3. PROJECT DESCRIPTION
The rationale for the Project, the current KNO operating permits and a detailed description of the Project schedule and implementation plans are included in this Section 3.

A 3-D plot plan for the relocation plant is shown in Figure 3.1 below. The relative size of the plot plan within the overall Ossiomo industrial park is also shown as an insert in Figure 3.1.

Figure 3.1 3-D Plot Plan of the relocated KNO Plant

3.1 PROJECT RATIONALE
Steady population growth and GDP growth per capita have resulted in shrinking arable land on a per capita basis and a shift in diets in the developing world. These factors, combined with the growing use of corn to produce ethanol, are driving the demand for fertilizers worldwide.

US Bureau of Census projects that world population will increase by 1.1 billion to 7.4 billion by 2020 (CAGR = 1.1%). Despite a decline in the birth rate in certain parts of the developed world, improving economic conditions, particularly in developing countries, are leading to higher life expectancy. The global population is projected to exceed 9 billion by 2050.
Long-term international consumer spending trends indicate a shift toward consumption of higher value food products across all income levels, requiring higher levels of fertilizer on a per capita basis. Consumers in lower income countries are shifting food purchases away from carbohydrate-rich staple foods such as rice and wheat, and increasing consumption of higher valued food items such as meat, dairy, fruits, and vegetables.

Increased production of corn to produce ethanol for the production of bio-fuels, particularly in North America and in certain areas of South America, will also drive demand for fertilizers in the medium term. The US Energy Independence and Security Act (EISA) of 2007 established specific targets for the production of bio-fuels in the United States, increasing the demand for agricultural commodities to produce ethanol. The act set a mandatory renewable fuel standard requiring fuel producers to use at least 36 billion gallons of bio-fuel by 2022, relative to a requirement of 9.0 billion gallons of bio-fuel in 2008. Corn is the predominant feedstock for bio-fuel production, with 23% of domestic corn production in the US supplying the ethanol market in 20081.

Global consumption of nitrogen fertilizers is the highest among the three fertilizer groups, with an estimated 100.9 million MT consumed in 2007, or 60% of the total nitrogen (N), phosphate (P) and potash (K) consumption of 168.7 million MT in 20072.

Nitrogen fertilizer consumption is growing faster than phosphate and potash. Nitrogen fertilizer consumption has grown at an average rate of 3% per annum since 1970, compared with growth rates of 1.6% per annum for phosphate and 1.4% per annum for potash.

It is estimated that 50% of the food production in North America is the direct result of nitrogen-based fertilization. Nitrogen is the plant nutrient most commonly deficient in agriculture. Ammonia and urea fertilizers play a major role in promoting high yields of nutritious food crops. Without them, not only would food prices rise, but food quality would also diminish.

Ammonia is a liquid fertilizer, while urea is a solid fertilizer, made by reacting carbon dioxide and ammonia under high pressure and temperature. Urea is the major fertilizer traded in international commerce, accounting for approximately 50% of the nitrogen fertilizer traded in the world. Ammonia application, production and trading is more predominant in the developed markets of Europe and North America where farmers have the technical capacity to handle liquid ammonia. Solid urea fertilizers dominate the lesser-developed markets of Asia-Pacific, South America, Middle East and Africa.

**Food Security/Fertilizer Supply and Application in Sub-Saharan Africa**

Fertilizer application in Africa and Sub-Saharan Africa, in particular, is the lowest in the world by a significant margin. The IFDC reports that fertilizer consumption in Sub-Saharan Africa in 2005/2006 was 7.1 kg/hectare compared with 188 kg/hectare for Western Europe and 202.3 kg/hectare for Asia.

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1 USDA
2 International Fertilizer Industry Association
Production of fertilizer in Sub-Saharan Africa, excluding South Africa, is very limited. Statistics from the International Fertilizer Industry Association (IFA) for 2006 indicate 96,500 MT of production in Sub-Saharan Africa excluding South Africa, with no production in Nigeria, one of the largest markets. The Food and Agriculture Organization of the United Nations (FAO) statistics indicate that fertilizer consumption in Sub-Saharan Africa in 2006 was 2.6 million MT excluding South Africa, with 539,000 MT of consumption in Nigeria. The supply-demand imbalance in Sub-Saharan Africa is further illustrated by fertilizer pricing in Nigeria at a 50%-plus premium to global markets.

**Natural Gas Feedstock and Gas Flaring**

Natural gas is the primary feedstock for nitrogen fertilizer (ammonia production) and accounts for up to 95% of the total production cost of ammonia in high-cost regions and approximately 50% in low-cost regions. On average, ammonia producers require 36 MMBTU of natural gas to produce one MT of ammonia. Given that the technology for the production of nitrogen fertilizers is widely available, long-term access to low-cost natural gas feedstock is the key barrier to entry and expansion in the nitrogen fertilizer business.

Growing demand for natural gas in the developed economies of North America, Western Europe and parts of Asia has led to a paradigm shift in the long-term price of natural gas. This has negatively impacted prospects for the production of nitrogen fertilizers in these countries in spite of rising fertilizer demand.

As a result, nitrogen based fertilizer production growth is occurring mainly in the Middle East (Egypt, Qatar, Saudi Arabia) and parts of Asia where there is access to low-cost natural gas, lower labor costs and/or access to major consuming markets. For example, between 2000-2007, China nitrogen fertilizer production grew from 22.5 million MT to 36.3 million MT\(^3\).

Nigeria has one of the largest reserves of natural gas in the world, currently estimated at approximately 185 TCF. Within Nigeria, gas utilization for export and the domestic market is at very low levels.

Nigeria is the second largest gas flaring country in the world, as identified by the Global Gas Flaring Reduction (“GGFR”), a public-private initiative led by the World Bank. Currently Nigeria is flaring over 2 BCF of natural gas per day, equivalent to 20 times the feedstock requirement for the Project, and constituting a severe environmental hazard. Gas flaring has been identified as a major contributor to global warming, as methane (the main constituent of natural gas) is a 21 times more potent greenhouse gas than carbon dioxide\(^4\).

Therefore one of the primary objectives of the Project is to eliminate gas flaring associated with oil production in the Project site area. The Project is expected to result in reduction in gas flaring of 100 MMCF/D, or 700 BCF over the life of the Project.

### 3.2 KNO OPERATING PERMITS

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\(^3\) International Fertilizer Industry Association  
\(^4\) United States Energy Information Administration
The KNO Plant has operated for almost 40 years with an excellent EHS record. The KNO Plant operates under the US and Alaska State environmental regime. The Project sponsors intend to operate the relocated to, at least, the same standard of operation in Kenai, Alaska consistent with international best practice and conforming with all relevant national and international standards.

Copies of Agrium's KNO emission files are attached in the Appendix to this ESIA.

These include:

1. Agrium’s renewal application to the Alaska Department of Environmental Conservation for the KNO Plant Air Operating Permit
2. Copy of the Alaska Department of Environmental Conservation Operating Permit No. AQ0083TVP01 issued 10 November 2003, effective 1 January 2004 and Expired 31 December 2008 under the authority of AS 46.14 and 18 AAC 50
3. The United States Environmental Protection Agency authorization to discharge waste water into the Cook Inlet in compliance with the provisions of the Clean Water Act, 33 U.S.C. §1251 et seq., as amended by the Water Quality Act of 1987, P.L. 100-4

3.3 PROJECT SCHEDULE
The current Project schedule envisages construction start in January 2011 and mechanical completion by July 2013.

Dismantling the KNO Plant and transportation of the KNO equipment to Ossiomo’s site in Nigeria is expected to take about 11 months. The detailed design of the plant will take about 8 months, civil works about 9 months and mechanical erection about 15 months.

All these activities will occur in sequence.

3.4 CONSTRUCTION PHASE
The Project EPC contractor will be a major international engineering company with recent experience in the relocation of petrochemical plants as well as global major project engineering, procurement and construction experience.

The EPC contractor will demonstrate historic good EHS record.

3.4.1 CONSTRUCTION PHASE ACTIVITIES
The primary construction phase activities comprise:

- Engineering and Design – most of which will take place in the EPC contractor’s design offices offshore Nigeria but supervised by the Project Company personnel
- Civil works at the site - consistent with construction works for a large Project of the nature and size. Most of the construction workers and construction activities will
take place enclosed within the GPC Project site which is located at least 7KM away from the nearest habitation.

- Import of the process equipment from Kenai, Alaska as well as construction equipment - most of the equipment will be delivered by marine transport direct to the Project site minimizing any impact on the local environment.

- Mechanical erection of the Plant at the site.

The Project will directly employ about 1,000 people during the construction phase. This will comprise about 5% managerial jobs, 70% professional jobs and 25% unskilled labor.

3.4.2 CONSTRUCTION EQUIPMENT AND MATERIALS LOGISTICS

Most of the construction equipment will be sourced locally. However the EPC contractor may import a certain number of large construction equipment which will be transported to the site via the Ossiomo river.

The major construction materials are available close to the Project site. In particular the sand required for construction will be "dredged" from the Ossiomo river as is the practice in the local area. Currently there are a number of dredgers dredging sand from various points along the Ossiomo river for road construction and other infrastructure works.

The sand from the Ossiomo river is non-toxic and is currently widely used for construction in the local area. The aquatic impact of dredging sand from these rivers is minimal.

The following photographs illustrate current sand dredging activities along the Ossiomo river in support of on-going construction activities in the area.

Plate 3.1 Sand Dredging on the Ossiomo River (June 2010)
Plate 3.2 Sand Dredging on the Ossiomo River (June 2010)
3.5 OPERATION PHASE
Following the construction phase, the ammonia-urea plant will be pre-commissioned by preparing and testing the facility for the initial plant start-up. Once commissioned the ammonia/urea plant will operate 24 hours a day, 345 days a year.

A maintenance facility staffed with skilled professionals will support the Plant’s operations. The major components of the project will be designed to have a life of 25 years.

In the initial phase of the operational period, the Plant will be operated by the EPC contractor, a major international engineering company with significant experience in the operation and maintenance of major petrochemical plants.

Subsequently the Project Company will develop and train its staff to operate the Plant. The Project Company staff will include professional with significant experience operating ammonia urea plants.

3.5.1 OPERATION PHASE ACTIVITIES
The primary construction phase activities comprise:

Plant Operation – the primary objective will be to operate the plant safely and maintain al EHS standards to achieve high availability and meet production targets.

Plant Maintenance – Plant personnel will develop and maintain a strong maintenance culture. Plant maintenance will comprise ongoing maintenance and major plant shutdown for overhaul every 3 or 4 years.
The Project will directly employ about 200 people during the operation phase. This will comprise about 7.5% managerial jobs, 82.5% professional jobs and 15% unskilled labor.

3.5.2 PRODUCT AND MATERIALS LOGISTICS
The primary feedstock for the Project is natural gas which will be delivered via a 15 KM, 16” pipeline owned and operated by the Nigerian Gas Company.

Urea product for the domestic market will be lifted by a fleet of trucks and then transported to other parts of Nigeria. There is a very good network of roads around the Project site area which will enhance domestic product distribution.

3.6 DECOMMISSIONING PLAN
The design life of the Plant will be in excess of 25 years. Post the useful life of the Plant, a decommissioning plan will be developed which will be cognizant of relevant legislation and international best practice at that time.

The primary objective of the decommissioning activities is return the site to as near its pre-operational state as technically and economically possible.

The decommissioning scope will include:
1. Dismantling of all major installations including tanks, buildings, auxiliary installations and pipes will be dismantled and removed from site.
2. Disposal of materials in controlled/authorized landfills suitable for the types of materials being disposed.
3. Clearing and re-vegetating of all concrete/asphalt/pavement areas.
4. Landscape regeneration should be implemented after the site has been cleared of installations, pits, pavement and services; the area should be reforested with autochthonous vegetation.

3.7 PROCESS DESCRIPTION
The Project involves the construction and operation of a world scale ammonia/urea production facility at Ossimo’s site located at Ologbo, Edo State, Nigeria.

The Project will entail the relocation of the 1,840 MTPD ammonia and 1,760 MTPD KNO Plant from Kenai, Alaska to the Project site in Nigeria.

The underlying philosophy for the Project is to relocate the process plant in a like-for-like manner to the extent possible. The ammonia and the urea plants will be relocated as is but the urea granulation plant will be replaced with a new fluidized bed urea granulator.
3.7.1 PROCESS FUNDAMENTALS

**Ammonia**
Ammonia is produced by the reaction of hydrogen and nitrogen in the presence of metal catalysts at temperature ranging from 390 °C to 510 °C. This reaction is an exothermic reaction (i.e. it releases heat). For energy efficiency, the heat generated by the ammonia synthesis reaction, will be used to generate high pressure superheated steam at 415 °C.

\[3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3\]

The hydrogen required for ammonia synthesis produced from natural gas (free from sulfur) using the reforming process. The reforming process comprises steam reforming and catalytic reforming. Natural gas and steam are reacted (in the presence of catalysts) into hydrogen and a mixture of carbon dioxide and carbon monoxide as follows:

\[\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2\]
\[\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2\]

These two reactions are endothermic reactions and heat for the reaction is provided by pre-heating the flue gas to 1,100°C.

\[\text{N}_2\text{ for the ammonia production comes from air. Oxygen, which is the major constituent of air is consumed in the reaction by combustion with natural gas:}\]

\[\text{CH}_4 + 3/2\text{O}_2 \rightarrow \text{CO} + 2\text{H}_2\text{O}\]

**Urea**
Urea is produced, under pressure of 140 bar and temperature of 180 °C, by converting the ammonia produced from the synthesis gas by the CO\textsubscript{2} stripping process in five main stages:

1. **Synthesis**
2. **Recirculation**
3. **Evaporation**
4. **Desorption, and**
5. **Granulation.**

Ammonia and carbon dioxide react to form ammonium carbamate, which is an intermediate product. Then the ammonium carbamate is finally converted to urea in the main urea reactor as follows:

\[2\text{NH}_3 + \text{CO}_2 \rightarrow \text{NH}_2\text{-COO-NH}_4\text{ (ammonium carbamate)}\]
\[\text{NH}_2\text{-COO-NH}_4 \rightarrow \text{NH}_2\text{-CO-NH}_2\text{ (urea)} + \text{H}_2\text{O}\]
3.7.2 AMMONIA PLANT

The manufacturing of ammonia uses basic principles of chemistry with readily available feedstock. Natural gas from NGC’s Escravos-Lagos pipeline will provide the primary fuel and feedstock. Water will supplied from the Ossiomo river whilst steam and ambient air is used as a source of nitrogen.

With the aid of catalysts, heat exchangers and compressors, the natural gas is reformed into hydrogen and combined with nitrogen obtained by compressing air to yield ammonia which is then liquefied and stored for urea production.

The process can be divided into six distinct areas.

1. Feed gas is prepared and reformed into its components.
2. The gas stream is purified of CO by conversion to CO2
3. CO2 removal in the MDEA area
4. Trace amounts of CO2 and CO are removed by methanation changing them back to natural gas before synthesis of ammonia occurs in the converter.
5. Gaseous ammonia is refrigerated and liquefied.
6. The liquid ammonia is pumped to the storage tank.

Plate 3.4 General view of KNO Plant looking south from Plant 5 with Plant 4 in the foreground.
In the Gas Preparation and Reforming Section of the ammonia plant, heated natural gas is passed through organic sulfur removal (OSR) vessels. This sulfur free gas stream is again preheated in the upper section of the Primary Reformer. Steam (550 psig) that is produced
by the boiler house and steam that has stripped of ammonia from process condensate is added to the gas stream. The steam and natural gas mixture is further heated before entering the catalyst tubes in the main section of the Primary Reformer. There, the gas burners create process temperatures of about 1350° F. This high temperature, along with catalyst, causes the methane (CH₄) to react with steam (H₂O) and rearrange (reform) into new gases, namely hydrogen (H₂), carbon monoxide (CO) and carbon dioxide (CO₂).

Not all of the natural gas is reformed. A small percentage passes through the Primary Reformer and moves to the Secondary Reformer. Before entering the Secondary Reformer, compressed air is added to the reformed gas. This compressed air immediately ignites the hydrogen to create a very high temperature and additional reforming of natural gas occurs within a catalyst bed. The addition of compressed air also serves to add nitrogen into the reformed gas stream; this nitrogen (N₂) will later react with H₂ to produce ammonia (NH₃). The reformed gas passes through the Waste Heat Boiler where excess heat, or waste heat, is used to produce 1500 psig steam. High pressure steam is also produced in the Primary Reformer.

Note that the reforming reaction is strongly endothermic (requires lots of heat input), hence the large high temperature furnace and the combustion process in the Secondary Reformer.

Plate 3.5 KNO Plant 4 Primary Reformer, Secondary Reformer and Waste Heat Boilers
NATURAL GAS PREPARATION AND REFORMING SECTION - HAZARDS

PHYSICAL:
Thermal: 2,000 °F in fire box, 1,950°F flammable gas, 900°F gas stream
Pressure: 1,500psi
Noise: 85dB and up
Electrical: 480V

CHEMICAL:
Methane: 99% fire hazard
Carbon Monoxide: 12% poison
Process Gas: Carbon Dioxide 8%, Hydrogen: 57%
             Nickel Catalyst & Activated Carbon
             Ammonia (NH3): Vapor
             Sulfur Compounds (H2S, etc)
Reformed gas must be purified of carbon monoxide before being converted into ammonia. The purification is accomplished by passing the reformed gas over a catalyst bed that promotes the combination of carbon monoxide and water (in the form of steam) into carbon dioxide and hydrogen. This conversion gives off heat. The additional heat gained,
plus the initial heat from the reformed gas, is used to produce high and low pressure steam. Because the primary carbon monoxide conversion is occurring at a relatively high gas temperature, this is usually referred to as the "high temperature shift conversion."

The high temperature shift conversion does not completely convert all of the carbon monoxide. Additional purification occurs in another catalyst bed that promotes the same chemical reaction. This time the combination of carbon monoxide with water as steam occurs at a lower temperature. This is referred to as the "low temperature shift conversion." The carbon monoxide content of the gas stream has been lowered to less than one percent of the total volume. Additional H₂ has been produced and the gas stream is ready for carbon dioxide removal.

During both conversions, excess heat is generated. The Excess or Waste Heat Boilers remove this heat and produce high pressure and low pressure steam.

Plate 3.6  KNO Plant 4 Methanator, Low Temperature and High Temperature Shift Vessels and Waste Heat Boilers

SHIFT CONVERSION SECTION - HAZARDS

PHYSICAL:  Thermal 900°F
Pressure:  Steam Turbine 1,500psi
Noise:  85dB
Electrical:  480V

CHEMICAL:
Methane: 40%  
Carbon Monoxide: 0.35%  
Process Gas: Carbon Dioxide 18%, Hydrogen 61%  
Iron base Catalyst & Copper/Zinc Catalyst
CARBON DIOXIDE REMOVAL

Figure 3.5 KNO Plant 4 Carbon Dioxide Removal Flow-chart.
Carbon dioxide (CO₂) is a by-product of producing synthesis gas for ammonia production. The CO₂ produced in the Reforming Section and Conversion Section of the Ammonia Plant is removed in the CO removal systems. The MDEA system (in Plant #4) is named for the fluid used to absorb the CO₂ from the gas streams. Removal of CO₂ occurs in the Absorber under conditions of high pressure and low temperature - 400 psi and 130° F. After the gas stream releases the CO₂, it proceeds to methanation and synthesis.

The CO₂ removal solution moves to accumulators where some of the CO₂ is quickly released along with other inerts. The Accumulators are referred to as "Fat Flashers" because the inerts "flash" out of the rich ("fat") solution.

All CO₂ must be removed in order to recycle the CO₂ removal solutions. CO₂ is removed in the Regenerators, where the warmed MDEA solution enters and additional heating occurs. Under conditions of low pressure and high temperature (20 psi and 257° F) the CO₂ is released and routed for use in the Urea Plants; some excess CO₂ is vented to atmosphere. Additional heat exchangers cool the MDEA solution, leaving the Regenerators, and pumps increase the pressure in preparation for another cycle through the Absorber.

Plate 3.7  KNO Plant CO₂ Removal, Regenerator and Absorber Sections
CARBON DIOXIDE REMOVAL SECTION - HAZARDS

PHYSICAL:
Thermal: 640°F Superheated Steam
Pressure: 550 psi Steam
Noise: 85dB
Electrical: 480V

CHEMICAL:
Methyldiethanolamine (MDEA) Process Sol. 26 to 43% MDEA
Carbon Dioxide: 100%
Hydrogen: 74%
Nitrogen: 25%
Dow Corning Antifoam: 80%
Silicone oil 10-25% silica solids
METHANATION AND SYNTHESIS

Methanation and Synthesis Flowchart
The synthesis gas must be free of all carbon monoxide and carbon dioxide. This is ensured by passing the synthesis gas stream over a catalyst bed that completes a chemical reaction opposite that of reforming. The CO and CO2 combine with hydrogen, which yields methane, water and heat. This reaction occurs in the Methanator. A small percentage of methane can be tolerated in the synthesis gas but the water must be removed. The amount of heat produced is directly proportional to the amount of CO and CO2 that is present. This heat is used to bring the Methanator inlet gas up to reaction temperature in the catalyst bed.

The synthesis gas (hydrogen and nitrogen) is now clean and ready to be converted to ammonia in the Ammonia Converter. The synthesis gas is compressed to 3,300 psig in the Syngas Compressor, preheated and sent to the Ammonia Converter. A chemical reaction occurs over catalyst beds, which combine the nitrogen and hydrogen molecules to form gaseous ammonia (NH3). Approximately 15% of the inlet gas stream is converted to ammonia. This reaction also produces heat, which like the Methanator is used to bring the converter inlet gas up to reaction temperature. Excess heat is also used to preheat high-pressure water that will be used to produce 1,500 psig steam. The 1,500 psig steam is used to power the Syngas Compressor.

Plate 3.8 KNO Plant 4 Ammonia Converter
METHANATION AND SYNTHESIS SECTION - HAZARDS

PHYSICAL:
Thermal: 1,000°F
Cold: -28°F
Pressure: Turbine: 3,300psi Steam
Noise: 85dB
Electrical: 480V

The ammonia converter (D-110) is a high temperature reactor which requires special design and operating safety features. The KNO ammonia converter was designed and licensed by Casale, SA of Switzerland. Casale has been at the forefront of ammonia technology for over 100 years and is one the leading licensors of ammonia plants globally. The Sponsors are concluding arrangements to extend the Agrium-Casale licensing agreements under which Casale will license and support the new plant.

In essence, the ammonia converter reactor was designed and built to the highest global standard. The reactor has been well serviced and maintained by Agrium with the support of Casale over the historic operating period. The Sponsors will, with the support of Casale, relocate, commission, operate and maintain the ammonia converter to highest global industry standards.

CHEMICAL:
Nickel Carbonyl Gas (produced in the methanator during startup & during decompressing and catalyst removal)
Iron base Catalyst & Nickel based Catalyst
Methane: <1%
Ammonia (NH3): 17%+ Vapors & Liquid
Petro Products: Lube Oils
Ammonia Refrigeration and Liquefaction Flow-chart
Gaseous ammonia must be cooled and the pressure reduced to atmospheric pressure to be stored as a liquid in the storage tanks. Ambient air and the refrigeration system provide the necessary cooling. Cooled gaseous ammonia enters the High Pressure Separator where liquid ammonia is separated from unconverted synthesis gas, or recycle gas. Recycle gas returns to the Syngas Compressor for another cycle through the Ammonia Converter. A small amount of this gas is purged to remove inerts (CH₄ and argon) from the system. Purge gas is treated in the Purge Recovery Unit to remove any ammonia before being used as a supplemental fuel in the Primary Reformer. Hydrogen and nitrogen are also returned to the Syngas Compressor from the purge recovery unit.

Ammonia from the High Pressure Separator is reduced in pressure and introduced into the refrigeration system. The refrigeration system operates on the same principle as a household refrigerator using ammonia instead of freon. Liquid ammonia is reduced in pressure in the Flash Drums, causing lower liquid temperatures and some ammonia to flash back to a gas. A refrigeration compressor increases the pressure of the ammonia gases, which are cooled, causing liquefaction, and the cycle is repeated. The High Temperature Pump circulates liquid ammonia at 18° F to cool gaseous ammonia from the converter while the Low Temperature Pump circulates liquid ammonia at minus 27° F and routes the product to the Ammonia Storage Tank.
and

Ammonia Flash Drums

REFRIGERATION AND LIQUEFACTION SECTION - HAZARDS

PHYSICAL:
Thermal: 600°F syngas and superheated steam
Cold: -28°F
Pressure: 3,300 psi
Electrical: 4,160 V

CHEMICAL:
Ammonia (NH3): 100%
Vapors & Liquid
Purge Gas: Methane 9%, Argon 7%
Process Gas (recycle) Hydrogen: 63%, Nitrogen: 21%
Petro Products: Lubes, Ethylene Glycol: 80%
Liquid ammonia from the refrigeration system is routed to the insulated Ammonia Storage Tank. Plant Four’s tank can hold 50,000 short tons, or 17,800,000 gallons of ammonia. The temperature of the liquid ammonia is minus 27° F, and is kept at a pressure slightly above
atmospheric pressure (about 1/4 psi).

During storage some liquid ammonia flashes back to a gaseous form. Ammonia vapors are collected and compressed by refrigeration compressor Vilter units. Compressed ammonia vapors are cooled, liquefied and then returned to the Ammonia Storage Tank.

Transfer pumps deliver liquid ammonia for use in the Urea Plant.

**Plate 3.10 KNO Plant 4 Ammonia Vapor Recovery and Ammonia Storage Tanks**
AMMONIA STORAGE SECTION - HAZARDS

PHYSICAL:
Thermal: 630°F
Cold: -28°F
Pressure: 550psi Steam
Noise: 85dB
Electrical: 4160V

CHEMICALS:
Ammonia (NH3): 100%
Vapors & Liquid Petro Products: Lubes, Ethylene Glycol: 80%
The Urea Plant #5 is designed to produce up to 1,760 MTPD of urea by reacting liquid ammonia and carbon dioxide gas. This is done at elevated pressures and temperatures in the high-pressure urea synthesis system. This combination of CO₂ and NH₃ spontaneously forms an ammonium carbamate solution, via an exothermic heat (releasing reaction). With residence time and heat, the reaction continues to form urea via an endothermic (heat absorbing) reaction. The process fluid is then let down in the low-pressure section for separation of the unreacted ammonia and carbon dioxide. The carbon dioxide and ammonia are condensed to form carbamate, which is recycled back to the high-pressure system. The remaining urea and water are sent to an evaporation section for water separation. The evaporated and condensed water is cleaned of ammonia and used for boiler feedwater to make steam. The Process solution, 99 percent urea, is sprayed onto an existing “seed bed” of urea to form granules, using ambient air for cooling. This forms a suitable product for storage and
shipping.

Figure 3.10 KNO Plant 5 Urea Plant Process Overview
Ammonia and carbon dioxide produced by the ammonia Plant is received at the compression section of Urea Plant #5. In this section, liquid ammonia is elevated to 2,250 psi via steam driven, positive displacement pumps. The gaseous carbon dioxide is compressed to the same pressure through a steam driven centrifugal, multi stage compressor.
Plate 3.11 KNO Plant 5 High Pressure Ammonia Pumps and CO₂ compressor
UREA COMPRESSION SECTION - HAZARDS

PHYSICAL:
Thermal: 630 °F Superheated Steam
Cold: -28°F
Pressure: 2,550psi
Noise: 85dB
Electrical: 480V

CHEMICAL:
Carbon Dioxide: 99%
Ammonia (NH₃) Liquid:
Ammonium Carbamate 18% NH₃, 7% CO₂, 75% H₂O
Petro Product: Lubes Ethylene Glycol: 50%
Pressure Synthesis Flow-chart

As the feedstock of ammonia (NH₃) and carbon dioxide (CO₂) comes from the Compression Section at 2,250 psi, it is then introduced to the High Pressure Synthesis Loop of the plant. This area is comprised of 4 larger vessels (reactor, condenser, scrubber and stripper), each operating at 2,150 psi and averaging 350°F. These vessels have their own unique design, each meant to enhance and control the urea reaction.
Plate 3.12 KNO Plant 5 High Pressure Urea Reactor
UREA HIGH PRESSURE SYNTHESIS SECTION - HAZARDS

PHYSICAL:
Thermal: 430 °F Steam
Cold: -28°F
Pressure: 2,550psi
Noise: 85dB and up
Electrical: 480V

CHEMICAL:
Carbon Dioxide: 99%
Ammonia (NH3): 100%
Liquid & Vapor Ammonium Carbamate 63% NH3, 23% CO2, 11% H2O
Urea: 58%
Petro Product: Lubes, Ethylene Glycol: 50%
VAPORecovery System

The Vapor Recovery System is designed to reduce Plant emissions during stable operating conditions. The system scrubs minor or fugitive emissions through a series of scrubbers. These scrubbers and their associated pumps, exchangers, tanks and steam purges reclaim nearly all of the ammonia and CO₂. Non-recoverable emissions are combusted by means of a continuous burning Vent Flare that is described in the Flare System section below.

Vapor Recovery System - Hazards

Physical:
Thermal: 450 °F Steam
Noise: 85dB
Electrical: 480V

Chemical:
Ammonia (NH₃): 8% Liquid & Vapor Petro Product: Lubes

Flare System

The Plant #5 Flare System is designed to reduce Plant emissions, particularly during unstable operating conditions. Normal, non-recoverable emissions are combusted by means of the continuous burning Vent Flare B-502. When large quantities of NH₃ need to be vented, the larger Emergency Flare B-501 will combust any ammonia that is released. The B-501 is not a continuous burning flare and is only used in the event of a large release or Plant upset.

Flare System - Hazards

Thermal: up to 700 °F
Natural Gas
Ammonia Vapor
Recirculation Section Flow-chart.

The urea process stream exits the High Pressure Synthesis Loop and enters the Recirculation Section, which is operating at 65 psi and 270°F. Here the liquid urea, and unconverted ammonia – carbon dioxide are separated. The unconverted gases are cooled and condensed to a liquid carbamate solution, and then returned to the High Pressure Synthesis Loop. The urea solution passes through to the Evaporation Section.
Plate 3.13 KNO Plant 5 Rectifying Column and Heater
UREA RECIRCULATION SECTION - HAZARDS

PHYSICAL:
Thermal: 430 °F Steam
Cold: -28°F
Pressure: 70psi
Electrical: 480V

CHEMICAL:
Carbon Dioxide: 99%
Ammonia (NH3): 100%
Liquid & Vapor
Ammonium Carbamate 18% NH3, 7% CO2, 75% H2O
Urea: 73%
Petro Product: Lubes
Ethylene Glycol: 50%
In the Evaporation Section, the water, which is a by-product of the urea synthesis reaction, is separated or boiled off in two vessels. These vessels are under a vacuum with steam applied to their shells to achieve approximately 270°F. The water, which has small amounts of free ammonia entrained, is sent to the Water Treatment Section of the plant.
Evaporators and Condensers
UREA EVAPORATION SECTION - HAZARDS

PHYSICAL:
Thermal: 340°F Steam
Pressure: 29” Hg vacuum
Noise: 85dB
Electrical: 480V

CHEMICAL:
Ammonia Aqua: 30%
Formaldehyde: 60%
UF85 Solution
Urea: 99%
Petro Products: Lube Oils
Treatment Flow-chart.

Process waste water containing urea, ammonia and CO₂ from the ammonia water tank, is heated in the Hydrolyzer. The Hydrolyzer reverts the urea back to ammonia and CO₂. The ammonia and CO₂ are then separated from the water stream in the Desorber and recycled back to the Low Pressure Section of the urea process Plant. The effluent (clean water) is used for waste heat boiler feed water to produce steam for use in the ammonia process.
Plate 3.15 KNO Plant 5 Water Treatment Plant
WATER TREATMENT SECTION - HAZARDS

PHYSICAL:
Thermal: 430°F Steam & Liquid
Pressure: 320psi Steam
Noise: 85dB
Electrical: 480V

CHEMICAL:
Ammonia (NH3): 50% Vapor
Ammonia Aqua: 20%
Ammonium Carbamate: 34% NH3, 26% CO2, 40%, H2O
Carbon Dioxide: 30%
Petro Products: Lubes
remaining solution from the evaporation sections is 99% urea, which will readily solidify below 270º F. This solution, or end product, is sent to the Granulation Section of the plant, which consists of four large rotating drums, each identical and parallel to the other. Inside these drums there is a bed of crushed minus size bed, recycled product that is constantly being churned. As this bed of material is lifted to the upper part of the drum, it falls down through a spray of urea solution from the Evaporation Section. As the spray comes into contact with the crushed, undersized “seed bed,” and as the material is rapidly cooled from the air being forced through the Granulator, it builds up repeated layers, until larger
granules of product are formed. These exit the Granulator via conveyors and are separated by sizing screens. The product-sized material is then sent to the warehouse for storage until shipped in bulk in trucks, ships and barges. Any under or oversized urea particles are recycled for reprocessing.

Plate 3.16 KNO Plant 5 Drum Urea Granulator, Scrubber & Exhaust System And Urea Warehouse

UREA GRANULATION AND STORAGE SECTION - HAZARDS

PHYSICAL:
Thermal: 280°F Urea Melt
Pressure: 90psi
Noise: 85dB and up
Electrical: 4,160V
Rotating Equipment

CHEMICALS:
Ammonia Vapor: 30%
Urea: 99%
Liquid & Solid Petro Products: Lubes
Figure 3.17 KNO Plant 5 Process Overview.
3.7.4 PRODUCT SPECIFICATION
The Plant will produce urea as its primary and sole product.

Product specifications for granular urea 46%N will be consistent with the standard specification widely recognized in the global nitrogen fertilizer industry.

Specifications for urea 46%N are as follows:

- **Nitrogen:** 46% min
- **Moisture:** 0.5% max
- **Buiret:** 1.0% max
- **Granulation:** 2 – 4 mm 90-94% min
- **Melting Point:** 132 degrees Celsius
- **Color:** Standard White or Pure White
- **Radiation:** Non-Radioactive
- **Free Ammonia:** 160 pxt ppm max

Free flowing, treated against caking, 100% free from harmful substances.
3.8 UTILITY PLANTS

The Utility Plant will receive raw water from the Ossiomo river located beside the Project site. The water is then routed to the Utility Plant where it goes through the water treatment sections to de-ionize the water. After the water is treated, it is sent to a storage tank. From there it is pumped up to the Ammonia plant Deaerator where it is stripped of dissolved oxygen. Vacuum Condensate from the NH$_3$ and Urea Plant is reintroduced into the system just upstream of the Deaerator. This water is re-used because it is clean and it helps to conserve water throughout the plant. The water will then sent to the ammonia plant to make 1,500 psi steam and to the Utility Plant to feed into the boilers. Superheated steam at 550 psi is then produced to supply steam to all the turbines in the plant.

Fuel gas in the Utility plant comes from the 16” NGC gas pipeline. This gas is let down in pressure through stations in the ammonia plants. The gas is then used to fire the Utility Plant boilers, the Centaur gas turbine generators (Solars) and as supplemental gas for firing the solar waste heat boilers.

There will be a dedicated power plant with 5 X 2.5 MW solar generators relocated from Kenai and 4 X 3.5 MW new solar generators. The power plants will generate more power than is required to feed the plant complex - the power generation configuration is designed to provide significant back-up and redundancy to ensure high availability. The turbine exhaust off the solar generators will supply heat to corresponding waste heat boilers. Here 550 psi superheated steam is produced and sent to the ammonia plants to be used in the reformers.

Most of the instrument and utility air for the Plant will be produced in the Utility Plant.

The effluent wastewater in the Utility Plant will run into a waste pit. The water is then collected and pumped to the settling ponds which will be located within the Plant complex. The water will then goes through a series of ponds for separation and pH balance. From there it will be pumped back to the Ossiomo river once it meets pH standards and other requirements of the relevant national and international standards.
Figure 3.18
KNO Plant 6 Utility Plants Basic Flowchart.
DEMINERALIZERS
The demineralizer system in the Utility Plant receives its water from water wells. Our main water wells are 7P, #6, #15 and #16. These wells are used mainly because of their low iron content, providing reduced contamination of the resin beds. The water from well #1 or #5 is used for make-up in the cooling tower in Plant #2 and Plant #5.

When water reaches the Utility Plant it enters the Cation Ion Exchange Vessels. Here inorganic cation materials, such as calcium, magnesium, sodium, iron and ammonium, are removed. When the resin beds become exhausted and can’t remove any more cations, then the resin is regenerated with a 2% & 4% acid solution. After the water is de-ionized, it will enter the Degasifier where air is injected up through the water to remove the carbon dioxide (CO2, a poison to the anion resin) to atmosphere. The water is then collected in a reservoir. From there it is pumped to the Anion Ion Exchange Vessels where the anion resin will remove the chlorides, sulfates and other inorganics in the water.

When the anion resin becomes exhausted it is regenerated with a 4% caustic solution. The water is then sent to the Mixed Bed Polisher, which has both cation and anion resin. This is the final step in cleaning of the water of the remaining inorganics. It is then sent to the storage tank and pumped to the Ammonia Plant to be used to make 1,500 psi steam in the reformer, and to the Utility Plant to feed its boilers for the production of 550 psi steam.

Plate 3.17 KNO Plant 6 Demineralizers
DEMINERALIZER SECTION - HAZARDS

PHYSICAL:
Thermal: 640 °F Steam
Pressure: Steam Turbine 550psi
Noise: 85dB

CHEMICAL:
Sulfuric Acid: 93%
Sodium Hydroxide: 50% (Caustic)
Demineralizer Storage Tank is pumped up to the De-aerator in the ammonia plants where steam runs counter-current to the water flow to de-aerate and partially preheat it. Oxygen scavenging chemicals are injected to help remove any unwanted oxygen still remaining in
The water. The water is then pumped to the Utility Plant through the low-pressure boiler feed-water pumps. After the flow is controlled with the aid of the Feed-water Controllers, it enters the Economizer where the water is further preheated with flue gas that passes up around interior tubes as it exits the boiler. The water then enters either through the Mud Drum or the Steam Drum, depending on the style of boiler. Once the water enters the boiler it is heated with a firing of natural gas to produce 550 psi of superheated steam. From there the steam goes to all the turbines throughout the plant. The 550 psi steam is also let down to various pressures throughout the plant for other operational functions.

The water used to feed the boilers comes from various tanks located around the Plant. The waste heat boilers will receive their feed-water mainly from the urea plants’ H₂O treatment sections and process condensate from the ammonia plants.

This water enters a surge tank. It is then pumped out and up to the waste heat boilers’ own de-aerator where the water is stripped of oxygen and preheated before going on to the boiler. Vacuum condensate from the ammonia and urea plants is also used for feed-water to the waste heat boilers. This steam is used as process steam in the reformers.

<table>
<thead>
<tr>
<th>Plate 3.18</th>
<th>KNO Plant 6 Package Boiler and Waste Heat Boilers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package Boiler B-700</td>
<td>Waste Heat Boilers B-705</td>
</tr>
</tbody>
</table>

**GENERATION SECTION - HAZARDS**

| PHYSICAL:  |
|---|---|
| Thermal: | 1,200°F, 2,000°F at fire box |
| Pressure: | Steam Turbine: 550psi |
| Noise: | 85dB and up |
| Electrical: | 4160V |

| CHEMICAL:  |
|---|---|
| Methane: | 96% (NG) |
| Carbon Monoxide: | Flue Gas |
| Carbon Dioxide |  |
| Nitrogen Oxides: | Flue Gas |
The Kenai plants were designed to be self-sufficient in electrical power and the same principle will apply to the relocated plant at Ossiomo's site in Nigeria. The Plant will have a separate distribution systems and powered by the Solar Generators alone. The plant will have an emergency backup system comprising a 1.5 MW diesel generator for “black-start”,

Generation Flow-chart.
lighting and critical control circuits.

Key equipment list is as follows:

A. KNO RELOCATED EQUIPMENT

Solar gas turbines
Rated power output: 2,500 kW
Actual power output: 1,860 kW
Number of sets: 5

Waste heat boiler
Rated steam 50,000 LBs/Hr
Steam temperature: 625°F
Steam pressure: 565 PSIG
Number of sets: 5

B. NEW EQUIPMENT

Solar gas turbines
Rated power output: 3,510 kW
Actual power output: 3,100 kW
Number of sets: 4

Waste heat boiler
Rated steam 50,000 LBs/Hr

Steam temperature: 625°F

Steam pressure: 565 PSIG

Number of sets: 4

Plate 3.19 KNO Plant 6 2.5 MW Solar Generator

POWER GENERATION SECTION - HAZARDS

PHYSICAL: Thermal 1,000°F
Pressure: Steam Turbine 150 psi
Noise: 85dB
Electrical: 4160V

CHEMICAL:
Ethylene Glycol 60%
Carbon Monoxide
Carbon Dioxide
Petro Products Lubes
Currently at Kenai 3 compressors are operated in the Utility Plant. There are two Worthington two stage compressors driven by 150 HP, 3 phase, 480V electric motors. These units can compress 600 standard cubic feet per min. (scfm) each. One compressor is connected to the Plant 3 power and the other is connected to the Plant 6 power. These
Worthington compressors take their suction from inside the building. Air is compressed in the first stage (low case) to about 28 lbs per sq. in. gauge (psig) at around 225°F. The air then goes through an intercooler where it is cooled to about 75°F. The air is then passed on to the second stage (high case) where it is compressed to 110 psig at about 300°F. From here it passes through an aftercooler where it is cooled to about 75°F. It then enters a receiver where more moisture is knocked out before it is passed on to the air dryers. Normally, one set of dryers is in operation while the other is being reactivated. Reactivation is accomplished by subjecting the absorbent material (silica gel) in the vessel to elevated temperatures. A bleed flow of air from the outlet tower in service passes through the tower being reactivated to carry off the moisture being driven out of the gel to an atmospheric vent. After a four hour cycle the process is switched.

On the Plant 6 side, there is one Elliott centrifugal three stage compressor. This is known as the Plant Air Package (P.A.P.). This compressor is driven by a 420 HP, 550 psi steam turbine and is capable of compressing 1,500 scfm of air. The Plant Air Package gets its suction from outside the building. This air goes through dryers first then on to the receiver. In the event one of the compressors is down for maintenance, air can be received from the Ammonia Plant’s process compressors.

Plate 3.20 KNO Plant 3 Utility Air Compressor
COMPRESSED AIR SECTION - HAZARDS

PHYSICAL:
Thermal: 640°F Steam
Pressure:
  Turbine 550psi Steam
  Air: 110psi
Noise: 85dB
Electrical: 480V

CHEMICAL:
Silica Gel: Moisture Absorbent
Petro Products: Lube Oils
The waste water in the Utility Plant goes into the neutralization tank and then to the Waste Pit. The water collected comes from the Demineralizer Regenerations. This water pH has been neutralized. Other water going into the pit includes cooling water blow-down, floor drains and water coming from the Solar Waste Heat Building.

The PE Lead Pond acts as a settling pond where the heavier sediments are dropped out. It also allows the pH of the pond to stabilize between 6.4 + 8.6. The water then flows over to the PE Lag Pond where more settling takes place. The water then flows over to the PE Main
From the PE and GE Main Ponds, water flows into a reservoir inside the pump building. This reservoir has two compartments. The east side is for pumping out the PE Main Pond while the west side is for pumping out the GE Main Pond. There is a Rodney Hunt valve in place by which, if necessary, these two waters can be mixed (though seldom done). Usually water is pumped from the GE Main Pond over to the PE Main Pond. This helps to control the pH and the amount of oil being pumped out to the Cook Inlet. Once every week, normally starting on Tuesday and running for 24 hours, official samples of this water is taken. When the lab receives these samples, they monitor the ppm of oil, urea and ammonia.

Plate 3.21 KNO Plant 6 Effluent Settling Ponds

**PUMPED EFFLUENT WATER SECTION - HAZARDS**

**PHYSICAL:**
- Thermal: 300°F Steam
- Pressure: 50psi Steam
- Noise: 85dB
- Electrical: 480V
- H₂O: Depth of 5 feet+

**CHEMICAL:**
- Sulfuric Acid: 93%
- Sodium Hydroxide: 50% (Caustic)
- Petro Products: Lubes
- Ammonia (NH₃): Vapors
The use of cooling water in the Plant helps to maintain the correct temperatures and
pressures needed to run the plants efficiently.

The cooling system used in the plants is an open recirculation system. It uses ambient air to cool the water, which is the most efficient method. This system consists of pumps, heat exchangers, piping and the Cooling Towers. The pumps keep the water circulating through the entire system, which includes various equipment in three plants where it picks up heat. The cooling water flow then passes on to the cooling tower where it is dropped down through packing to the basin. The system circulating pumps take suction from a pit in this basin. Fans on the top of the Cooling Towers draw air counter current to warm water flow. There is a loss of cooling water through evaporation and blow down, so makeup water is constantly added to the system. Because the systems are open to the air, chemical treatment of the water is required.

### COOLING WATER SYSTEM - HAZARDS

<table>
<thead>
<tr>
<th>PHYSICAL:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal:</td>
<td>640°F Steam</td>
</tr>
<tr>
<td>Pressure:</td>
<td>550psi Steam</td>
</tr>
<tr>
<td>Noise:</td>
<td>85dB</td>
</tr>
<tr>
<td>Electrical:</td>
<td>4160V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHEMICALS:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Water</td>
<td></td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td>93%</td>
</tr>
<tr>
<td>Chorine</td>
<td></td>
</tr>
<tr>
<td>Petro Products</td>
<td>Lubes</td>
</tr>
</tbody>
</table>
Figure 3.24 KNO Utility Plants

Process Overview – Utility Plants 3 & 6
Overview

3.9 FEEDSTOCK NATURAL GAS SUPPLY

Ossiomo has signed a GSPA under which NGC will supply natural gas feedstock to the Project. The gas will be supplied via a 200 MMSCF/D, 15 KM, 16” natural gas pipeline from the ELPS. The Daily Contract Quantity (DCQ) under the GSPA is up to 100 MMSCF/D. The major gas suppliers to the ELPS are Shell Petroleum Development Company and Chevron Nigeria Limited.

Under the GSPA, NGC has the obligation to deliver natural gas to the Project site. Therefore NGC will be responsible for the EPC of the interconnecting pipeline. However there is an existing oil pipeline which traverses the northern segment of the Ossiomo site area. In addition, NGC is currently completing the construction of a 12” 100 MMSCF/D natural gas pipeline using the same “Right of Way”. NGC expects to use this existing “Right-of-Way” to construct the 16” 200 MMSCF/D pipeline for the Project. Alternatively, NGC could elect to supply the natural gas for the Project via the 12”.

Figure 3.25 Ossiomo Natural Gas Supply Schematic Layout.
Pipeline Right-of-Way with underground pipelines (oil and gas) traversing approx 3KM of the northern segment of Ossiomo industrial site (March 2010)
3.10 INFRASTRUCTURE

3.10.1 EXISTING INFRASTRUCTURE

The region surrounding the Project site contains a good infrastructure network that will support Project execution. This includes road, marine and commercial aviation infrastructure.

This section contains a summary of the existing infrastructure and the Project’s requirements and usage during construction and commercial operation.

3.10.1.1 ROAD NETWORK

Nigeria and the Project site area, in particular, have a good network of roads.

A single-carriage road bisects the site. This road is located off the Benin-City to Sapele motorway which is a 4 lane dual-carriage road with heavy load capacity that is used extensively by the oil and gas operators in the area.

Benin-City itself is a major road hub in Nigeria with motorways radiating west to Lagos, north to Abuja and east to Port Harcourt. This good road network will support the distribution of the urea production into the local market.

A map illustrating Nigeria’s road network is illustrated on the overleaf.
Plate 3.23 Nigeria Road Network
Distances from the Project site to the capitals of the 19 northern states of Nigeria are shown in the Table below.

Table 3.1: Road Distances From the Project Site to the Capitals of the Northern Nigeria states

<table>
<thead>
<tr>
<th>State</th>
<th>Capital</th>
<th>Distance from site (KM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adamawa</td>
<td>Yola</td>
<td>854</td>
</tr>
<tr>
<td>Bauchi</td>
<td>Bauchi</td>
<td>676</td>
</tr>
<tr>
<td>Benue</td>
<td>Makurdi</td>
<td>391</td>
</tr>
<tr>
<td>Borno</td>
<td>Maiduguri</td>
<td>1,064</td>
</tr>
<tr>
<td>Gombe</td>
<td>Gombe</td>
<td>786</td>
</tr>
<tr>
<td>Jigawa</td>
<td>Dutse</td>
<td>764</td>
</tr>
<tr>
<td>Kaduna</td>
<td>Kaduna</td>
<td>541</td>
</tr>
<tr>
<td>Kano</td>
<td>Kano</td>
<td>740</td>
</tr>
<tr>
<td>Katsina</td>
<td>Katsina</td>
<td>807</td>
</tr>
<tr>
<td>Kebbi</td>
<td>Birnin Kebbi</td>
<td>734</td>
</tr>
<tr>
<td>Kogi</td>
<td>Lokoja</td>
<td>238</td>
</tr>
<tr>
<td>Kwara</td>
<td>Ilorin</td>
<td>304</td>
</tr>
<tr>
<td>Nasarawa</td>
<td>Lafia</td>
<td>433</td>
</tr>
<tr>
<td>Niger</td>
<td>Minna</td>
<td>414</td>
</tr>
<tr>
<td>Plateau</td>
<td>Jos</td>
<td>572</td>
</tr>
<tr>
<td>Sokoto</td>
<td>Sokoto</td>
<td>783</td>
</tr>
<tr>
<td>Taraba</td>
<td>Jalingo</td>
<td>728</td>
</tr>
<tr>
<td>Yobe</td>
<td>Damaturu</td>
<td>954</td>
</tr>
<tr>
<td>Zamfara</td>
<td>Gusau</td>
<td>954</td>
</tr>
</tbody>
</table>

Plate 3.24 Benin City to Sapele Motorway located about 10KM from the Project Site (March 2010)
Currently a significant amount of traffic (trucks and heavy motorized equipment) is created from drilling campaigns and seismic surveys conducted by the Exploration and Production companies in the area. Typically the oilfield service company contractors who carry out these activities will mobilize to sites and work for about 9 to 12 months at a single location following which they move to other location in the area to conduct exploration activities. These activities temporarily boost the local economies by creating employment (mainly unskilled labor) and increase vehicular traffic.

Current estimates indicate that the Project will result in an increase of about 10% vehicular traffic on average during the construction period and 15% during the operation period.

Plate 3.25 Rig currently drilling for oil located at Ologbo village about 10KM from the Project Site (March 2010)
In summary:

1. The Project area is well served with a good network of access roads connected to the national road network

2. The Project site area already hosts a steady stream of contractors undertaking
drilling and seismic activities for exploration and production companies operating in the area

3. The Project estimates incremental truck traffic of 20 trucks per day on average during the construction phase. The Project will result in about 10% incremental vehicular traffic during the construction phase mainly for the use of contractors for ingress and egress to the Project site.

4. The Project estimates incremental truck traffic of 75 trucks per day on average during the construction phase. The Project will result in about 37.5% incremental vehicular traffic during the operation phase mainly for the transport of the urea product into the domestic market. Note that the incremental traffic is mainly around the site. Traffic on the main road network is not incremental given that urea import is already mainly trucked from port in the southern part of Nigeria to inland markets mainly in the western and northern parts of Nigeria.
3.10.1.2 MARINE INFRASTRUCTURE

A Google map of the marine access to the Project site is shown as Plate 5.2, Section 5.1 of this ESIA.

There are a number of ports in proximity of the site including:

- **Koko Port** 45 KM east of the site
- **Sapele Port** 70 KM east of the site
- **Warri Port** 95 KM east of the site
- **Onne Port** 335 KM east of the site
- **Lagos Ports** 335 KM west of the site

These ports are essentially owned by the Nigerian Ports Authority but the operation of the ports is gradually being franchised/transferred to independent operators.

The focus from the Project’s perspective are Koko Port, Warri Port and the Lagos Ports. Koko Port and Warri Port are part of the Delta Ports system.

**Koko Port**

- Located on the Benin River approximately 76 KM from the Atlantic Ocean
- Benin river channel ranges from 800-1,000 meters wide
- Channel depth is approximately 7 meters, although depth at the entrance from the Atlantic Ocean is less than 5 meters. As a result the port is currently accessed via the Escravos river where depth is approximately 5 meters, plus a tidal range of approximately 2 meters (the port is quoting 7 meters)
- The Nigerian Ports Authority plans to dredge the channel to 9 meters at low tidal range, which with a tidal range of 1.5 meters will provide maximum depth of 10.5 meters
- Current maximum shipping capacity is about 8,000 – 10,000 DWT ships
- Shipping capacity post the dredging will be circa 25,000 DWT
- The distance from the site to Koko port is about 82.7 KM (44.7 KN) via the Ossiomo river and the Benin river
- Journey time for self-propelled barges from the site to Koko port is about 9-15 hours cruising at 3-5 KN/hour dependent on river conditions
- Trucking from the site to Koko port will take about 1 hour
- Koko port is currently under-utilized, making the port ideal for the import of equipment and export of products from the plant.

**Warri Port**

- Located on the Warri River approximately 98 KM from the Atlantic Ocean
- Channel depth approximately 7 meters, although depth at the entrance from the Atlantic ocean is less than 5 meters. As a result the port is currently approached via
the Escravos river where depth is approximately 5 meters plus a tidal range of about 2 meters (the port is quoting 7 meters)

- The Nigerian Ports Authority plans to dredge the channel down to 9 meters at low tidal range which with a tidal range of 1.5 meters will provide maximum depth of 10.5 meters
- Current maximum shipping capacity is about 8,000 – 10,000 DWT ships
- Shipping capacity post the dredging will be circa 25,000 DWT
- The distance from the site to Warri port is about 195.6 KM (105.6KN)
- Journey time for self-propelled barges from the site to Warri port will be about 1-2 days cruising at 3-5 KN/hour dependent on river conditions
- Trucking from the site to Warri port will take about 2 hours
- Warri port currently experiences significant shipping traffic, most of which is carriers importing equipment for oil and gas operators
- Warri port is currently being used as the import terminal and laydown area for the circa US$5 billion Escravos Gas-to-Liquid (“EGTL”) project sponsored by Chevron
- Most of the equipment for the EGTL is imported into Warri port. Some pre-assembly is carried out at Warri port prior to trans-shipping the equipment to the EGTL site at Escravos

**Lagos Ports**

- Apapa and Tincan are the two main Lagos Ports
- Other new Ports are developing such the Lagos Deep Offshore Logistics Port (LADOL) and the new Lekki Free Zone Port (under development)
- Apapa Port is Nigeria’s largest port
- The container terminal located at the Third Apapa Wharf extension and covers an area of about 44 hectares
- Maximum capacity of the terminal is 22,000 TEU and served by six designated container berths with a quay length of 950 meters. There is 6,400m² of covered storage space
- Tincan Island Port is a self contained port entered through the Badagry channel which is a 200m wide channel which has been dredged to 8.5m.
- Tin Can provides 11 berths including seven break-bulk general cargo berths, one dry bulk cargo berth and two dedicated RORO berths (numbers 9 and 10). Total length over the quays is over 2,000 meters and has a maximum draught of 10 metres
- Tincan Island Port can accommodate up to 13 at a time.

**Current Marine Traffic around the Project Site**

The current marine traffic on the Ossiomo river around the Project site mainly comprises of local people using the river for transport as well as commercial entities with large marine dredgers and barges dredging sand from the river for the large construction activities underway in the area (refer to Plate 3.1, Section 3 of this ESIA).
PROJECT PROPOSITION FOR MARINE INFRASTRUCTURE

In summary:

1. The marine access to the Project site is via the Ossiomo river

2. In addition the Project is close to the nearby Ports of Koko and Warri as well as the Lagos Ports system (the largest in Nigeria)

3. Current traffic on the Ossiomo River comprises transportation and marine dredging activities

4. The Project is considering shipping the urea for the export market by barges from the Project site to the Ports of Koko or Lagos for onward shipping in large ocean-going vessels to the international market. This will be an alternative to transport by trucks to the main port.

5. The Project will result in about 15% incremental marine traffic during the construction and operation phase mainly for the transport of the urea product into the domestic market.
3.10.1.3 AIRPORTS

Nigeria has a good network of regional airports with the main international airports located in Lagos, Port Harcourt and Abuja. There are several international flights into Lagos daily.

The nearest airport to the site is located in Benin-City approximately 10 KM from the site. The Benin-City airport is a regional airport with frequent local flights to Lagos and Abuja. In addition to the Benin airport, there are new airports located at Warri and Asaba (opening shortly) less than 100 KM from the site.

Plate 3.26 Nigeria International and Regional Airport Network

It is envisaged that Benin Airport will be the main functional aviation infrastructure for the Project for the transportation of mainly expatriate personnel during construction and the
operation phases of the Project.

PROJECT PROPOSITION FOR AVIATION INFRASTRUCTURE

1. Use of Benin airport for the inbound and outbound traffic of expatriate personnel connecting from Lagos and/or Abuja international airports

2. There are currently about 7 daily flights between Lagos and Benin City and 2 daily flights between Abuja and Benin City

3. The additional traffic induced by the Project during the construction phase will be minimal but with a spike in traffic during the mobilization and de-mobilization periods

4. The additional traffic induced by the Project during the operations phase will be minimal.
3.10.1.4  ACCOMODATION AND HOUSING

There are extensive accommodation facilities at competitive prices in Benin City. The best hotels are generally 3/4 Star by international standards and rates are currently average US$100 per night. There are a number of new hotels under construction in Benin City. The Project is expected to have a positive impact on the hospitality industry in and around Benin City.

It is estimated that about 1,000 jobs will be created during the construction phase comprising:

- Managerial 5%
- Professional 20%
- Skilled 50%
- Unskilled 25%

The plan is to develop temporary/permanent accommodation within the Project site to limit traffic and promote work efficiency. A limited number of senior professionals and management are expected to live in Benin City and commute to the site. There will be temporary use of hotels facilities in Benin City.

It is estimated that about 300 jobs will be created during the operation phase comprising:

- Managerial 7.5%
- Professional 22.5%
- Skilled 55%
- Unskilled 15%

The main workforce will work in shifts and it is anticipated that most of the shift workers will live in the permanent accommodation within the Plant site. A limited number of senior professionals and management are expected to live in Benin City and commute to the site. There will be temporary use of hotels facilities in Benin City for visiting professionals.
Benin and the local areas have a number of sports facilities, cultural centers including a landmark eco-lodge which will provide useful recreation facilities.

PROJECT PROPOSITION FOR ACCOMODATION IN THE PROJECT AREA AND BENIN-CITY

1. The Project has been designed to minimize the impact of the ingress of personnel into the area to execute the construction and operation of the Plant

2. The bulk of the circa 1,000 workers required for the construction will be housed in dedicated facilities within the Project site

3. Plant operation is expected to generate about 300 jobs which will have minimal impact on housing and accommodation in the local villages and Benin-City

4. A number of professionals are expected to reside in Benin-City (both permanent and hotel accommodation) during the construction and operation phase. This will enhance the economy of the city in the medium term.
3.10.1.5 NATURAL GAS SUPPLY INFRASTRUCTURE

A detailed overview of the natural gas infrastructure in the area is outlined in Section 3.9

PROJECT PROPOSITION FOR NATURAL GAS INFRASTRUCTURE

1. One of the key rationale for the Project is utilize the abundant gas reserves in the area and assist in the elimination of gas flaring which is a great environmental hazard.

2. NGC will supply natural gas feedstock to the Project under a long-term contract. NGC is responsible for the delivery of natural gas to the Project site.

3. NGC is considering 2 alternatives to supply natural gas the Project – either utilizing an existing 100 MMSCF/D pipeline which runs through the Ossiomo industrial park OR to construct a new 200 MMSCF/D pipeline parallel to the existing pipeline.

4. In the event that the existing pipeline is selected, there will be nil impact on the environment in the context of the natural gas pipeline infrastructure.

5. In the event that a new pipeline is selected, there will be impact on the immediate environment during the construction of the new pipeline. Such impact will be limited as the new pipeline will use an existing Right-of-Way. Furthermore there is a significant pipeline network in the area so the local communities have good experience of pipeline construction procedures.
3.10.1.6 POWER SUPPLY AND INFRASTRUCTURE

Power demand in Nigeria is currently estimated at 30,000 MW against current power generation capacity of circa 3,500 MW. Hence there is a significant gap in power supply which is somewhat mitigated by the use of stand-alone generators, a very-high cost and environmentally damaging option. Addressing the power supply problems is a key policy priority for the Federal Government of Nigeria.

Ammonia-urea plants require stable, consistent power supply. So given the constant power outages, the Project has been designed to have its own independent power supply. However ammonia-urea plants are relatively very energy efficient. For example, a 1 MTPA ammonia-urea plant requires circa 25MW whilst an equivalent value steel plant (mini mill) 1 MTPA requires circa 250MW.

The Project requires about 25MW power generation capacity. Fortuitously, the KNO Plant due to its remote location has an independent 12.5MW power plant comprising 5 X 2.5MW gas fired power plants. These units will be relocated and additional new 4 X 3.5MW power plants will be installed as part of the relocation Project.

In addition a 2.5MW diesel-fired power plant will be installed during construction to provide Project site power during construction. Post construction (during the operation phase) the diesel generator will serve as back-up and for black-start.

In essence the plant will be independent of the national grid. However it is important to note that the main transmission line is located only about 13KM from the Project site. So the Project Sponsor anticipates constructing the short connection to the national grid to provide surplus power to the grid and support government’s efforts to provide sustained power to the populace.
1. The Plant will have its own power generation facilities comprising 5X2.5MW gas-fired power plants relocated from Kenai plus new 4X3.5MW power plants.

2. In addition, a 2.5MW diesel generator will be installed to provide site power during construction. The power plant will subsequently provide back-up power and for emergency black-start during the operation phase.

3. The Project will consider supplying excess power to the national grid to help address the chronic power outage currently experienced in the country.

4. In essence, the Project will have minimal impact on the power supply infrastructure in the immediate area.
3.10.1.7 WATER SUPPLY AND WATERWAYS

The plant requires a substantial amount of water for process (feedstock and cooling) and potable water supply during the operation phase. Most of the water required during the construction phase will be potable water requirements.

There are 2 options for water supply to the Plant during construction and operations:

1. Groundwater – the Project geotechnical surveys identified substantial water-bearing aquifers underground the site.
2. Ossiomo River – the river provides a source of substantial water volumes and the plant requirements is insignificant and will not have any material effect on the river.

Liquid effluents from the plant will be disposed into the Ossiomo river. The effluent will be treated in the plant's treatment plant and tested to ensure it meets the IFC and national guidelines for waste-water disposal for nitrogenous fertilizer plants prior to disposal.

The allowable levels for liquid effluents from nitrogenous fertilizer plants is shown in Table 2.2 of Section 2.

The Ossiomo river will also provide a major transportation option for the Project both during construction and operation.

The Project plans to use the Ossiomo river for the transport of the relocated KNO equipment to the site.

In addition to the transport and distribution of the urea product by trucks, the Project has the option to transport the bulk urea by barges. This option has become more attractive with the recent dredging of the River Niger, which is the main inland waterway in Nigeria. The Government plans to complete the dredging of the River Niger by December 2010.
PROJECT PROPOSITION FOR LOCAL WATER SUPPLY AND THE WATERWAYS

1. Potable water supply and water supply for activities during construction will come from the Ossiomo river. Taking water from the river for this purpose will have negligible effect on the river or other users of the river.

2. Potable water supply and water for feedstock requirements will also come from the Ossiomo river. Hydrological studies have established that there are large volumes of water in the river and drawing water from the river for this purpose will not have any material effect.

3. Water will be supplied to the plant via a circa 0.5KM underground pipeline. The water pipeline, intake water facilities and water processing equipment will be installed during the construction phase.

4. Liquid effluents will be disposed in the Ossiomo river after treatment in the Plant’s water treatment plant. Any effluent disposed in the river must meet the IFC GUIDELINES for nitrogenous fertilizer plants which is outlined in Table 2.2 of Section 2.

5. Navigation via the Ossiomo river provides significant logistics advantage to the Project. Most of the plant equipment will be transported via the Ossiomo river to the site and the river will also provide a route for the barging of the bulk urea for both the local market and the international market. Transport via the water-ways will avoid the environmental impact and nuisance associated with road traffic.
3.10.1.8 FIRE SERVICE

The nearest fire station to the Project site is the Edo State fire service station located in Benin City, about 10KM from the Project site. This is clearly inadequate for a Plant of this size and nature.

So the Project scope will include the design, engineering, procurement and installation of a dedicated fire station inside the plant battery limits. This will incorporate the provision of fire tenders and the plant will be designed with an extensive fire-fighting system integrated with the plant control systems.

There will be scope to share the fire-fighting equipment with other plants to be developed at the Ossiomo industrial site.
1. A major petrochemical plant of this size and nature requires support from a fire station to respond to major incidents to be within about 10 minutes drive from the site but the nearest fire station is located at the centre of Benin City about 10KM and perhaps an 45 minutes drive from the plant (due to traffic).

2. Therefore the installation of a dedicated fire station within the Plant battery limits is included in the Project scope. The fire station will be manned 24 hours a day fully trained fire fighters that would be in a position to respond to any major incident within 5 minutes.

3. There will be scope to share the fire-fighting infrastructure with other Plants to be developed at the Ossiomo industrial site, in due course.