 hours assessment of CO emission
    - The results of the modeling program in the table below show that there is no exceedance of CO emissions of the 8-hrs values beyond the limits of Jordanian Standard and WHO standard.

Stability and wind speed	Max. gr. level conc. (C_{max}), ppm	Distance from start up boiler stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.005	1.0
D4	0.002	2.3
F2	0.001	16.0

15. There is no daily and yearly assessment of PM10 emission
    - The results of the modeling program in the table below show that there is no exceedance of PM10 emissions of the daily and annual average values beyond the limits of Jordanian Standard and WHO standard.

Stability and wind speed	Max. gr. level conc. (C_{max}), $\mu g/m^3$	Distance from start up boiler stack at which C_{max} occurs (D_{max}) downwind (km)
B1	18.9	0.7
D4	5.9	2.0
F2	3.8	10.0

16. There is no daily and yearly assessment of P_2O_5 emission
    - If 100% of PM10 measurements is assumed to be as P_2O_5, there is no probability of exceedence of Jordanian Standard limits which average daily value is estimated at 100 $\mu g/m^3$ and yearly average value is 40 $\mu g/m^3$.

17. There is no daily assessment of HF according to WHO guidelines, and the assessment of hourly value mentioned in the report has no meaning because there are no guidelines to compare with?

- The results of the modeling program in the table below show that there is no exceedance of HF emissions of the daily average values beyond the limits of WHO guidelines which is estimated at about of 1μg/m^3.

Stability and wind speed	Max. gr. level conc. (C_{max}), μg/m^3	Distance from H_3PO_4 plant stack at which C_{max} occurs (D_{max}) downwind (km)
B1	0.699	1.3
D4	0.435	2.6
F2	0.017	37.0

18. The assessment of the noise impact shall be clarified, what is the approach taken to assess the impacts and how the assumptions were set?
    - The impact of noise from the project activities during the construction and operation phases in both Eshidiya and Aqaba sites was assessed on the surrounding people and on the workers. The results in the study are based on the theory such noise level will be reduced by 6 dB (A) as the distance from the noise source is doubled referring to the reference of (Davis, M., and Cornwell, D., 1991, Introduction to Environmental Engineering, McGraw Hill).

19. There is no real assessment of the pollutants on occupational health and safety?
    - The assessment of the pollutants (dust, SO_2, HF …etc) on the occupational health and safety was conducted in Chapter VI.

20. There is no accumulative daily and annual assessment of SO_2 emission?
    - The answer of question no 14 and the results in the table below show maximum hourly concentration in employees residential complex during the weather condition of B1, D4, and F2 are 0.072, 0.075 and 0.0 ppm respectively.

Stability and wind speed	Wind direction	Max. gr. level conc. (C_{max}), ppm	Distance from final absorption stack at which C_{max} occurs (D_{max}) downwind (km)
B1	S	0.144	2.5
D4	S	0.094	3.5
F2	S	0.046	12.0

21. There is no accumulative daily assessment of HF emission?
    - The answer of question no 14 and the results in the table below show the maximum hourly concentration in employees residential complex during the

weather condition of B1, D4, and F2 are 0.467, 0.309 and 0.0 ppm respectively.

Stability and wind speed	**Wind direction**	**Max. gr. level conc. (C_{max}), µg/m^3**	**Distance from H_3PO_4 JIFCO plant stack at which C_{max} occurs (D_{max}) downwind (km)**
B1	S	1.100	2.2
D4	S	0.719	2.9
F2	S	0.268	9 and 25.3

22. The general security and civil defense stations shall be added as important surrounding residential areas?
    - The addition is done in the study report.

23. Although 50% of the people included in the survey show their concern of existence of foreigners in their area, but this point has not been covered in the study.
    - This issue was discussed in the study report (Page VIII/17) where it is mentioned that the workers will provide a special complex which will reduce the possibility of contact between foreign workers and the locals.

Annex (4)

Comments of ASEZA and the replies

1. Page ii is unacceptable, where according to the Environmental Protection Regulation in Aqaba, ASEZA has the right regarding to disseminate the EIA study for public.
   - The paragraph in page ii was added to be complying with the copy right regulation of the Royal Scientific Society to guarantee the confidentiality of the information unless used for this study purposes.

2. There are some differences of summaries that were written in Arabic and English.
   - The two summaries were modified.

3. The environmental issues were not included for the comparison between phosphoric acid production methods like the economic issues.
   - The reference "Booklet No. 4 of 8: Production of Phosphoric Acid, European Fertilizer Manufacturers Association, 2000" is used in the study for the comparison between phosphoric acid production methods as mentioned in Table (1.4). This is considered the best available technology adopted in the phosphoric acid production. Also, the paragraph in page (I/14) is modified to include the environmental and technical issues.

4. The amount of lime shall be added in page (I/14) as a major raw material for phosphoric acid production to neutralize off-grade fluosilicic acid which is by product of phosphoric acid production.
   - Limestone is considered as secondary raw material which is used for necessary cases and it is added in the report in page (I/15).

5. It is not mentioned in the report the disposal method of gypsum resulting from the tankers transporting phosphoric acid product into Aqaba zone and from the storage tanks in Aqaba area after the cleaning.
   - The trucks transporting the phosphoric acid shall be cleaned at plant site at Eshidiya where the effluent generated due to washing will be recycled to the process.
   - The storage at Aqaba will be provided with agitators and hence no accumulation of sludge in these tanks in expected. If any gypsum amount is generated in the storage tanks it will be sent into gypsum dumping site that belongs to JPMC.

6. The strength of the soil/rock of the storage tanks area in Aqaba zone shall be investigated.
   - Soil investigation of the storage tanks will be carried out at Aqaba before designing of foundations.

7. Regarding to the fluosilicic acid, the followings shall be clarified:
   - ❖ The capacity of the aluminum fluoride plant in the industrial complex belongs to JPMC of the fluosilicic acid.
   - ▪ The amount of fluosilicic acid required by JPMC for 100% plant operation is about 200 ton/day
   - ❖ The actual amount of the fluosilicic acid produced, because there is misleading of the figures of the production fluosilicic acid amount in the report (200 ton/day or 744 ton/day).
   - ▪ The actual amount of fluosilicic acid produced is 200 ton/day as mentioned in page (I/18). However, the figure of 744 ton/day is mentioned by mistake and it is modified in the figure (Fig. I/15) in page (I/29).
   - ❖ The full storage capacity tanks of fluosilicic acid in the industrial complex in Aqaba and is it needed to construct more storage tanks.
   - ▪ JPMC has 4 fluosilicic acid storage tanks of 2000 MT capacity each and there is no need to construct new storage tanks there. Also, it is requested from JIFCO to do registration of the produced and transported amounts of fluosilicic acid to be monitored.
   - ❖ The impact of the silicate substance produced while neutralization of the off-grade fluosilicic acid with lime on the workers and on the gaseous emissions in the project site area.
   - ▪ Requirement of neutralization of off-grade fluosilicic acid is very rare since as a first priority the off-grade fluosilicic acid will be recycled to process. The produced materials from the neutralization of the fluosilicic acid, if any, will be sent to the gypsum dumping site and it will be in the wet form and hence chances of silicate dust emission are not expected. Also, a monitoring program for ambient air quality of the project site area is recommended. It will include a periodic measurement of this emission according to environmental management plan.

8. The report did not mention the mitigation measures that shall be taken for the transportation of sulphur on roads and how to deal with sulphur spills and the probability of explosion due to sulphur particles friction on the road and other public safety issues.
   - ▪ The study mentions in page (VI/63) the mitigation measures to be implemented to reduce the possibility of the sulphur spill such as covering tightly the bulk sulphur in trucks, do periodic inspections on the trucks used and all drivers shall be well trained to deal with these mitigation measures in profession way.

9. The regulations and standards:
   - ❖ Jordanian standard of Drinking water (JS:286/2001) shall be modified into (JS:286/2008)
   - ▪ The new standard has not been accredited legally, and the standard of JS:286/2001 is now implemented

- ❖ Jordanian standard of industrial wastewater (JS:202/1990) shall be modified into (JS:202/2007)
  - The new standard has been modified
- ❖ Regulations of Aqaba Special Economic Zone Authority relating to the management of the used oil in and environmental impacts evaluation shall be added.
  - The regulations are added in the report in page (II/8).
- ❖ Noise Prevention Regulation of 2003 shall be added.
  - This regulation is added in the report in page (II/8).

10. According to our reply to the scoping session report, the modifications on the issues that were mentioned in Table 3.2 and Table 3.3 have not been done in the report.
    - The modifications are done in the report in Table 3.2 and Table 3.3 as below

Construction Phase

Impact of	Significance	Potential Impact	VEC
Not having coordination with the Ministry of Water and Irrigation regarding the location of the water wells and the waste water treatment plant	3b	Yes	Water Resources

Operation Phase

Impact of	Significance	Potential Impact	VEC
Earthquakes on the equipment and instruments.	3C	Yes	Public Health
Not covering the conveyor belts of raw materials.	3C	Yes	Public Health
Noise from operation activities on workers.	3C	Yes	Occupational Health and Safety
Disposal of hazardous waste (e.g. vanadium pent oxide).	3C	Yes	Occupational Health and Safety
Not installing the necessary control devices (e.g.: refrigeration systems, vents, alarm systems) on the storage tanks.	3b	Yes	Occupational health and safety
Not installing the necessary control devices (e.g.: refrigeration systems, vents, alarm systems) on the storage tanks. (public health)	3a	Yes	Public Health

11. The amount of the by-products such as fluosilicic acid during the operation phase shall be added in page (IV/19).
    - There is no data of the amount of fluosilicic acid in the present due to the production of this acid is done during abnormal conditions.

12. The assessment of the impact of flood on the storage tanks in Aqaba located near to wadi shall be done. Also, it is not mentioned the mitigation measures to reduce the impact of the flood on the storage tanks.
    - The assessment of the impact of flood on the storage tanks and the mitigation measures are mentioned in the report in chapter IV, page (IV/23). Also, the final and suitable measure will be adopted according to the final selection of the storage tanks site.

13. The impact of noise from the construction machinery on workers shall be added in page (VI/1)
    - The impact of the noise from the construction machinery on workers is added in the report in page (IX/2) not (VI/1) due to its relation to the occupational health and safety not on public health.

14. The impact of dust from moving belts and the mitigation measures shall be added in the report in page (VI/1).
    - The point is mentioned above is added in the report in page (VI/1).

15. The study includes some of the international guidelines and regulations; it is not clear how these will be implemented during operation phase.
    - The study aimed at referring to the regulations of International Financial Corporation (IFC) to be implemented by JIFCO since the project will be financed by World Bank. Also, JIFCO shall comply with all the related local standards and regulations during all project phases to reduce and prevent the environmental impacts.

16. The emergency response, HAZOP, environmental management and monitoring plans shall be a part of EIA study and shall be submitted to the authority before getting an approval to commence the project.
    - JIFCO is absolutely committed to submit an emergency response plan prior to the operation phase and HAZOP plan prior to the construction phase. The consultant prepared the environmental management plan in Volume II which contains all mitigation measures that shall be taken by JIFCO under supervision of the regulatory authorities by submitting a periodic action plan to them. The monitoring program is also mentioned in this report which contains the environmental parameters that shall be monitored by JIFCO periodically and submitting the reports to the regulatory authorities.