# Abstract


Nynas Petroleum is one of the world´s largest producers of naphthenic specialty oils. They have refineries in several parts of the world and their largest production facility is situated in Nynäshamn, Sweden. They also have oil depots in all continents and their largest depot is located in Antwerp, Belgium.

In the beginning of 2007 Nynas introduced a new type of transformer oils, called Nova grades, to the market. Nova grades consisted of oils produced both in Nynäshamn and at other refineries around the world. This forced Nynas, who had previously blended these oils in Nynäshamn, to blend the nova grades at the central hub in Antwerp.

This change complicated the handling of the depot in Antwerp as some of these oils needs to be oxidation tested, a process that can take up to 23 days. They realized that they did not have control of their hub in Antwerp and how much tank volumes that were needed to fulfill their customers´ service expectations.

This thesis maps the factors that are crucial for the hub in Antwerp and from this knowledge a simulation model was built using the simulation software Extend. The model was built up around a number of logical blocks, which makes decisions depending on different criteria.

The model was then used to simulate a number of different scenarios. A total of 15 different scenarios were simulated where the tank setup, the demanded volumes, the quarantine times and the number of boats transporting oil to Antwerp were altered. Each run generated a report consisting of average inventory levels, service levels, average service level, filling station utilization, and more.

With help from the reports we were able to examine the performance of the Antwerp hub and how the different parameters impacted on the overall efficiency.

After running the simulations we can establish that the tank setup as it was in 2007 cannot cope with the alteration in product slate, with the introduction of the Nova grades and especially not with the anticipated growth in sales volume.  In the first phase investments in tank capacity is needed and if the anticipated sales growth

becomes reality investments in boat capacity will also be necessary as the vessels is the next bottleneck. Another option, which would lessen the need for investments in tank capacity would be to drastically cut the oxidation test time. This would make the system easier to overview and handle.

By investing in the hub in Antwerp the service level can be kept at a high level, leading to higher customer satisfaction and increased likelihood for returning customers. It is always hard to put a certain value on this type of investments but our beliefs are that investments to keep service level reasonably high are needed in a market where competition is fierce.

# Preface

This mater thesis is the final phase of our M.Sc. Industrial management and Engineering. It was written during the summer and fall of 2007. While working on the thesis we were situated at Nynas Petroleum's head office in Johanneshov. The thesis comprises 30 points and was conducted in collaboration with the Department of Industrial Management and Logistics department Production Management at Lund Institute of Technology and Nynas Petroleum AB in Stockholm. Our supervisors have been Stefan Vidgren at the university and Andreas Jerper at Nynas Petroleum.

We would like to take this opportunity to thank the people who have helped us through the thesis. First and foremost we would like to thank Stefan and Andreas for their support. Next we would like to thank the whole supply department at Nynas Petroleum in Johanneshov for taking time to answer our questions, especially Anders Nilsson who has always encouraged us and been very enthusiastic over this thesis.

Another person who we must not forget to thank is Matts Nordlund who helped us find the data necessary to complete this thesis.

Thank you!

Stockholm 2008-01-18

Erik Andersson　　　　　　Oskar Lönn

# Contents

# 1 Introduction

## 1.1 Problem introduction

Nynas Petroleum has recently made a radical change in their production slate for naphthenic special oils. After extensive research and development Nynas introduced a new generation of transformer oils, called Nova grades. These grades have been developed to meet tougher operating conditions that the new generation of transformer faces. The benefits are good oxidation stability and improved performances in terms of less copper corrosion. Both which have a positive impact on transformer lifetime expectancy and maintenance cost. During the introduction phase older products have gradually been removed from the market.

The previous generation of transformer oils contained mainly ingredients that were produced in Nynäshamn and therefore it was natural to blend these at the Nynäshamn facility and then transport them to the Antwerp distribution depot. The new generation is blended, partly of oils from Nynäshamn and partly from other refineries. This has pushed the blending operations down to the Antwerp depot. This has made the planning operations for the supply chain department more complicated.

Nynas is experiencing high demand for their naphthenic products at the moment. This puts the company in a position where they in many cases can sell more products than they can produce.

Even with the high current demand Nynas is anticipating a large volume increase in the forthcoming years. This will put additional stress to the European Supply Chain, especially the Antwerp distribution hub.

Altogether Nynas find themselves in a position where they need to question the infrastructure of their European supply chain. Especially the setup of the Antwerp hub needs to be examined in order to find out where capacity improvements are necessary.

## 1.2 Purpose

The master thesis consists of three parts. The first part is examining the factors that affect the performance of the Antwerp hub (i.e. number of stock outs, service level, average storage levels etc.). In the second part we are developing a simulation model over the European supply chain with focus on the Antwerp depot. In the third part we are simulating a number of scenarios to examine the effects of increased sales volumes and different investments to improve capacity. With help of the simulation model a proposal for how the hub should be set up for 2008 will be created.

## 1.3 Directives

The directives for this master thesis are to build a simulation model of the European supply chain focusing on the hub In Antwerp. The model should be a good enough representation of reality so it could be used to compare different investment proposals. A proposal for the setup for 2008 will also be produced.

## 1.4 Constraints

Since we only have a limited time period to undertake this master thesis some constraints are necessary. The simulation model will focus on the Supply chain connected to the Antwerp facility. Other depots and production facilities will not be included. A constraint in number of products used will also be included.

There are also numerous delimitations in the simulation model. These will be described in more detail further on.

## 1.5 Target group

The target group for this Master thesis is first and foremost Nynas Petroleum and especially its supply department. The thesis should also serve as a guide for management when they discuss the need for future capacity investments at the Antwerp hub. Secondly this thesis is intended for other students at university level with an alignment towards supply chain management and simulation in particular.

# 2 Nynas

## 2.1 Nynas history

The origin of Nynas can be traced to the later parts of the 1920's when Charles Almqvist and consul-general Axel Axelsson Johnson started Sweden's first oil refinery in Nynäshamn. In 1928 the first shipment of crude oil was delivered from America to the newly built refinery. After Nynas was established by Axel Axelsson Johnson in 1930 the company began building a national network of petrol stations (Nynas Petroleum u.d.).

Nynas played an important role in the domestic supply of oil substitutes during the Second World War. By using supplies of coal tar and wood tar, which both could be found domestically, Nynas could continue to produce oil products.

After the War the demand for Nynas products increased dramatically due to the rise of private motoring and the many road construction projects undertaken. These developments lead to an increase in the total number of gas stations and the opening of Nynas second refinery in 1956 (Nynas Petroleum u.d.).

During the 1960's the company expanded continuously with the ambition to become a national integrated oil company. Besides fuels and bitumen the company also sold lubricants and solvents.

The oil crisis during the 1970's showed that Nynas was too small to compete with larger international oil companies in the gasoline and diesel market. This forced the company to change direction and focus on special products. Nynas sold its network of petrol stations to Shell Sweden. Nynas quickly transformed from a traditional oil company to an international player focusing on naphthenic oils and bitumen.

During the 1980's Nynas increased its production capacity by acquiring a refinery in Antwerp and undertaking major investments in Nynäshamn.

In 1986 the state owned Venezuelan oil company Petroleos de Venezuela (PDVSA) acquired 50 % of the Nynas shares. The final owner structure was established in 1989 when the Finnish company Neste acquired the remaining stocks (Nynas Petroleum u.d.).

## 2.2 Nynas today

### 2.2.1 Organization

The parent company of the organization is AB Nynas Petroleum which is situated in Sweden. Under this company lies a group specializing in producing and selling specialty oil products. This group is divided into different departments handling manufacturing, naphthenic, bitumen UK and continental and bitumen Nordic.

#### *2.2.1.1 Supply chain organization*

The supply chain department at Nynas is divided in four divisions; crude, bitumen, naphthenic specialty products and planning and optimization. Responsible for these divisions is the supply chain director, Simon Day who reports directly to the president, Staffan Landström.

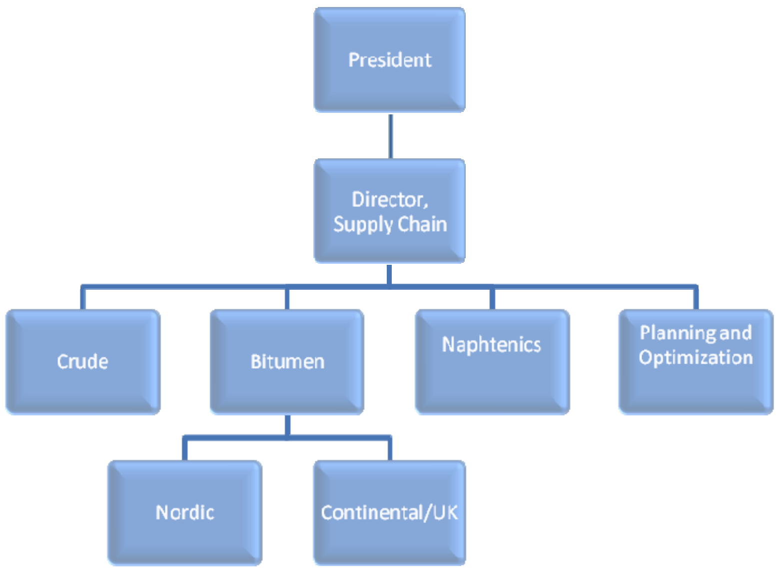



**Figure 1 - Organization schedule over the Supply Chain Department**

### 2.2.2 Vision

To become successful as a small specialized oil company competing in a world where large oil companies dominates the markets it is important for Nynas to have clear visions and objectives. They must aim high in terms of customer satisfaction, have a modern product portfolio, outstanding quality and extraordinary service. Nynas has therefore stated a vision, which is spread within the company. The vision is stated as the following:

*"Through the world-class dedication of our people, Nynas will be the best long-term partner in specialized oil applications, doubling the business every five years".* (Nynas Petroleum n.d.)

### 2.2.3 Nynas Bitumen

As mentioned earlier Nynas have been a supplier of bitumen for about 75 years. Bitumen is mostly used as a binding component in asphalt but can also be used in roofing felts and insulation. Bitumen is one of the heaviest components that come out of a refining process. Nynas delivers bitumen all over Western Europe including the Nordic and the Baltic markets. Nynas is the leader of bitumen supply in Sweden and Norway with over 95% of the market. To secure its position in the future Nynas acquired one of the leading bitumen emulsion manufactures in Sweden in 2007. Nynas is also distributing bitumen in the U.K. with separate refineries in Hull and Dundee (Nynas Petroleum 2007). When Nynas refines its crude oil about 70% of the outcome is bitumen. The additional 30% is split evenly between naphthenic oils and fuels. An illustration of this can be seen in Figure 2. This can be compared to a "normal" oil company where 96% of the outcome is fuels. The big difference in output depends on what oil is used as a base. The oil found in the Middle East is excellent for fuel productions while the oil found outside Venezuela is better suited for bitumen production. Modern large-scale refinery's can make fuel from the heavier output such as naphthenic oil in a process called cracking.

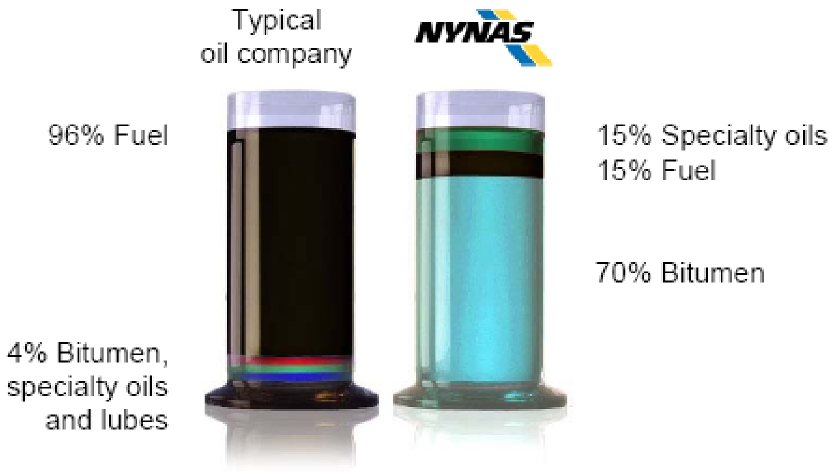



Figure 2 - Comparison between Nynas and a traditional oil company (Nynas)

### 2.2.4 Nynas Naphthenic

Nynas Naphthenics are one of the world leaders in naphthenic specialty oils and the business grows with about 20% per year. Nynas delivers naphthenic oils to companies in the electrical, lubricant and chemical industry around the world. The naphthenic oils are divided into three groups depending on their use. The three groups are; base oils, process oils and transformer oils. Base oils are used as cutting and grinding fluids, industrial lubricants and grease. Process oils are used in applications such as explosives, fertilizers and tires (as a supplement for the forbidden HA-oils). The tire industry is a relatively new business for Nynas with potential to sell large amounts of process oils in future years. Transformer oils are mainly used in transformers as insulating and cooling elements. The characteristics of naphthenic oils make them an excellent choice in transformers. They have low viscosity at high temperatures and high solvency at low temperatures, which means that their characteristics are static as temperature shifts.

The naphthenic division has sales offices in all parts of the world. They are represented in Africa, Asia, Australia, South and North America and Europe. To shorten lead time for their customers Nynas rents depot space in most locations where they have sales offices and on some additional locations as well. Totally Nynas has 23 depots with 182 tanks available around the world. (Nynas Petroleum 2007)

### 2.2.5 Naphthenic Supply Chain

Nynas supply chain department is centralized to Johanneshov, Sweden with an additional office in Houston, US that is responsible for the South and North American market. Although most supply personnel are situated in Johanneshov they are in contact with the other sales offices, depots and refineries on a daily basis. Nynas claim that the closeness to their customer (sales offices) and sources are of crucial importance to gain “supply excellence” which is what they strive for. This goal is set but a bit hard to define. The overall goals are to guarantee deliveries of agreed volumes in the most cost effective way. This is made possible by:

- Predictable deliveries
- A cost efficient supply chain
- Transparency in delivery costs

In 2006 Nynas shipped 666.652 tons of naphthenic specialty oils in 196 shipments around the world.

This year Nynas changed their product line and introduced a new line of transformer oils called “Nova Grades”. Before these were introduced the transformer oils were blended in Nynäshamn and then shipped to the depot in Antwerp. After the introduction the blends are made in the hub in Antwerp. The new grades have components that are shipped in from Curacao and Houston and because of this Nynas found it better to blend these grades in Antwerp and through that minimize transport costs. The new structure has made the hub in Antwerp more difficult to operate in an efficient way.

The majority part of the products in Antwerp comes from the refinery in Nynäshamn. As the naphthenic products come out of the same crude oil as the bitumen it is important to co-operate the naphthenic and bitumen supply departments. Different crude oils give different blends and qualities of naphthenic oils and bitumen. The two supply departments meet every month to make sure that both parts are up to date with the production plans and crude oil purchases (Nynas Petroleum 2007).

A bottleneck is the insecurity in the crude oil deliveries from Venezuela. The political (in) stability in Venezuela is a serious issue for Nynas, which receives a majority of its crude oil from oil fields in Venezuela. As mentioned earlier fifty percent of Nynas is owned by PDVSA, which is controlled by the government in Venezuela. Negotiations are currently held with PDVSA to secure deliveries in the next few years and parallel with this new crude oil sources are contracted to diminish the dependence on Venezuelan sources. Additional sources of supply will be needed to cover the expected future growth in sales. In addition to this, new partners with naphthenic oil production are contracted. These partners are often fuel producers who do not see naphthenic oils as their core business. This means that Nynas can expand its naphthenic sales without investing in expensive production facilities.

The contracted companies' oils are laboratory tested to see in which recipes they can be implemented without changing the end products chemical characteristics. It is important that the changes in recipes can be made without any changes of the end product to avoid spending time to sell in new products to existing customers. If the new recipes have other characteristics it might be possible to create and launch new products if there is place for them in the market.

### 2.2.6 Production

Nynas main production utility is the refinery in Nynäshamn, which was built as early as 1928. Through the years the refinery has been upgraded and modernized and is now specialized in production of bitumen and naphthenic oils. The utility is running 24/7 all year round except for maintenance which is required every other year. Added to this are unforeseen breakdowns such as the fire in a hydrogen treater in 2006 and other malfunctions.

As mentioned earlier Nynas sells all the products they are producing and could probably sell even more if the production capacity was higher. This means that every stop in the production is extremely costly and results in large profit losses. The supply chain has an important mission, to make sure that production facilities have the correct level of the right crude oil at the right time. If the facility would run empty it would take several days to get it restarted again and this would of course render large financial losses.

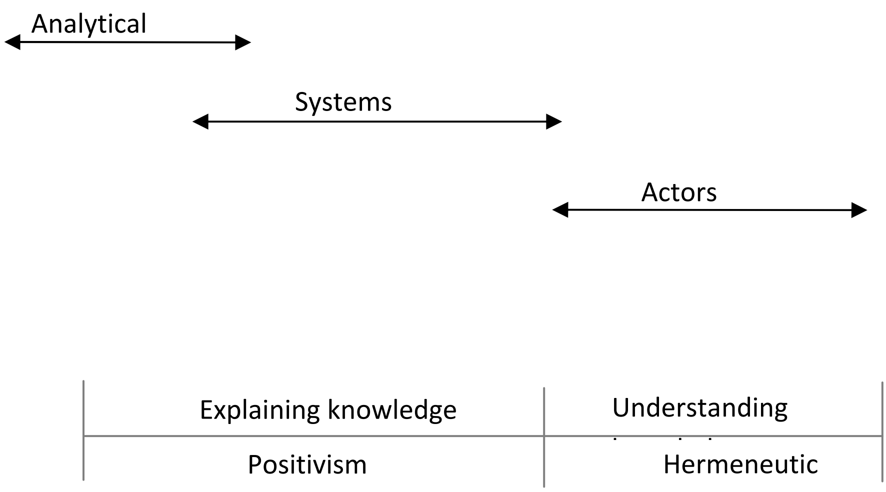
# 3 Methodology

## 3.1 Introduction

Methodology is important to ensure that a scientific paper holds the quality that is required in order to appear trustworthy. There are several different methods to ensure this in the theories around methodology. In this chapter we will briefly take the readers´ through some of the most commonly used terms around this subject. In the end of each section we will explain which method we chose to work according to and the reasons why we chose this, subject to the conditions in our project.

## 3.2 Scientific approach

The scientific approach on methodology is historically divided into three different groups; the analytical approach, which is the oldest, the systems approach and the actors approach. In addition to these you can divide the examiners into those who seek to explain reality and those who seek to understand it. These two groups are commonly named positivists and hermeneutics. The figure below is a guide to how the different approaches relate to each other.




### 3.2.1 Analytical approach

The analytical approach means that a result can be seen as a sum between the parts it consists of. If the examiner can find all parts that will sum up to the result it is possible to sum these parts and get the solution to the task (Arbnor and Bjerke 1994, 65-66).

The approach is presuming that reality is independent. The examiner strives to distinguish objective and subjective facts and only take the objective facts into consideration. Things that are invariable are seen as more true than those that change according to the environment around them (Arbnor and Bjerke 1994, 97).

An illustrative example of the analytical approach can be described as a football team where the coach forms the team by selecting the players that are the best at the time in each position. No consideration is taken to how they cooperate with each other; only their current form is considered (Arbnor and Bjerke 1994, 66).

### 3.2.2 Systems approach

The systems approach is different from the analytical approach in the way that the sum of the parts does not add up to the solution. The reason is the synergic effects that exists between the parts, when you add the parts up the sum might be larger or smaller than the expected sum i.e. 1+1=3 (Arbnor and Bjerke 1994, 67).

If we yet again refer to the football example the coach would choose the team where the players that, when playing together, adds up to the best team available at the moment. Therefore some of the best players can be left out of the game because they cannot cooperate with the others (Arbnor and Bjerke 1994, 67).

According to the systems approach the examiner can use the entirety to explain and understand the parts of it (Arbnor and Bjerke 1994, 67).

### 3.2.3 Actors approach

The actors approach means that the characteristics of the parts are used to understand the entirety. This approach works out of the social aspects of the issue. In the same environment different actors can experience the solution differently. A system of this type is said to be owned by the examiner and she can put her own values into it.

Back to the football example once again; if the coach chooses the team by doing reviews with the players and choosing those that are highly motivated or has something to prove and therefore can be considered to do his best in the game the actors approach is chosen. Another coach could choose an entirely different team because he might evaluate the players’ motivation in another way.

### 3.2.4 Positivism and hermeneutism

There is a significant difference between those examiners who seeks to explain the reality and those who seeks to understand it. The former are usually called positivists or explanatics and the later are referred to as hermeneutics. The positivists decline that there is a difference between nature and society sciences. If one method can be used on nature science it can be used on society science projects without any changes (Arbnor and Bjerke 1994, 62-63). Positivists would like all hypothesis and theories to be described as mathematical formulas and that the research should be performed according to the hypothetic-deductive model. That is that the research should start with the theory and test the theories with empirical methods (Patel and Davidsson 1994, 24). Positivists work on the principle of reductionism which means that the problem can be divided into many smaller problems that can be solved independently to find the solution to the original problem (Patel and Davidsson 1994, 23). This is a very clear connection to the analytical approach discussed earlier. Another important thing is that the examiner is interchangeable and another examiner can take over in any phase and the result of the study would be the same (Patel and Davidsson 1994).

The hermeneutics on the other hand consider the methods used in nature science as totally unsuitable in research for social sciences (Arbnor and Bjerke 1994, 62-63). The hermeneutics seeks to understand the problem and approaches the problem with subjective thoughts in mind. The examiner tries to find connections between the entirety and the different parts. By approaching the problem from different angles they find an understanding about the problem (Patel and Davidsson 1994, 26-27).

### 3.2.5 Our approach

In this study the systems approach has been used. The reason is that we believe that in this study the interactions between different parts of the supply chain are important. The discussions in the beginning of the study showed that the interactions between the different parts are very important and a small change in one factor can change the whole supply chain drastically. By using the systems approach both the understanding and explaining knowledge can be used. The use of both these approaches is important as the thesis will be carried out both through studies of computer material from the ERP system and from dialogs with personnel at Nynas.

## 3.3 Research approach

To produce theories the examiner needs to relate it to reality, the empirics. There are two ways two connect these two, deduction and induction.

Deduction is also called the proving way. When taking this path the examiner use general theories to prove a hypothesis. He uses theory as a base and then tries to apply this on the hypothesis. If the assumptions are correct the hypothesis is proved and can be used to build the theory. If the examiner chooses to precede his work according deduction it comes with a focus on the working method base (Patel and Davidsson 1994, 20). Induction on the other hand is called the discovering way. In this case the examiner uses separate events to assign a theory. The examiner finds the information that he wants to collect and examines the data and constructs a theory according to this.

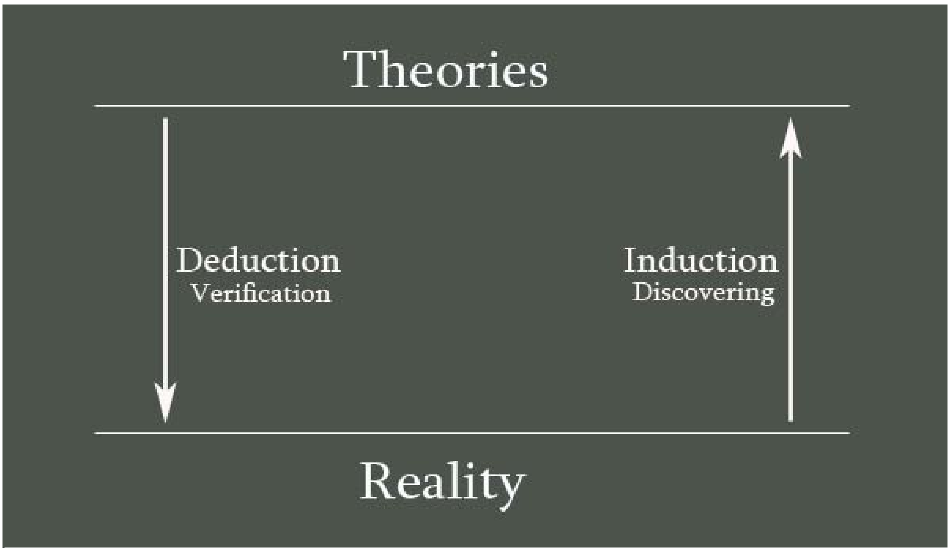



**Figure 3 - Picture of the relations between theory and reality (Patel and Davidsson 1994) modified by the authors**

When using the inductive way the work is not as focused on the method as it is when using deduction. In this case the answer the examiner is giving to his or her problems is in focus. The scientific quality of the work depends on the patterns which are traceable in the gathered information (Patel and Davidsson 1994, 20-21).

### 3.3.1 Our approach

The research approach used for this study is the abductive approach. When using abduction you can shift between different levels of abstraction as the master thesis work is evolving (Björklund and Paulsson 2003, 62). In our case we will start by study reality to get an overview of the situation and the problem. After that we'll study theories to see which ones that can be used and then we will gather actual data to build our model with the theories in mind. As the simulation model grows the connection between the empirics and the theories will be regarded at all levels.

## 3.4 Data gathering

### 3.4.1 Validity and reliability

In what extent the measurements have been concluded accordingly to the chosen subject is called validity. If the study can be performed again with the same instruments and still obtain the same results the reliability is said to be high (Björklund and Paulsson 2003).

A simple illustration of validity and reliability can be seen in Figure 4. The leftmost illustration shows an example with both low reliability and low validity. The spread is large and the accuracy is bad. The middle figure shows an example with high reliability but low validity. In this case the spread is small but the accuracy is still bad.

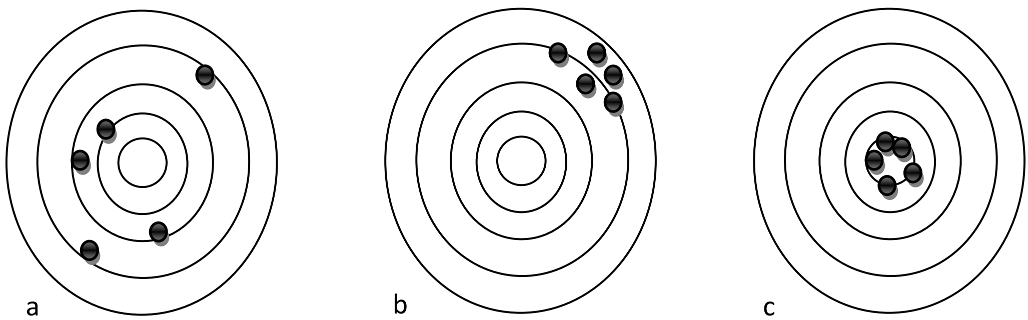



Figure 4 - Illustration of validity and reliability (Björklund och Paulsson 2003)

The rightmost illustration shows an example with both high validity and reliability. In this case there is a low spread and good accuracy.

A way to increase the validity of a study is to make questions in questionnaires as objective as possible.

To increase the reliability of the study the examiner can use multiple methods that all shows the same results.

### 3.4.2 Qualitative and Quantitative data

Quantitative data gathering is performed through searches in databases and ERP systems to find for example sales data over time, volumes, profit, and so on. As the company's auditors verify the data it can in most cases be seen as objective and trustworthy. The data represents actual events in the company's history.

Qualitative data is collected through interviews or questionnaires with people with knowledge of the subject. This often gives a deeper understanding of a specific subject or situation (Björklund and Paulsson 2003, 63).

There are several important issues to consider when collecting qualitative data. People tend to be subjective by nature and in order to decrease this bias it is of great importance to do several interviews with different people to confirm details and double-check facts. By doing multiple interviews the information can be confirmed and viewed as reliable. When making an "eye-to-eye" interview the interviewer can also read the body language and get additional information out of that (Björklund and Paulsson 2003, 70). When an interview guide is designed the interviewer must consider that the questions are not leading in any way. The interview guide must be neutral and objective of its nature to give the interviewee a chance to answer as correctly as possible.

# 4 Theory

## 4.1 Inventory management

Inventories are held in all parts of the supply chain from raw materials, work in progress to finished products. There are several reasons to hold stock i.e.

- Create buffers against uncertainties in supply and demand
- Transports of larger volumes can be done at a lower cost per item
- Producing large batches gives a lower production cost per item

To be able to minimize the inventory levels there are several functions where uncertainty needs to be minimized. Forecasts must become more accurate, sales information and forecasts should be shared with suppliers, production variation should be reduced, and the differentiation of products should be moved downstream in the supply chain. Although these steps are carried out there might still be substantial uncertainties left in the system. All uncertainties can never be entirely reduced and inventories will be required as a buffer for these. Holding costs, shortage costs, replenishment delays and probabilistic demand distributions for products are all parts of the inventory management problems (Shapiro 2001, 477-478).

## 4.2 Inventory costs

To understand how the different ordering systems work it is necessary to have some basic knowledge about the cost associated with holding stock and transporting goods. The reason why you cannot hold infinite stock is quite clear; the capital tied up in stock could be better utilized in other ways. Then we need to know how to find the optimal stock level. The optimal stock level is the level at which customer satisfaction can be guaranteed at a minimum cost. Generally you consider three costs when you determine the size of your inventory. These costs are; holding costs, ordering costs and shortage costs (Axsäter 2006, 43-46).

Holding costs are costs related to the physical holding of the products. It includes for example warehousing, material handling, damage and insurance. These costs are all variable costs and are closely tied up to a separate unit of the product. Fixed costs that do not origin directly from the products should not be considered (Axsäter 2006, 44).

Ordering costs on the other hand are costs that can be directly associated to a single replenishment order. This cost is fixed no matter how big or small the order is. Examples of ordering cost are filling out order forms, receiving, and handling of invoices (Axsäter 2006, 44-45).

Shortage costs are costs that occur when a customer have ordered a product which cannot be delivered to him on time. These costs are difficult to estimate. The customer can choose either to wait for his order to arrive, which would cause the company small or no shortage costs depending on if the customer is still satisfied. The customer might also choose another supplier and might not return. These costs are not tangible and could for example be loss in good will, which is very hard to estimate a price on. Service levels are often used as a substitute for shortage costs. Even if these are not easy to put a price on they are often more straight/forward than shortage costs (Axsäter 2006, 45).

## 4.3 Ordering systems

In ordering systems the physical stock level is not the only thing to consider before sending a replenishment order. To know when and how much to order you must know how much has already been ordered and is on route between supplier and warehouse. These are called outstanding orders. Another issue to consider is the backorder log i.e. the number of orders that have been placed but not delivered. When you put these three aspects together you get the inventory position according to the following formula (Axsäter 2006, 46):

$$inventory\ position = physical\ stock + outstanding\ orders - backorders$$

Holding costs and shortage costs however are derived out of the inventory level (Axsäter 2006, 46):

$$inventory\ level = physical\ stock - backorders$$

There are two different ways to investigate the inventory levels; continuous review and periodic review. If continuous review is used it means that the inventory level is updated continuously and orders are made as soon as a certain level is passed (this level is called the reorder point, R). When an order is laid the time until the products are in stock is called lead time and often denoted L.

Periodic review means that the inventory level is read at certain predetermined interval (the interval is denoted with T). This means that the reorder point, R, must be slightly higher than on a continuous review system because the review period is added to the lead time as an uncertainty. Periodic review is mainly used on articles with high demand and is also preferred when synchronization of orders is required. Continuous reviews are best applied on articles with low demand due to the costs of running an inventory control system (Axsäter 2006, 47).

One of the most commonly used ordering systems is the (R, Q) system. The basic principle is that when the inventory position sinks below a certain point, R, the quantity Q is ordered. If demand between the inspections is higher than anticipated it might be necessary to order a quantity n*Q to get the inventory position to a point above R. If a continuous review system is used the inventory position will become R+Q when an order is triggered. If a periodic review system is used it is likely that the level R+Q will not be reached as the inventory position at the time for review often will lie below R.

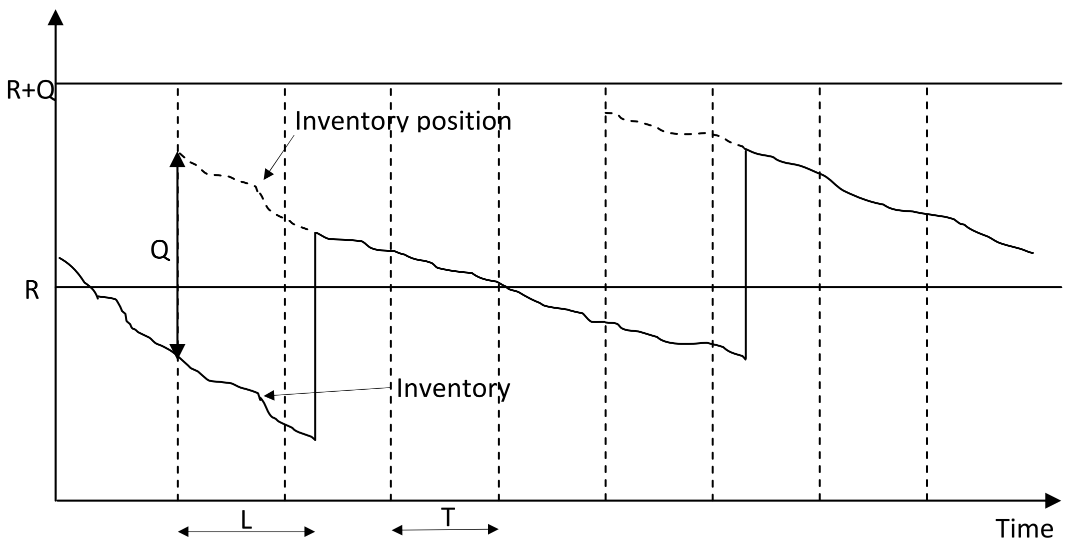



Figure 5 - (R, Q) policy with periodic review (Axsäter 2006, 48), modified by the authors

Another commonly used ordering system is the (s, S) policy. In contrast to the (R, Q) policy, the ordered quantity is not fixed. When the inventory position drops below the reorder point, s, an order is triggered that set the inventory position to S. No matter how far below s the inventory position is the order-up-to level is always S. If continuous review is applied the (s, S) and (R, Q) policies perform similarly. With a small modification on the (s, S) policy we can achieve the S policy or base stock policy. In this policy there is no reorder point but orders are triggered up to S at every inspection as long as the demand during the time between reviews is greater than zero (Axsäter 2006, 49-50).

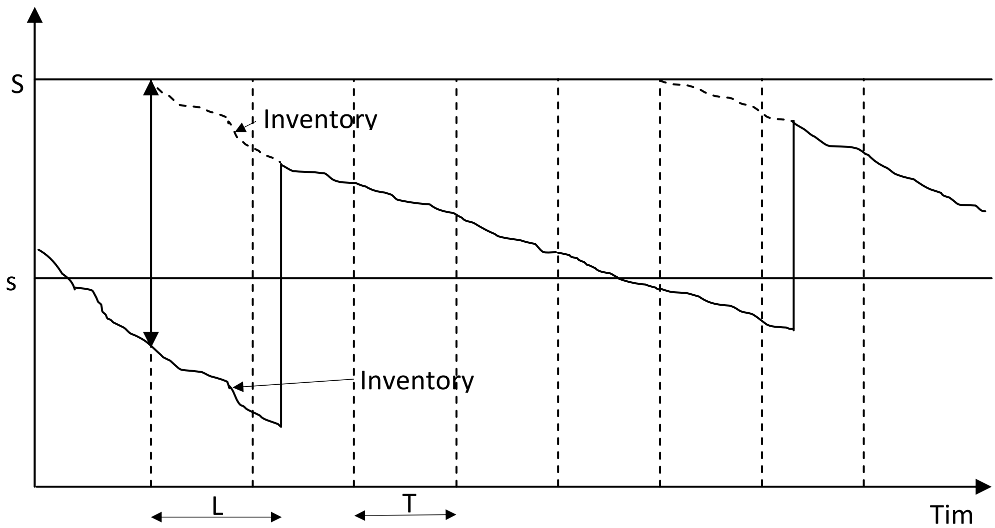



Figure 6 - (s, S) policy with periodic review (Axsäter 2006, 50), modified by the authors

## 4.4 Service levels

Service levels are a quite easy way to determine reorder points or safety stocks. Three different definitions are usually considered S1, S2 and S3.

S1 is calculated as the probability that there are no stock-outs during an order cycle. That is the probability that a replenishment order arrives before the inventory has gone empty. This is the simplest variation to the service level definition but also the one with the most uncertainty. Depending on size of the ordered batches it can give probabilities that are not even close to the actual service level. With a small batch size it is easy to overestimate S1 and with large batch sizes it is easy to underestimate it (Axsäter 2006, 94-95).

S2 is the fraction of time when orders can be delivered immediately from stock and is also called “fill rate”.

S3 is called “ready rate” and is the fraction of time when the physical stock is larger than zero. These two service levels are the same if the demand is continuous or Poisson distributed. Although this is not true if customers orders several units per order, as stock on hand can be positive but still the order can be larger than the sufficient stock. (Axsäter 2006, 94-95).

Demand often grows rapidly as service levels increases from a low level. Although, as service level comes closer to 100% the demand is not increasing as much. This can be seen as the S-shaped curve in Figure 7. In most markets a certain service level is required to be able to collect market shares. This can be seen as the lower left part of the S-curve, as this level is passed demand increases up to a level where the marginal utility starts to decrease and the curve flattens out. As this happens demand will not rise with the same intensity as before this level was reached (Mattsson, Effektivisering av materialflöden i supply chains 2001). Where this level is situated is linked to the service levels of the competition in the market. The conclusion is that a company should strive to maintain a service level that is slightly

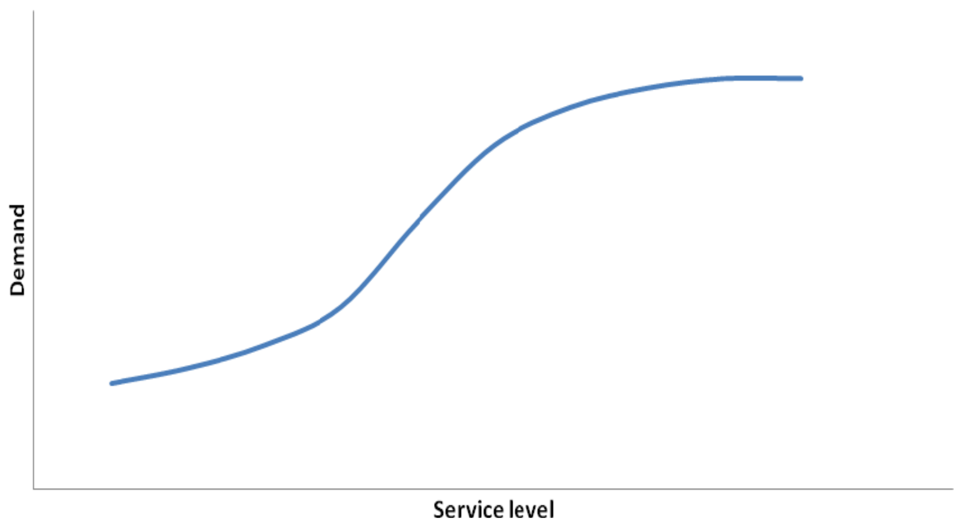



**Figure 7 - Connection between demand and service level (Mattsson, Effektivisering av materialflöden i supply chains 2001)**

higher than its competitors.

The cost of increasing service level is higher as the service level comes closer to 100%. The cost of increasing service level is not linear as the service levels rise. This is linked to the cost of the tied up capital in the system, which is increasing faster as service level comes close to 100%. A visualization of this can be seen in Figure 8. The optimal service level would be the one where the difference between the benefit of the service level and the cost of that service level are at its maximum.

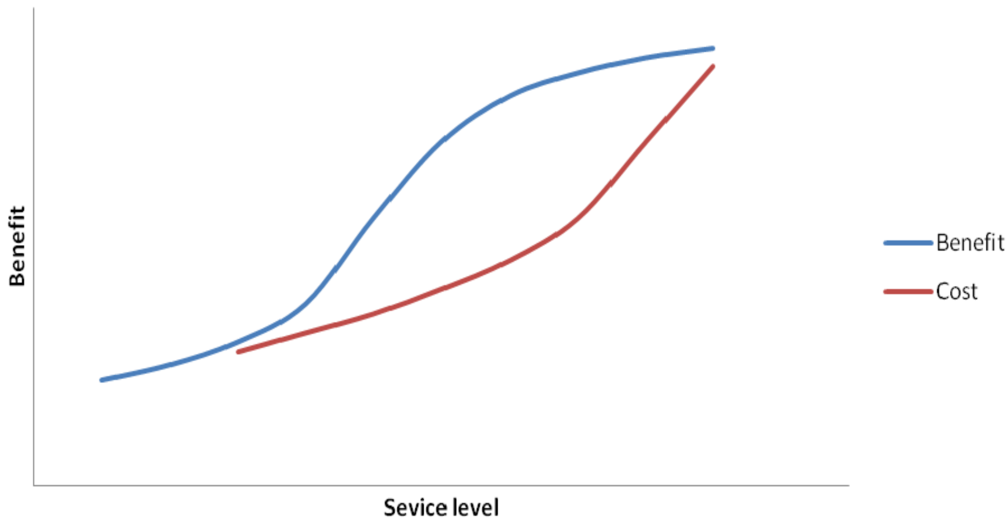



**Figure 8 - Costs vs. benefit of increased service level (Mattsson, Effektivisering av materialflöden i supply chains 2001)**

## 4.5 Transport and carrying devices

Transport of physical goods are conducted in four different ways; sea, rail, road, and air. For each and one of those there are several different types of vehicles that can carry the goods. For example can road transports be carried out by large trucks, small cars, and in many other ways (Mattsson och Jonsson, Logistik - Läran om effektiva materialflöden 2005).

Different types of transportation have different characteristics, which makes them suitable for different types of goods.

### 4.5.1 Boats

Vessels are the most commonly used transporting device for bulk products on long distances. The only competitors on long distances are pipelines and railway. There are pros and cons with the different methods. Vessels have the disadvantage that they only can ship products where there are harbors to unload oil in. On the other hand are pipelines and railways expensive to build and hard to change once they are built. Tankers also have an advantage that they can be used on different routes around the world whereas pipelines and railways are fixed to where the infrastructure is built. Vessels have the lowest cost per ton km in almost all cases (Mattsson och Jonsson, Logistik - Läran om effektiva materialflöden 2005).

A ship takes approximately 20 hours to load depending on the pump equipment in the harbor and the number of different compartments that are used in the boat. When unloading, the boats own pumps are used and in most cases the unloading takes longer time due to lower pump capacity on board. In general the unloading procedure takes twice the time of the loading procedure.

### 4.5.2 Trucks

When it is time to send oil out to customers, trucks are usually the best choice. Their flexibility is the main advantage and customers can get the oil to the exact locations they want it. Truck transports can be used for almost all goods but tend to have a cost disadvantage against rail and sea transport as it comes to low value goods. Another disadvantage that often is discussed today is the environmental issues compared to rail freight (Mattsson och Jonsson, Logistik - Läran om effektiva materialflöden 2005). The capacity of the trucks is between 22 and 28 tons depending on how they are equipped.

## 4.6 Drums and containers

Before the introduction of tank ships, barrels were the most common way to transport oil. Still the 42 US Gallon barrel is the main pricing unit of crude oil in the market. Drums are nowadays used as carriers when there are no other ways of storing liquid material or if they are transported to remote locations where smaller amounts of oil is needed. The most common size of drums today is 208 liters (55 US Gallons). Oil storing barrels made of steel is most common. In some cases plastic barrels might also be used. Often the barrels have ribbings on the outside to strengthen them against pressure damages.

# 5 Empirics

## 5.1 Mapping the Nynas supply chain

This thesis is concentrating on the third part of the logistic pipeline, the distribution (see Figure 9). The two preceding parts are not included. Even though they have a large impact on the Supply chain performance as a whole it is not desirable to include them in the simulation model. The reason for this is that the disturbances generated further up in the supply chain would make it harder to evaluate the distribution part. In order to compare scenarios it is important to keep the prerequisites equal among the scenarios. In this case all activities concerning crude oil purchase and transportation as well as the refining process are left out. The distribution in this case begins with transportation of products from the production facilities.

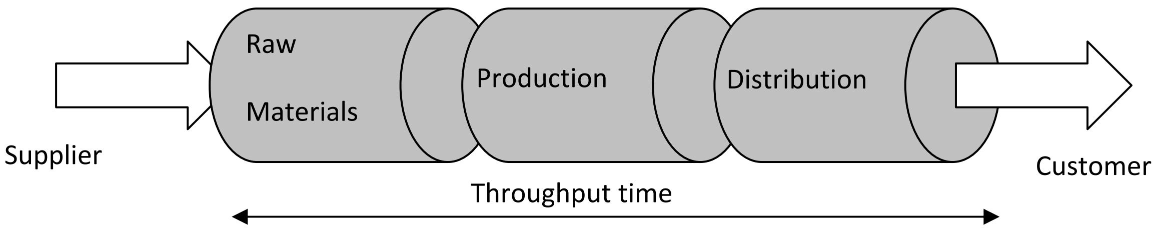



Figure 9 - Logistic pipeline

There are two major components that affect the performance of the distribution. First we have the physical layout of the distribution system. Secondly we have the different activities in the distribution system.

### 5.1.1 Physical layout

All activities in the supply chain are limited by the physical setup of the Antwerp hub. There are limitation in tank capacity, transportation capacity and customer lifting capacity. In order to increase capacity major investments are necessary. Since there is a long planning horizon for such investments the infrastructure will be considered fixed. All activities must therefore be contained within the existing setup. The infrastructure of the supply chain will be investigated in further detail in the data collection chapter.

### 5.1.2 Activities in the supply chain

There are three different concepts that affect the distribution in the supply chain. They all have a direct influence on the service level Nynas can provide for its customers. In order to understand these concepts and their roll in Nynas supply chain each of them will be examined in detail.

- Lead times
- Demand
- Inventory

### 5.1.3 Lead times

Because we only focus on the third part of the logistic pipeline the lead time will in this case be the time between a replenishment orders is issued until it is available to the end customer. In Nynas case lead times can be split down into three components. The first component corresponds to the time it takes for a replenishment order to be loaded onto a vessel. In order to load onto a vessel a ship needs to be present at the quay connected to the refinery. The ship must also have available capacity. If several replenishment orders are issued in the same time span orders might have to be prioritized. This could lead to a situation where orders have to wait for another vessel to arrive. The second part of the lead time corresponds to the actual transportation time between the refinery and the target destination. This time is dependent on the vessels average speed and weather conditions. The third part corresponds to the quarantine time. Even though all components for a blended oil are available it does not mean that the blend is available for the customers. The oil might be stored in order to perform quality testing.

### 5.1.4 Demand

The variation in demand plays a major role in the supply chain. At the Antwerp facility there are two types of demand. There are internal demand, which consists of shipments to smaller depots around the world and external demand, which corresponds to external customers. The demand by external customers is of three types, namely truck, boat and drum lifts. The demand will be examined further in the data collection chapter.

### 5.1.5 Inventory

The third part that plays a major role in the supply chain's ability to maintain a high service level is inventory. In Nynas case inventory consist of several large tanks. This is a special situation since each tank can only hold one product. In an ordinary inventory each product can be stored on shelves independent of what other products are stored around them. Since each tank only can hold a single product it is harder to keep a high utilization of the inventory capacity.

There are two main parameters that affect the average inventory in the system. These are the reorder point and the batch size. These parameters will be examined in the data collection chapter.

## 5.2 Nynas replenishment order system

The responsibility for replenishment orders to the facility in Antwerp lies on the supply chain department in Johanneshov. The main responsibility lies on the “supply planner Europe” who controls oil inventory and is the link between the refineries, the shipping agency, the Antwerp hub, and the sales department.

The main control tool for this job is an Excel-sheet where all Nynas base oils are included. Underlying this sheet is a number of other sheets and calculations. The basic sheet is one where all oils that are being sold by Nynas are included. In this sheet the different sales departments insert their sales forecast for the next three months. The sheet is being updated every month to give better accuracy. The sheet can then be crunched down to the base oils that are produced at the refinery. The sheet is used to see how much base oils that needs to be produced, how much that needs to be transported to Antwerp to avoid running out of stock and when blending of oils are planned.

An example of how an Excel sheet can look like can be seen in Figure 10.

B1451 fx Clipper Marianne

| | A | B | C | D | E | F | G | H | I | J | L | M | N | O | P | Q | R | S | U | V | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Antwerp** | | | | **Nynäshamn to Antwerp** | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | |
| 22 | | | | | | 607 | | | 3 100 | | | | 1395 | | | | | 2 700 | | | |
| 23 | | | | | | **NS 3** | | | **NS 8** | | | | **NS 100** | | | Fill | Fill | **T 9** | | | |
| 24 | | Ship | Sum | Grades | Fill | Stock | Out | Fill | Stock | Out N10XT | Out | Fill | Stock | Out blend | Out | Isla | AWP | Stock | Out blend | Out | Fill |
| 1444 | 07-10-20 | | | | | 20 | | | 1 317 | | | | 1 531 | | | | | 1831 | | | |
| 1445 | 07-10-21 | | | | | 10 | | | 979 | 265 | | | 1 494 | | | | | 1739 | | | |
| 1446 | 07-10-22 | | | | | | | | 906 | | | | 1 457 | | | | | 1647 | | | |
| 1447 | 07-10-23 | | | | | -10 | | | 833 | | | | 1 420 | | | | | **1880** | | | |
| 1448 | 07-10-24 | Amarant | 5 200 | 4 | 300 | 280 | | | 760 | | | | 1 383 | | | | | 1788 | | | 2 500 |
| 1449 | 07-10-25 | | | | | 270 | | | 687 | | | | 1 346 | | | | | 1696 | | | |
| 1450 | 07-10-26 | | | | | 260 | | | 614 | | | | 1 309 | | | | | 1604 | | | |
| 1451 | 07-10-27 | Clipper Marianne | 4 850 | 5 | | 250 | | 1 000 | 1 541 | | | | 1 272 | | | | | 1512 | | | 1 400 |
| 1452 | 07-10-28 | | | | | 240 | | | 1 468 | | | | 1 235 | | | | | 1070 | | 350 | |
| 1453 | 07-10-29 | | | | | 230 | | | 1 395 | | | | 1 198 | | | | 1 000 | 1978 | | | |
| 1454 | 07-10-30 | | | | | 220 | | | 1 322 | | | | 1 161 | | | | | 1886 | | | |
| 1455 | 07-10-31 | | | | | 210 | | | 1 249 | | | | 1 124 | | | | | 1794 | | | |
| 1456 | 07-11-01 | | | | | **256** | | | **1 303** | | | | **1 412** | | | | | **2149** | | | |
| 1457 | 07-11-02 | | | | | 246 | | | 1 229 | | | | 1 375 | | | | 473 | 2539 | | | |
| 1458 | 07-11-03 | | | | | 236 | | | 1 155 | | | | 1 338 | | | | | 2456 | | | |
| 1459 | 07-11-04 | | | | | 226 | | | 1 081 | | | | 1 301 | | | | | 2373 | | | |
| 1460 | 07-11-05 | Stolt Kestrel | 4 904 | 4 | 300 | 516 | | 510 | 1 517 | | | | 1 264 | | | | | 2290 | | | 2 500 |
| 1461 | 07-11-06 | | | | | 506 | | | 1 443 | | | | **1 350** | | | | | 2207 | | | |
| 1462 | 07-11-07 | | | | | 496 | | | 1 369 | | | | 1 313 | | | | | 2124 | | | |
| 1463 | 07-11-08 | | | | | 486 | | | 1 295 | | | | 1 276 | | | | | 2041 | | | |

**Figure 10 - An example of a planning file**

In the next few paragraphs we will explain how the order planning in the Excel sheet works.

The first column is the date and the next illustrates what date a certain boat will arrive. The third column shows how much oil the ship will carry to Antwerp and the fourth is how many different oils that will be on the specific shipment. After this the oil's specific fields come. There are different numbers of fields depending on the oils different supply patterns. The first oil is a basic oil where there are only three fields. The first field represents deliveries to Antwerp. This has impact on the second field, which is the inventory level in Antwerp. This column represents the lifts on trucks and drums and is calculated from the forecast. The third field is where the planner puts the boat lifts when one is planned to come. This also affects the inventory level. When the inventory level is red the planner knows that he must put a delivery earlier to cover demand. He must then check if there are any changes he can do to get a delivery on an earlier boat and if the oil is available at the refinery at the earlier time.

The second oil (NS8) has an extra column where it says "Out N10XT". This column is for planned lifts of an oil that is NS8 only with a small addition of a chemical substance. These are not made as blends but are mixed straight into the transport vehicle of choice.

The fourth oil in the table (T9) has more attributes than most oils have in this planning file. Excessive of those of the first oil it also has fillings from Isla, which represents deliveries from the refinery in Curaçao. In the column after the forecasted inventory there is also a field where lifts for blends are scheduled. When the planner schedules a blend of oil the components required volumes automatically shows in this field for each oil that is included in the blend.

In some cases oil can also have fields for deliveries from other refineries and depots such as Houston and Hull.

The reason that large volumes lifted by boats are handled separately is that they are different from truck and drum lifts in many aspects. The demand for truck and drum lifts can be seen as evenly spread between the replenishments. They are calculated as the monthly forecast divided by the number of available lift days in the month. The boat lifts on the other hand are very irregular in both time between arrivals and order size. The boat lifts are also known longer in advance than the other lifts and can therefore be planed better.

The tricky part in the planning is to make sure that all oils are covered at all times. Nynas current situation with high demand makes this very difficult. Almost all oils are stressed at all times and the planner needs to prioritize between oils in order to make sure the most important oils are delivered on time. In some cases negotiation with customers can be held and it may turn out that they can wait a couple of days extra before they receive the oil. Maybe the customers can receive two smaller deliveries of oil with a few days between the deliveries. If there are no possibilities to change any of the deliveries Nynas might be forced to prioritize between customers. This might be the case for long distance shipments where boats are booked months in advance and there are no possibilities to change the terms. Orders of this kind are always prioritized as the demurrage fees Nynas has to pay if an oil is not lifted to the boat on time are huge. In cases of prioritizing there is a certain risk that a customer feel ignored and Nynas reputation is negatively affected.

The planning of shipments are made in co-operation with the refinery in Nynäshamn and the ship-booking agency Nyship. Flawless communication between those departments is a major component for successful operations.

The refineries inventory levels and production plans are studied continuously to see if oil deliveries to Antwerp have to be rescheduled in order to make sure the most essential oils are shipped. Discussions with the production department can lead to production plan changes that can enhance the performance of the Antwerp hub without making too much impact on the refinery's production yield.

Nyship controls the boats and has full overview over this part of the supply chain. The supply planner checks with Nyship which volumes are booked, how much available volumes there are on the ships and how many compartments that can be used. Nyship also handles the contact with harbors and books unloading and loading slots for the ships. If the supply planner needs more information about departure and arrival times Nyship is the information source.

## 5.3 Data Collection

### 5.3.1 The Antwerp depot

As mentioned earlier in this thesis Nynas have 23 depots worldwide. This master thesis is focused on the Antwerp facility, which is the main hub in Europe. The tanks in the Antwerp depot are leased from LBC, one of the world's largest operators of tank storage facilities for bulk chemical products. Nynas shares the facility with other companies, as they do not have the volumes to fill it up themselves. LBC is responsible for planning and scheduling the depot. Nynas collects orders from customers which are then scheduled by LBC. The same goes for Nynas internal shipments, which must get scheduled lift dates from LBC. There are usually no problems to get slots for unloading replenishment orders arriving to Antwerp. Most of Nynas replenishment orders are shipped on their own boats and they can therefore give LBC information about arrival times relatively long time in advance. The intercontinental shipments are also planned in advance and relatively easy to schedule.

#### *5.3.1.1 Physical equipment*

Currently Nynas is leasing 55 tanks from LBC in Antwerp with a total capacity of about 70.500 $m^3$ (at a filling grade of 95%) which corresponds to about 62.000 tons of oil (calculated with the medium density of 0.88kg/$m^3$). The 95% filling grade is set because of operational reasons. The size of the tanks varies from 180$m^3$ to about 4.000$m^3$. The smallest tanks have a radius of 3 meters and are 6.5 meters high and the largest tanks have a radius of 9.5 meters and are 14.5 meters high. An overview of the Antwerp depot is pictured in Figure 11. The depot area is approximately 97000$m^2$ (570m*170m).

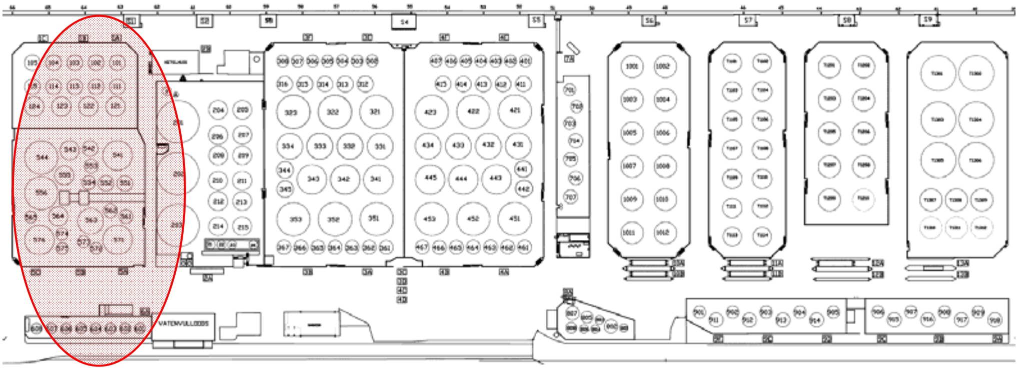


Figure 11 - Drawing of the Antwerp depot (LBC, modified by the authors)

The tanks are divided into different tank farms depending on what quay connection they are connected to, and in some cases if they are able to load onto trains. Some tanks are not connected to a quay and must receive oil by transfers from other tanks. An example of a tank farm can be seen in Figure 11. The tanks marked in red to the left are connected to the same quay connection but only the tanks on the bottom half is connected to train loading. This divides the tanks into two different tank farms. The first digit(s) in the tank number explains which tank farm the tank belongs to.

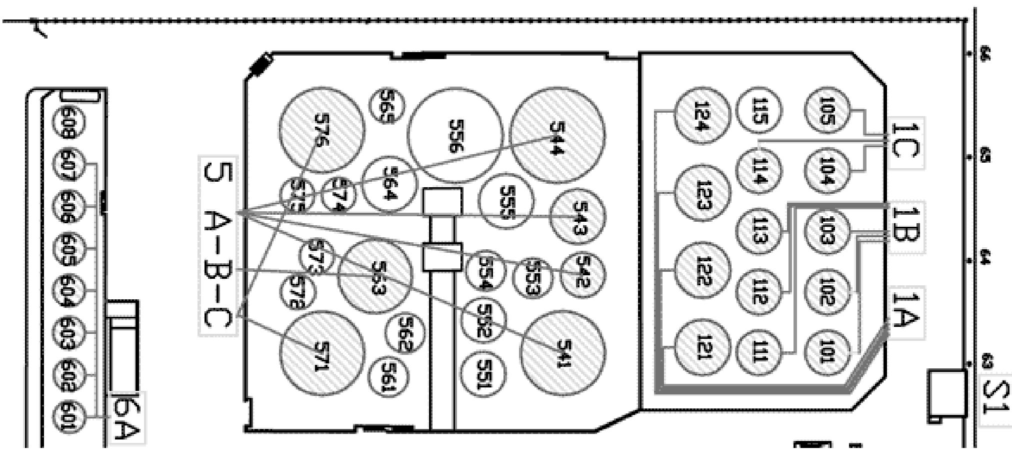



Figure 12 - Three tank farms in the Antwerp layout enlarged

In Figure 12 an example can be seen of how the tanks are connected to their different truck loading racks. More information about these racks follows further on in the chapter. All tanks in the 100- and 500-series are connected to the S1 quay connection for filling of the tanks from vessels. The 600-series are not connected to the quay so they must receive their oil from other tanks or from trucks.

When a tank is filled from a ship the tank is blocked from transferring oils to filling racks and other tanks. This is necessary as the level in the tank is measured before and after the filling procedure to control transferred volumes. If they tap oil from a tank that is currently being filled there are obvious risks that the measuring of volumes would fail. The unloading of a ship takes around 20 hours depending on transferred volumes and pump capacity.

Nynas has access to 19 different truck loading racks for transfers of oil from tanks to trucks and trains. Each tank is connected to one loading rack (some of the very large tanks are not connected to a loading rack), meaning several tanks share the same rack. Nynas shares the racks with other LBC customers and has approximately 10 slots per loading rack and day available. These slots are planned by LBC to in advance to optimize the hub's throughput. Since LBC must take several customers into consideration there are sometimes capacity problems for slots. In these cases some of the orders are kept on hold until there are available slots or, in some cases when transports are urgent, LBC personnel work overtime to allow more trucks to load in a single day.

Some of the tanks are connected to an inline blender which take oils from different tanks and make blends straight into the truck or vessel. In Nynas case this works on the tanks connected to quay connection S1 (see appendix 2 for information). In this case the pumps are reversed and instead of pumping into the tanks they pump out through the S1 connection. The inline blender is used to make blends that are not stored in Antwerp. When a tank is pumping out to the inline blender it is locked from filling trucks and transfer oils to other tanks. The inline blender can serve about 10 trucks for Nynas every day. The total number of possible slots is something LBC does not share with its customers.

Nynas also has the option to drum oils from some of the tanks in the facility. They have currently 26 tanks available for drumming operations of which 6 are transfer tanks that is almost exclusively used for drumming procedures. These six tanks are the smallest in the facility and the reason they use small tanks for the drumming is that they, by transferring oil to these tanks, are able to avoid locking large tanks during the drumming process. These six tanks are not connected to any quay line and can only receive oil by transfer from other tanks via pipelines or trucks. There are two lines for drumming in the facility, each with a capacity of 400 drums a day which corresponds to about 73 tons oil per day and line. Nynas also keep a stock of drums on certain oils, in order to offer a high service level to its customers. The batch size when making new drums are fairly high since long setup times are associated with the change of oils in the drumming process.

Different tanks are also differently equipped when it comes to heating and insulation. Some of the oils require heated tanks to remain at a viscosity that can be handled by the pumps in the system. The heating consists to one part of heating coils in the tanks and to the other part of insulation in walls and roof of the tanks. Some tanks are only equipped with heating coils and no insulation. It is of course more energy consuming to warm a tank without insulation than one with insulation. Measuring tank levels are made either by radar or a servo in the tank.

## 5.4 Operations in Antwerp

### 5.4.1 Oil transfers

Almost all tanks in Antwerp are connected to one another through a complex net of pipes over the facility. There are valves and pumps to change directions of flows through the depot. Nynas tries to minimize the transfers due to costs.

### 5.4.2 Blending stored oils

There are currently 9-15 products that are being blended and stored at the depot in Antwerp (depends on at which point in time the system is examined). Blends of these oils are done once the oil reaches a certain reorder point or if the responsible planner sees an upcoming increase in demand.

When a new blend is ordered the first thing is to identify a tank to process the blending in. Often a large tank is chosen. Nynas tries to make the blends in large tanks to minimize the number of laboratory tests and to avoid locking too many tanks at the same time. Before the blending procedures start any oil in the selected tank is transferred to other tanks. Because the cost associated with transferring oils Nynas tries to match arriving boats with making blends. It is preferable to transfer the volume directly from boats and not take the detour via another tank. Some ingredients that are only needed in small quantities are transferred from other tanks in Antwerp. If the volume is really small LBC often use trucks to transfer the oil internally.

Once the blend is made it is quarantined. This locks the tank for lifts until the oil is tested. In some cases it is just a day to make sure that the ingredients are dissolved into each other or in the worst cases 23 days. These laboratory tests are currently made both in Antwerp and in Nynäshamn and are made to ensure the quality of the blend in terms of corrosiveness, flame point and other important oil specific criteria.

### 5.4.3 Inline blending

Inline blended oils are not stored as ready blends but are blended directly when the demand arises. The inline blender works by connecting a large number of tanks via an intricate pipeline system. This setup and special equipment for measuring volumes while pumping gives the filling station S1 the ability to make blends directly into trucks.

The main benefit with this approach is that you can create a large number of products from a relatively small number of tanks. The downside is that the blending operation is time consuming and costly.

The demand for inline blend oils, are not as in the former case with stored blends, depending on stock levels but on the actual demand from customers. When an order is received on an inline blend it goes down to the planning office at LBC that plans the slots at the truck loading station. Once the truck arrives at filling station S1 the process of pumping oil starts.

### 5.4.4 Truck loading

The truck loading is performed on the 19 truck loading racks. The most common sizes of trucks are around 23 tons. Often there are several different compartments in the truck which enables the truck to transport several different oils on a single trip. A trailer can also be attached to enhance the loading capacity. The slot system is based on that one truck compartment is equal one slot. This means that every compartment of a truck takes one loading slot. Of the total loading time the connection time is the same whether a tank is filled with 5 or 25 tons and the actual "filling time" is relatively short compared to the connection time. Filling time of a regular truck is about 10-12 minutes.

## 5.5 Nynas ships

At the moment Nynas charters two ships full time for transports of naphthenic products and distillates. Distillates are commonly shipped to Nynäshamn on return trips from Antwerp. Naphthenic products are transported from Nynäshamn to

Antwerp and from Antwerp to other depots in northern Europe. Transports outside Europe and to the refineries in Eastham and Dundee are contracted through Nynas own ship agency called NyShip. NyShip is located in Johanneshov and has responsibility of booking of ships.

The two chartered ships are on so called time charter which is a long-term obligation from both the owner of the vessels and Nynas.

Figure 13 – Amber and Amarant

The smaller of the two ships, Amber, has a capacity of 4600 tons of oil. The larger ship, Amarant, has a capacity of about 6500 tons.

The ordinary route is to round Denmark and then head south to Antwerp. In case of strong winds in the Northern Sea the Kiel Canal can also be used.

The two vessels have similar cruise speeds. This made it possible to create a distribution that could be applied to both ships. The distribution for transportation times was created by reviewing historical data in Nynas ERP-system. All boats arriving to Antwerp from Nynäshamn under a 15 month period (2006-01-01 to 2007-03-31) were examined. The average transportation time was 4.08 days. An empirical distribution was created to describe the transportation times. No data was available for times between Antwerp and Nynäshamn but there is no reason to believe they should differ noticeably, even though they carry less cargo on return trips.

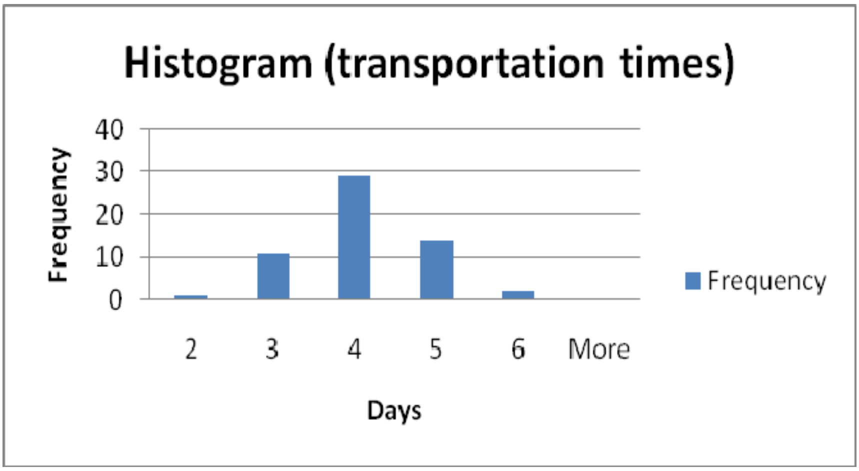



Figure 14 - Histogram over transportation times

Table 1 - Empirical distribution

| days | percentage |
|---|---|
| 2 | 1,75% |
| 3 | 19,30% |
| 4 | 50,88% |
| 5 | 24,56% |
| 6 | 3,51% |
| 7 | 0,00% |

## 5.6 Demand

The demand at the Antwerp hub could be separated into three different types. First we have demand acquired by trucks. These orders occupy loading slots in order to be fulfilled. Demand for containers that are filled in loading stations but transported by ship or rail cars also belong to this group. The second group is orders acquired by ships. These are usually large volume orders and are transported in the ships internal tanks. The third type is drum orders, which include all orders lifted in drums. Drums may then be transported on trucks, railcars or ships.

Nynas supplies approximately 100 different oils from Antwerp. In order to narrow down the number of products, oils with a low yearly demand (under 100 tons/year) were removed. This reduced the number of oils significantly but less than one percent total volume was removed. In order to reduce the number of products even further, oils with relatively low demand and similar recipes was grouped together. Two groups, called BT Group 1 and BT Group 2 were created. Each group consists of five to six BT oils. A new weighted recipe was calculated for each group. After this reduction approximately 40 oils remained.

To gather demand data a new module of Nynas ERP system was used, ICE (inventory control excellence). Due to the change in product portfolio and production problems after the maintenance stop in Mars only the last three months (August – October) could be used. Data for earlier months was not representative and would be misleading. It would have been desirable to use a more extensive data material but it was not possible due to the factors mentioned above. The aggregated volume for the three months period adds up to 113.000 tons. This implies a yearly volume of approximately 450.000 metric tons, which is in line with Nynas own prognosis. Out of the total volume roughly 42% are ship orders, 52% truck orders and remaining 6% are drum orders. The lifted volumes from Antwerp during this period can be seen in Figure 15.

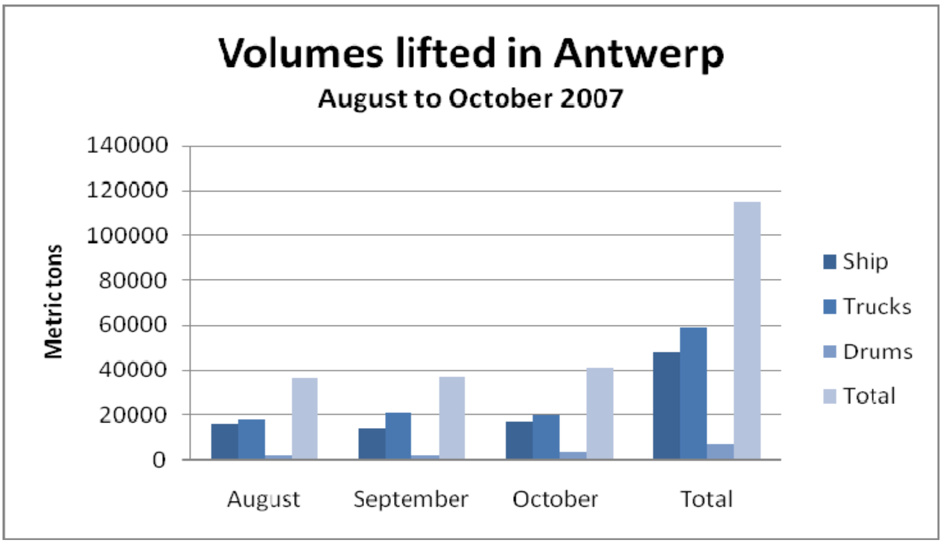



Figure 15 - Monthly demand in Antwerp

The demand had to be separated into two parts, namely number of orders per day and order size. This was necessary because the capacity limitations in Antwerp were both on volume and on number of served orders.

After the demand was split, suitable distributions to describe the frequency and lot sizes were tested. This was made both manually by eyeballing plotted histograms and by using the software StatFit. Neither method identified any suitable distributions that could be applied to all oils. Since no good match was found the use of a general distribution was abandoned.

Instead an empirical distribution was created for each oil and demand type describing the number of orders each day. The empirical distribution was created by calculating the number of days with zero, one, and two orders and so on. This numbers were then divided with the number of days in the period (for the truck and drum orders only weekdays was added). Since no suitable distribution for order sizes were found we decided to sample the historical data and in this way create random order sizes. This would give us an accurate mean and standard deviation.

Because no generic distribution was found we decided to use Excel to feed data into the simulation model. This have two clear advantages over incorporating the data directly into extend. The first and most important is that it will be much easier to get an overview and change the data. Secondly the data can be reused, meaning that different tank setups can be tested with exactly the same demand.

To make it easy to create new sets of input data a VBA (visual basic) script was created. The script uses three different sheets as input, namely truck data, drum data and boat data. Each sheet contains two parts; the first contains the empirical distribution for each of the 50 oils that are used in the model. The second part contains all orders that occurred during August to October.

When the script is initiated it creates 1.500 data points for each oil and demand type using the empirical distributions. Each data points represent the number of orders for a specific day. Then the script creates 30.000 data points for each oil order size and demand type by sampling (randomly picking numbers from a data population) the order size data.

The generated data have means and standard deviations that are very accurate if compared to the base data.

### 5.6.1 Truck lifts

Truck orders is the largest demand group in Antwerp both measured in volume and in number of lifted products. The truck orders are fairly homogeneous in terms of size, because trucks have standardized loading capabilities. The average truck order is around 19 metric tons and roughly 11000 trucks arrive at the Antwerp hub every year.

Truck orders only arrive at weekdays as the loading stations are kept closed over weekends, mainly because the cost associated with personal working over time.

After drum and ship orders were sorted out from the ICE data the remaining truck orders were split down to oils. Then the data were split into two components, first number of trucks per day and secondly order size. Among the data material there were orders with volume over 26 tons. This depends on the way order information is collected in ICE. Individual trucks are not recorded but orders are, so an order for 70 tons is actually collected by three trucks. This is a result of the largest trucks are only capable of transporting approximately $30m^3$ (approx. 26 tons of oil). All truck orders larger than 26 tons were split down into several smaller parts in the following manner. The order was first divided into two equal parts, if the parts still exceed 26 tons the original order was split into three equally large parts instead. This procedure was repeated until the parts fall short of 26 tons. We were able to split orders because we did not take in consideration specific orders but trucks. Service levels are also measured on trucks, not order.

When the data was split down into oils and number of trucks per day an empirical distribution was created for each oil. An example of a table of this kind can be seen in Table 2. A separate list of all order sizes was also created.

**Table 2 - Example of empirical table (T400)**

| nbr of orders per day | share |
|---|---|
| 0 | 0,333333333 |
| 1 | 0,393939394 |
| 2 | 0,181818182 |
| 3 | 0,045454545 |
| 4 | 0,045454545 |

### 5.6.2 Boat lifts

Boat lifts is the second largest demand group measured in volume although only ten different oils are lifted by boat. The boat orders are generally large, ranging from almost 4.000 metric tons to 100 tons. Each year approximately 400 ship orders are carried out in Antwerp. The ship orders arrive seven days a week and are served on weekends as well. As for truck orders the demand was split into orders/day and order sizes. An empirical distribution and a separate list of order sizes were created for each oil.

### 5.6.3 Drum lifts

Drum order is the smallest demand group in Antwerp. The aggregated yearly volume is around 25.000 tons. Most of the drum orders are for standard barrels (D1182); they have a capacity of 0,182 cubic meters. This means that around 140.000 barrels are lifted each year. The drum order sizes have large standard deviations and ranges from a handful to several thousands.

As for the other demand types an empirical distribution and a separate list of order sizes were created.

## 5.7 Oil data

The characteristics for the approximately 40 oils remaining after the cut were collected. The oil's density is needed to determine what quantities can be stored in a specific tank since tank capacity is measured in cubic meters. Some oils also need tanks with heating capabilities because they have a high viscosity, which complicates pumping procedures. This is especially true during the colder winter months. Recipes for blended oils were collected from the ERP system.

### 5.7.1 Base oils

Oils that are not blends between several components are called base oils. Nynas produces around 17 base oils at their own refineries. Some of the base oils are sold as they are whilst others are almost exclusively used in blends. Nine of the base oils are produced in the refinery in Nynäshamn. These nine oils have sales volume form Antwerp on ca. 150.000 tons in their pure form and an additional 215.000 tons in blends. This means that these nine oils stand for over 80% of the total sales volume in Antwerp.

The 11 oils produces at Nynas refineries in Huston and Curaçao accounts for 11% (~50.000 tons) of the total sales volume. These oils are mainly used as components in blends.

### 5.7.2 Blend oils

All blended oils are mixed in Antwerp and most of them are stored in blended form while others are only available through the S1 filling station. The supply manager at Nynas uses a separate excel sheet to plan these oils. When the oil inventory reaches a certain level the supply chain manager triggers a new blend. As mentioned earlier the needed volumes of base oils to complete a blend are automatically put into an Excel sheet like the one in Figure 10 as he approves a new blend in the blend sheet.

Among the blended oils the new Nova oils stand for the largest volumes. Of the total volumes sold in Antwerp, Nova oils stand for about 38% (~170.000 tons). This is also the segment that is assumed to grow the fastest in the next few years as it is in the growth phase of its product life cycle. The growth rate is estimated to be 20% per year.

Another segment with a large market potential is the tyre oils. These oils are at an introduction phase and are at the moment being tested by manufacturers. This could potentially be an enormous market for Nynas and help them meet their goal of an annual growth rate of 20%.

# 6 The simulation model

## 6.1 Extend overview

The model was built using the simulation tool Extend. In Extend you create dynamic models from included building blocks. Each block represents a part of the process being simulated. To make the model easier to work with blocks that together create a function are encapsulated into hierarchical blocks.

There are three main types of building blocks in Extend, discrete event blocks, flow blocks and generic blocks. The discrete event blocks are used to model all events that occur at an instance in time. All events are represented as a chronological sequence that is handled in order. There is a built in clock that keeps track of the simulation time, and it jumps to the next scheduled event.

The flow block works in a different way; they do not rely on the simulation clock to jump to the next scheduled event but instead take place over a period of time. The benefit with this approach is that it is a much faster way to simulate for instance oil flowing from one tank to another. It is faster because in order to simulate this in a good way with discrete event simulation you would have to split the volume into a large number of pieces (more pieces will give better precision). Then you would need to queue up all pieces and send them to the next tank with a small delay, all this to make the level of the receiving tank rise as the other tank is emptied. This forces the simulation scheduler to create a large number of events which all takes time to execute.

The generic blocks are used to make calculation and decisions based on values. In addition to these there is a separate library which can be seen as generic block used to control a built in database. This database is used to store information that is needed throughout the model.

In order to make the model run as fast as possible both flow and discrete event blocks were used.

## 6.2 Concept of time in the model

The model simulates one day at a time, which means that it is not meaningful to study a specific day to determine in what order activities take place. Because the model simulates whole days all measurement including waiting times, service levels, lead times etc. will be in entire days.

## 6.3 Simulation order

In the model each day is divided into several sections. In each section all activities covering a specific function, for example truck loading or drumming take place. In this way it is assured that the different activities does not interfere with each other even though they are using the same resources.

In the first section all boats arriving to Antwerp with replenishment orders are agreed to transfer the oil they carry to the tanks. This will trigger the tanks to lock (to simulate that the pumps have limitations in transferred volume per unit of time), for the period of one day, meaning that they can not be used for transfers, truck loading or drumming. If a tank is used for creating a blend the tank is locked for an additional time period equal to the quarantine time for the specific oil.

In the second section all orders carried out by boat, both internal depot to depot shipments and shipments to customers are carried out. This operation requires a free tank to be dedicated to this operation for a full day meaning it is locked for other activities. As in the former activity the locking of the tanks is a way to simulate the limitations in pump capacity.

In the third section all drum orders and possible drum rest orders are allowed into the system. The orders are then served in a first come first served manner. Because drumming requires tanks to be connected to the drumming station a minimum of hundred drums are produced at a time. This operation requires a free tank to be dedicated for this task for a full day, locking the tank for any other activities. In this section transfer orders are also performed. If oil needed for drumming is out of stock in all tanks connected to the drumming station but available in another free tank a transfer order is triggered. This order is carried out instantaneously and does not lock the tank. This is because in reality such an order would be scheduled to minimize the impact on the system.

In the fourth section all truck orders and possible truck rest orders are allowed to enter the system. The trucks are served according to a fist come, first serve manner. The orders are one of three main types, base oils, stored blends or non-stored blends. The different order types are sent to a filling station according to a different set of rules. The orders for non-stored blends are all sent to the inline blender. In this station mixtures are produced directly into the tanks of the receiving trucks.

If the order is for oil stored in a swing tank they are in first hand sent to the filling station connected to the swing tank. If it is not possible, orders are sent to the filling station connected to the free tank with the largest volume.

## 6.4 Detailed description of the model

In this chapter a description of the model structure is presented.

All logic in the model can be found in eight different modules. These are

- Replenishment order generator
- Truck demand manager
- Ship demand manager
- Drum demand manger
- Ship loading
- Ship unloading
- Ship manager
- Thirteen tanks

How the different modules are linked together and operating will be explained in the following paragraphs.

### 6.4.1 Replenishment manager

Each of the fifty oils in the model has its own replenishment manager. The replenishment manager's only function is to create a replenishment order when an oils inventory position falls below its reorder point. This is the first event triggered by the model when a new day starts. Replenishment orders for oils that are not stored in Antwerp are rejected since they do not have their own tanks. Replenishment orders for stored blends are somewhat more complex than replenishment orders for base oils.

Replenishment orders for blends starts with the manager identifying the largest tank the oil is stored in. When the tank is identified the replenishment order manager tries to empty the tank by transferring its content to other tanks containing the same oil. If there still is content in the tank after this procedure the manager tries to transfer the remaining oil to swing tanks. Then the manager reserves the tank so two replenishment orders cannot be issued to the same tank. After this step the volume to blend is set to the tank capacity minus the remaining volume. The manager then adds the volume to be blended to outstanding orders for the specific oil. Then the volume is split into its components according to the recipe. After this step the manager checks if the required oil is available in large enough quantities to be transferred directly from a tank in Antwerp. The condition for this is that the oil to be transferred needs to be available in a single tank and the inventory level minus the required volume must exceed the oils reorder point. If any component meets this prerequisite the oil is transferred immediately. Remaining component(s) is then handled as a base oil order with the exception that they have a predefined tank destination.

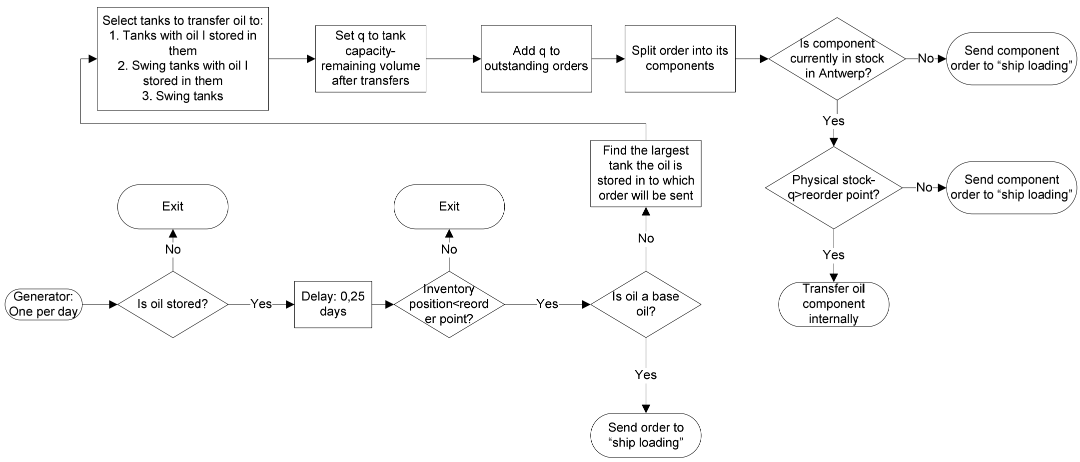



Figure 16 - Flowchart of replenishment manager

## 6.4.2 Truck demand manager

The truck demand manager creates a new set of orders each weekday. The demand data is read from an Excel sheet containing both number of orders per day and order sizes. When new orders are placed they are given a random priority between one and two and are queued up together with possible backorders. This ensures that orders arrive in a random manner when they are released to the filling station. In reality the orders are scheduled so that the number of orders served each day is maximized. This procedure is very complex because the number of slots at each filling station is limited and some oils might be connected to several filling stations while others only are connected to a single filling station.

At time 0.75 on weekdays, orders and possible backorders are released to the filling stations one at a time. The order with the highest priority (i.e. lowest random number in Extend) is released first. Depending on whether an order is for a stored blend, a none stored blend or a base oil the manager choose different paths for the order. Orders for non stored oils can only be served at the inline blender so they are sent to the S1. If there are free slots and all components are available in large enough quantities the order is sent to the inline blender. The components are taken from respective tank and the number of free slots at the filling station is decremented by one. If there are no free slots or some of the required oils are unavailable the order receives a new priority equal 1/(1+nbr of days in the system) and is sent back to the order queue with a delay of 0.5 days. This ensures that the order will not pass through until the following weekday. The reason that we chose 1/(1+nbr of days in the system) was to ensure that they would receive the highest priority (lowest number) as they passed over and over again.

Orders for stored blends and base oils are handled in the same way. First the demand manager identifies if the oil is stored in a swing tank. If a possible swing tank is free and the corresponding filling station has free slots the order is sent to that filling station. If the quantity is large enough to satisfy the order the demanded volume is collected and the order is sent out of the system. If the volume is less than the required volume the swing tank is emptied and a rest order for the remaining quantity is created. Then the backorder is sent back to the order queue again. In this way swing tanks capacity are made available for other products.

If the oil is not stored in a swing tank, the order is sent to the filling station connected to the tank with the largest available volume. By doing so we maximize the number of filling station the base oils are present at. The stored blends are also treated this way because we wanted them to be available at as many filling stations as possible as well.

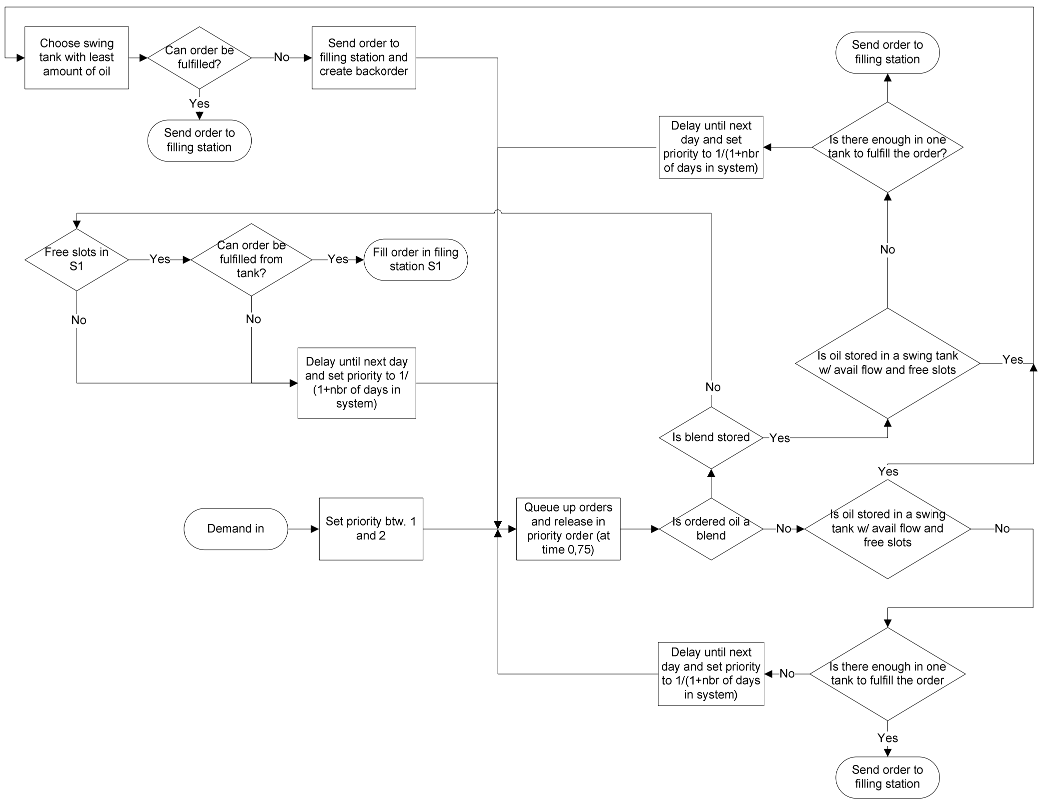



Figure 17 - Flowchart of truck demand manager

### 6.4.3 Ship demand manager

The ship demand manager creates a new set of orders for ship lifts each day. These orders are generated seven days a week as boat orders are handled on weekends as well.

Because ship orders are large volume orders they are scheduled in advance so the volume required can be collected with a minimal interference on the daily operation. To incorporate this behavior in the simulation model all ship orders are included in the inventory position 15 days before they actually arrive. This will add the boat order volume to the oils reorder point temporarily which will trigger a replenishment order if the inventory position is under the temporary reorder point. This will ensure that the required volume will be available when the ship arrives.

When the ship arrives it's given a priority between one and two and is queued up with other ship orders and any possible backorders. At the time 0.5 the orders are released one at a time to the filling station for boats. The order with the lowest priority is released first. The Ship demand manager then locates the largest free tank containing the required oil. If the oil is stored in a free swing tank that tank is selected. In order for a tank to be selected it must contain at least 10 tons of the required oil. If no such tank is available the order is sent back to the priority queue with a delay. The order is given a new priority equal to 1/(1+nbr of days in the system). If a tank is located the manager transfers the minimum of the ordered volume and tank content. The manager then locks the used tank for a day to simulate the pumping procedures. If the order is fulfilled it is allowed to exit the system. If additional volume is needed to fulfill the order the boat is sent back to the priority queue with a delay. The order is given a new priority equal to 1/(1+nbr of days in the system).

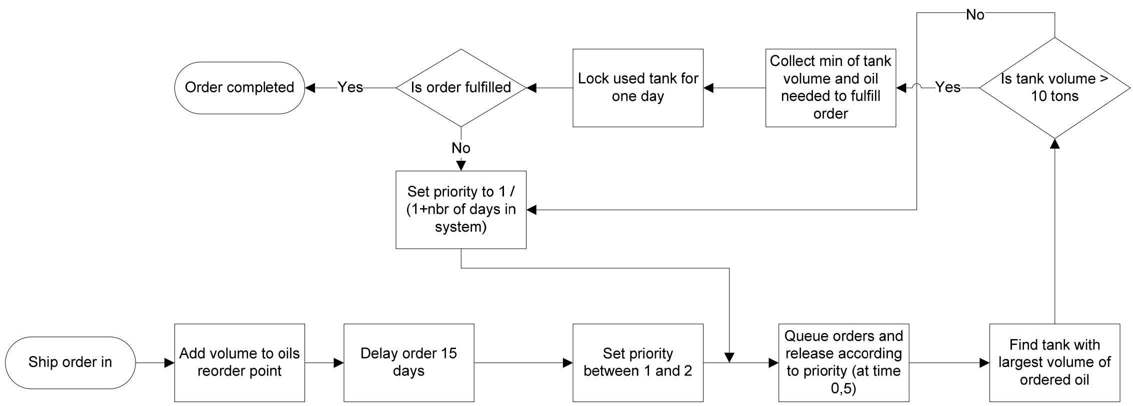



Figure 18 - Flowchart of boat demand manager

In the ship demand manager there is one exception from the main rules. The exception applies to blended oils not stored in Antwerp which the model cannot deliver with boats. In reality a swing tank is dedicated to make the blend which is then transferred to a waiting ship. This capability is not included in the model. Instead the model splits the ordered oil into its components and creates a demand for each component. In this way we ensure that the total volumes are correct. The drawback is that we will not receive service level data for the particular oil but it will show up in the service level of its components. This is a reasonable setup as there is only one blended oil that is not stored in Antwerp that shipped by boat.

### 6.4.4 Drum demand manager

The drum demand manager handles all orders for oil in barrels. When a new order arrives it is given a priority between one and two. The orders are then queued up with possible backorders and released to the drumming stations at time 0.6 each weekday. One order at a time is allowed and they are released according to their priority. When an order is executed the manager check the drum inventory and if there is a positive stock for the required oil a minimum of the order size and drum inventory is collected. If the order is fulfilled it is released from the system. If additional drums are needed the manager creates an order for new drums to be filled. The order size is rounded up to the nearest hundred with a maximum of 400 hundred drums. The manager then checks if there are free tanks connected to the drumming station holding the required oil. If not the manager tries to transfer oil from a different tank to a tank connected to the filling station. If this procedure is successful the manager checks the number of available drumming slots. If the number of slots is less than the ordered number the production order is modified down. If no slots are available the order is cancelled and the original order is sent back to the priority queue with a new higher priority (i.e. lower number in Extend). If slots are available the drumming process is initialized. The manager then distributes the new drums to the order and if additional drums exist after this the drums are sent back to the drum stock. The manager then checks if the order is fulfilled. Completed orders are allowed to leave the system while incomplete orders are sent back to the priority queue with a new priority.

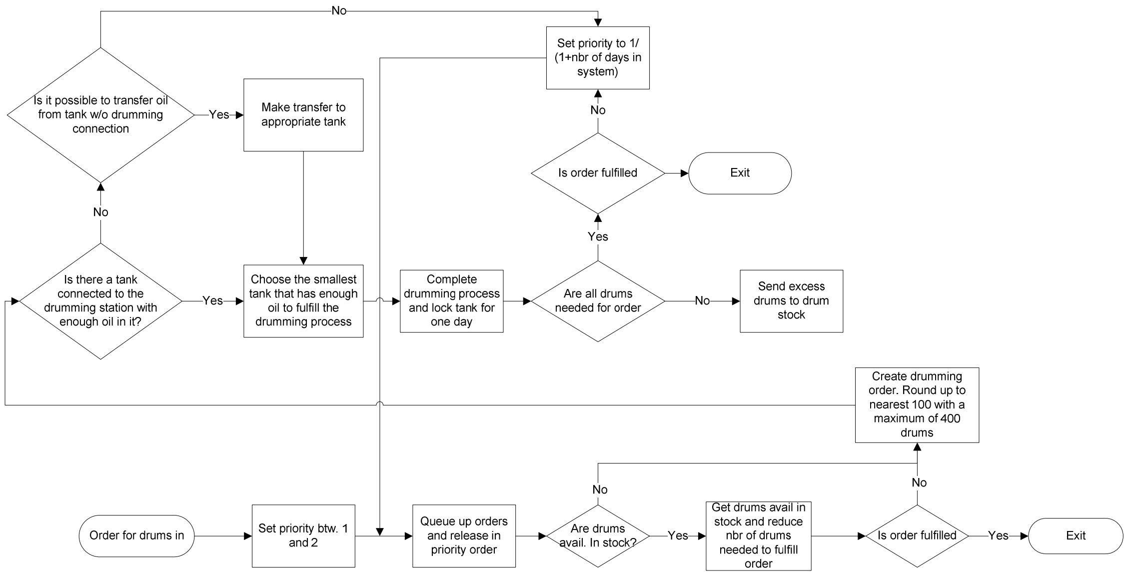



Figure 19 - Flowchart of drum demand manager

### 6.4.5 Ship manager

The ship manager controls the ships that are used in the model for replenishment orders. The manager checks once a day if there is a vessel in Nynäshamn. If there is a vessel the manager controls the vessels filling percentage. If the filling percentage is above the required level the vessel is allowed to depart. The travel time is set using an empirical distribution based on historical data. After the set travel time has elapsed the ship arrives at Antwerp and is handed over to the ship unload manager.

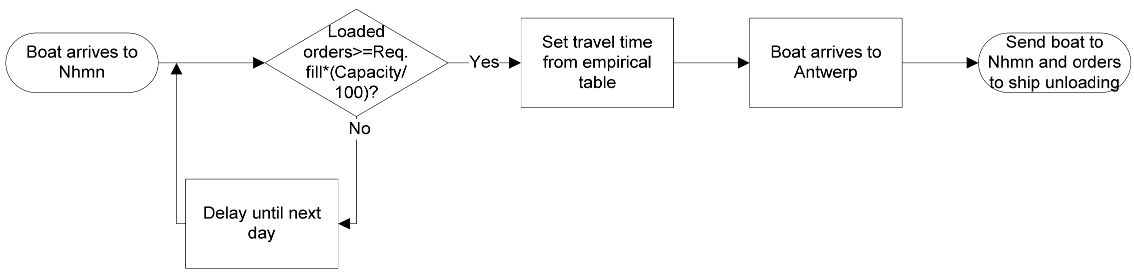



Figure 20 - Flowchart of ship manager

### 6.4.6 Ship loading manager

The ship loading manager is responsible for loading boats in Nynäshamn. Each boat has a limited capacity and a minimum filling percentage that needs to be reached before the ship is released. One ship at a time is allowed to enter the harbor in Nynäshamn.

When the replenishment order manager issues a replenishment order, the required volume will always be available in large enough quantities. The manager first checks if the replenishment order is for a blend or not. If the order is for a base oil the order quantity is added to outstanding orders. The manager then separates oils that are ordered from Nynäshamn from oils ordered elsewhere. Oils that are ordered elsewhere are assigned a fix lead time and delayed accordingly before they are sent to the ship unloading manager. Orders for oils that are stored in Nynäshamn will always be available in sufficient quantities. This means that the boat loading procedure will start instantaneously if there is a ship present. If the entire replenishment order is for more than 100 tons and does not fit in the ship the order is split into equal halves. One half is delayed and sent back to the priority queue while the second half repeats the above mentioned procedure immediately to see if it can fit in the ship. If no boat is present the order is given a new priority and is sent back to the priority queue with a delay.

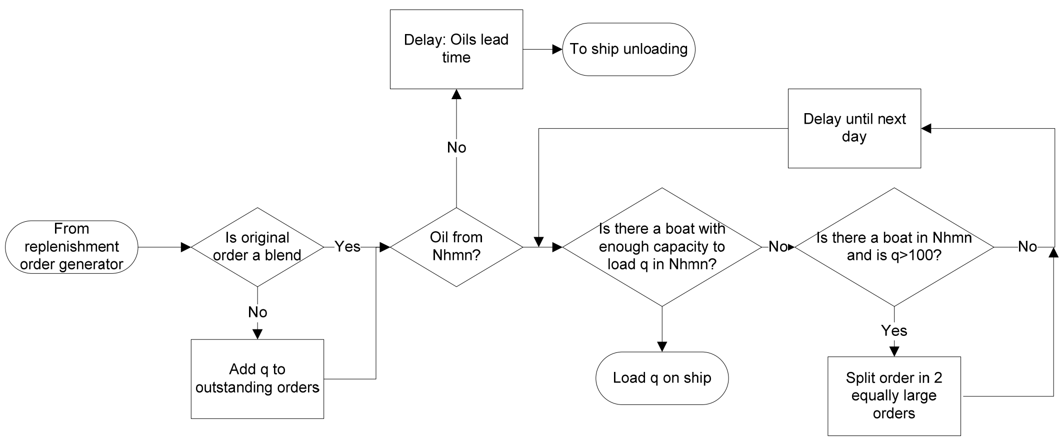



Figure 21 - Flowchart of ship loading manager

### 6.4.7 Ship unloading manager

The ship unloading manager controls the unloading of arriving replenishment orders and makes sure that the right tanks are used for storage. The replenishment orders are allowed to enter the system at time 0.1 each day. The manager first checks if the replenishment is for a blend or not. If the order is for a blend the receiving tank is predetermined and the manager locks the tank when the first component in the blend is transferred to the tank. If the component is the last remaining part needed to fulfill the replenishment order the volume is subtracted from outstanding orders. If there is a quarantine time for the oil it’s set to start.

If the replenishment order is for a base oil the manager first subtract the volume from outstanding orders. The manager then identifies which tank is least filled measured in percentage holding the specific oil. If the volume fit in the selected tank the oil is transferred to it, otherwise the tank is filled up to its capacity and the manager identifies a new tank using the same principles. If the order has gone through this process three times without being fulfilled it is sent to check if there is a swing tank available for the oil. The first thing that happens is that the manager checks if the oil requires heating. If it does only tanks with heating can be chosen. If the order goes through without finding a suitable swing tank the replenishment oil is put in the ship unloading queue with a two day delay. This is a simplification of reality. In reality these orders should have forced Nynas to rent extra capacity elsewhere. In this model there is a possibility that there is too much oil coming in to Antwerp at a certain time. To make the model more like reality we chose to keep these volumes in the system with a delay instead of throwing them away. This scenario is unlikely if the tank capacities are distributed wisely among oils and a sufficient number of swing tanks exist in the system.

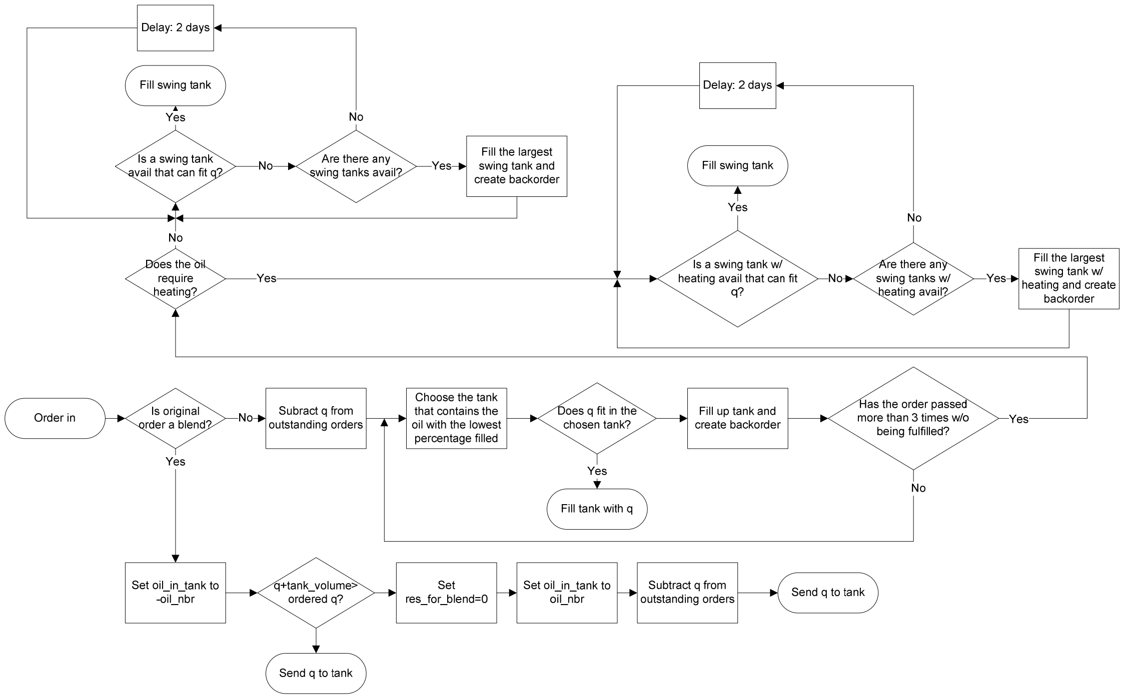



Figure 22 - Flowchart of ship unloading manager

### 6.4.8 Thirteen tanks

The 13-tanks (1301 and 1302) have a special logic because they are not connected to any truck loading stations. They are only connected to the quay and to other tanks via pipelines. These tanks are mostly used to make large batches of blends. The blends are after completion distributed to other tanks connected to truck filling stations. In the model these tanks tries to distribute oil to other tanks every second day. This is done to ensure that there is oil in tanks connected to trucks and drumming even if the actual blend is made in a 13-tank. To make sure that no trucks come to these tanks the number of available slots for truck loading is set to zero. By doing this no orders on trucks are allowed to enter the filling station number 21.

## 6.5 Input data

In order to run the simulation model there are numerous parameters that has to be set. The parameters are stored in the built in data base of Extend. They are divided into six different categories; tank data, boat data, filling station data, drum data, oil recipes and oil data. By changing these parameters you can alter the model's behavior. You can for example decide which oil should be stored in which tank.

### 6.5.1 Tank data

Each tank in the model has a separate field in the database. In this field a number of parameters are defined. Most of the parameters here are "fix" because they are limited by the physical layout of the Antwerp facility. Today 55 tanks are in use but there are an additional 16 tanks in the models. These tanks will be used to examine how performance can be improved by adding additional tank capacity. Each tank has the following attributes.

- Tank number
- Tank capacity (capacity in $m^3$)
- Oil (states which oil the tank holds)
- Swing (set to 1 if tank is a swing tank, meaning it can hold any oil otherwise 0)
- Start q (start volume in tons for content in tank)
- Heating (set to 1 if tank have heating capabilities otherwise 0)
- Connected to filling station (states which filling station a specific tank is connected to)
- Connected to drumming (set to1 if tank is connected to the drumming station otherwise 0)
- Connected to quay line (set to 1 if tank is directly connected to a quay line otherwise 0)
- Connected to inline blender ( set to1 if tank is connected to the inline blender otherwise 0)

### 6.5.2 Boat Data

The model supports up to 4 boats to be used for replenishment orders from Nynäshamn to Antwerp. Each boat has a unique set of attributes.

- Boat name
- Boat number
- Capacity (Boat capacity in metric tons)
- Required fill percentage (Required minimum filling percentage for boat departure from Nynäshamn.

### 6.5.3 Filling station data

There are 19 regular filling stations and a filling station with inline blending ability used for truck loading in the model. In the filling station data the user can change these attributes:

- Station name
- Slots/day (number of trucks that can be served each day)
- Weekends (a one if the filling station accepts orders on weekends which means that rest orders from the week are handled in the weekends )

### 6.5.4 Drum data

- Oil name
- Initial inventory (number of drums of oil *i* that is in stock at time zero)

### 6.5.5 Recipes

The parameters for the recipes are stores in a n x n matrix where n is the number of oils used in the model (the maximum number of oils that can be used at once is set to 50). Each oil recipe is stored in a row corresponding to the oil number. The sum of each row is equal to one. If an oil *i* is a blend there will be a zero at (*i, i*) in the matrix and the relative percentage of each component is stated in the column corresponding to the component oil number. If oil *i* is a base oil there will be a one at position (*i, i*) in the matrix.

### 6.5.6 Oil data

The model supports the use of up to 50 different oils. There are two groups of oils, base oils and blends. The blends are made up of two or more components (base oils). All oils used in the model may not be stored in tanks at the Antwerp facility. Oil that has a demand but is not stored in Antwerp is blended directly into trucks.

- Oil number
- Oil name
- Reorder point ( oils are ordered with a (R, Q)-policy where R is the reorder point)
- Batch size ( is the q in the (R, Q)-policy )
- Heating (is set to 1 if oil needs to be stored in a tank with heating capabilities)

- Lead time mean (if oil isn't ordered from Nynäshamn this is the mean lead time from order to delivery in Antwerp)
- Lead time std (standard deviation for order lead time)
- Oil from Nynäshamn (is set to 1 if oil is shipped from Nynäshamn and 0 if oil is ordered elsewhere)
- Reorder point modifier (with this attribute you can modify the reorder point without modifying the R. This can be valuable if an oil is used for blends in Antwerp. With a reorder point modifier the reorder point is lowered so that blends can be done even if it means that the oils stock becomes lower than the "real" R. This is especially useful for oils that don't have any own demand in Antwerp.

### 6.5.7 Demand data

The simulation model is demand driven. This means that all events occurring in the model are triggered as a result (direct or indirect) of demand.

The demand at the Antwerp facility is separated into three different types. These are boat orders, truck orders and drum orders. Boat and drum orders vary in size while the truck orders are quite uniform around twenty metric tons. Boat orders can be as large as 3500 metric tons and as small as 100 metric tons. The drum orders vary between a few barrels up to several thousand barrels.

Because no common distribution was found among the three different demand groups a different approach was used. Instead of letting Extend create the demand from a set of parameters the demand data was retrieved from excel. In excel historical data was used as a sample to create input data. By doing so the mean, variance and the overall characteristics of the data remain intact. A visual basic script was created to simplify creation of new input data. The drawback with this method is that it is more time consuming to alter the mean if you would like to examine how an increase in demand would impact the system performance.

## 6.6 Visual interface

The simulation model has a graphical interface where the user can follow tank levels and filling station utilization. All tanks are mapped out on a schematic picture over the Antwerp facility.  Each tank have a visible tank number, oil number for stored oil and an indicator light for displaying tank status. During simulation three graphs are also visible; these graphs show how the daily demand plus the backorders for trucks, boats and drums develop over time. We added extra tanks on all filling stations to enable shifting and increasing tank capacity. These tanks were made red to make them easy to locate in schematic picture.

## 6.7 Reports generated by the model

The simulation model creates the following reports by continuously sending data to excel.

### 6.7.1 Filling station utilization

This report summarizes the average utilization of the filling stations used in the model.

### 6.7.2 Boat data

This report contains the day and filling percentage of all boats arriving at Antwerp with replenishment orders.

### 6.7.3 Lift data (trucks)

This report contains fifty columns, one for each oil used in the model. In the columns the time an order spends in the system is stated. If the time an order spend in the system falls short of one day the order is considered to have been “served without delay”. From this data the service level is calculated, both for individual oils and as a total service level. In addition to service levels mean time orders spent in the system is also calculated, both for individual oils and as a total.

### 6.7.4 Inventory levels

In this report the inventory levels at the end of a day is stated. This data can be used to calculate average inventory levels for separate oils or for the total inventory levels.

### 6.7.5 Inventory level drums

States the daily inventory level for each oil stored in drums.

### 6.7.6 Replenishment orders

This report contains all replenishment orders arriving to Antwerp.

### 6.7.7 Lift data (boats)

This report contains fifty columns, one for each oil used in the model. In the columns the time an order spends in the system is stated. From this data the service level is calculated, both for each oil and as a total service level.

#### 6.7.8 Lift data (drums)

This report contains fifty columns, one for each oil used in the model. In the columns the time an order spends in the system is stated. From this data the service levels for all drum oils are calculated.

#### 6.7.9 Backorders

In this report the daily number of truck backorder we have for a specific oil is stated.

These reports can be used to evaluate the performance of a specific scenario. They can also be used to identify bottlenecks and other problems under a certain tank setup.

The key elements that the performance is measured upon are boat, truck and drum service levels. The service level is measured for each oil individually and for each demand group as a whole.

## 6.8 Test and verification

In this phase the model was tested to ensure it was working properly and that it was a good reflection of reality. This was done in a series of steps. First each module was examined individually to ensure it was working correctly. After all modules were tested they were connected and the whole system was tested. The third step was to set all parameters to make it an adequate reflection of reality.  To ensure the model was a satisfactory representation a number of key figures were studied and compared to actual data. These were oil volumes going through the system, average inventory levels, filling station utilization and boat filling percentage.

### 6.8.1 Testing the modules

Each of the modules in the model was tested individually. Since all modules have different tasks the structures differ significantly. Therefore each module was tested in correspondence with its structure.

#### *6.8.1.1 Replenishment order generator*

The replenishment order generator was tested by studying the inventory position and check when a replenishment order was triggered. The ordered volume was also monitored. Blending operations was followed to make sure the recipes and quarantine times were correct.

#### 6.8.1.2 Truck demand manager

First it was controlled that the demand was allowed into the system at the right time. Then the demand was compared with the excel files to ensure resemblance.

#### 6.8.1.3 Ship demand manager

Same as for truck demand generator

#### 6.8.1.4 Drum demand manger

Same as for truck demand generator

#### 6.8.1.5 Ship loading

The ship loading procedure was monitored to ensure that no boat was overfilled. The condition for boats leaving Nynäshamn was also controlled to make sure no boat with filling percentage less or equal to its required filling percentage could leave.

#### 6.8.1.6 Ship unloading

The unloading procedure was monitored to ensure that oil was transferred to the correct tanks. The use of swing tanks was also monitored.

#### 6.8.1.7 Ship manager

The assigned travel times between Nynäshamn and Antwerp were studied and the compared with the empirical distributions.

### 6.8.2 Testing the entire model

After verifying all individual modules the entire model was tested. This was done in a number of steps. First a single order was followed through the system. This was done by using the visual interface in Extend. It enables the user to follow an order, which is represented by a green sphere, traveling through the model blocks. Each decision made by the model was reviewed by checking the input parameters used. As with the individual modules all possible situations was recreated and tested. This procedure was then repeated with all order types; replenishment orders, blending procedures and all transfer types. In order to test the model with several oils at the same time a number of plots were placed at strategic points in order to monitor the system. With the help of these plots it was possible to review what was happening and check if it was in line with what was expected. After the model testing was completed the model stability was tested.

#### 6.8.2.1 Model stability

After the model was tested the stability was analyzed. This was done by calculating the aggregated service levels for trucks, boats and drums over time, see Figure 23. Three sets of data were used in three different simulations. Each of the data sets were generated from the same empirical distributions and sampling material. This ensured that the mean and standard deviations of the three data sets were comparable. The service levels of the three different data sets generate three different curves. The curves fluctuate heavily in the beginning but converge toward a single value over time. This is a good indication of model stability.

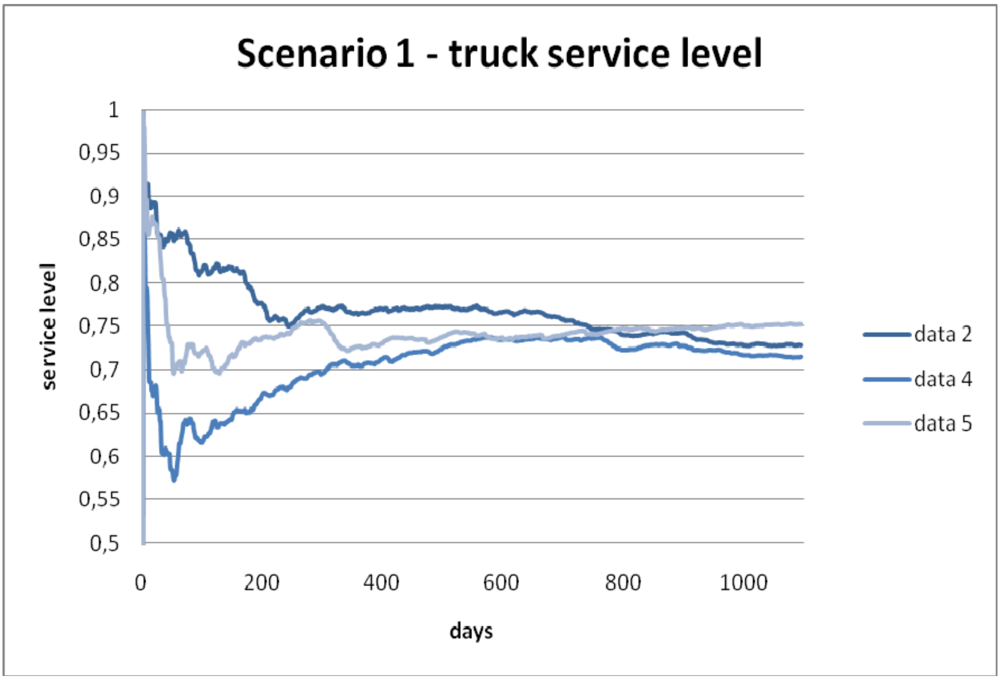



Figure 23 - Service level under low demand

In order to see the effects of putting additional stress on the system the demand was increased. As in real life the model responded by getting more and more unstable as the demand grow closer to capacity constraints. It took longer and longer before the three different curves converged and the initial fluctuations were larger, see Figure 24. When a certain demand was reached the system became unstable. This was the effect of capacity constraints somewhere in the system, which leads to steadily growing backorder queues. The system's ability to handle variations was reduced until a chain of events led to a situation where the backorder stock grows towards infinity.

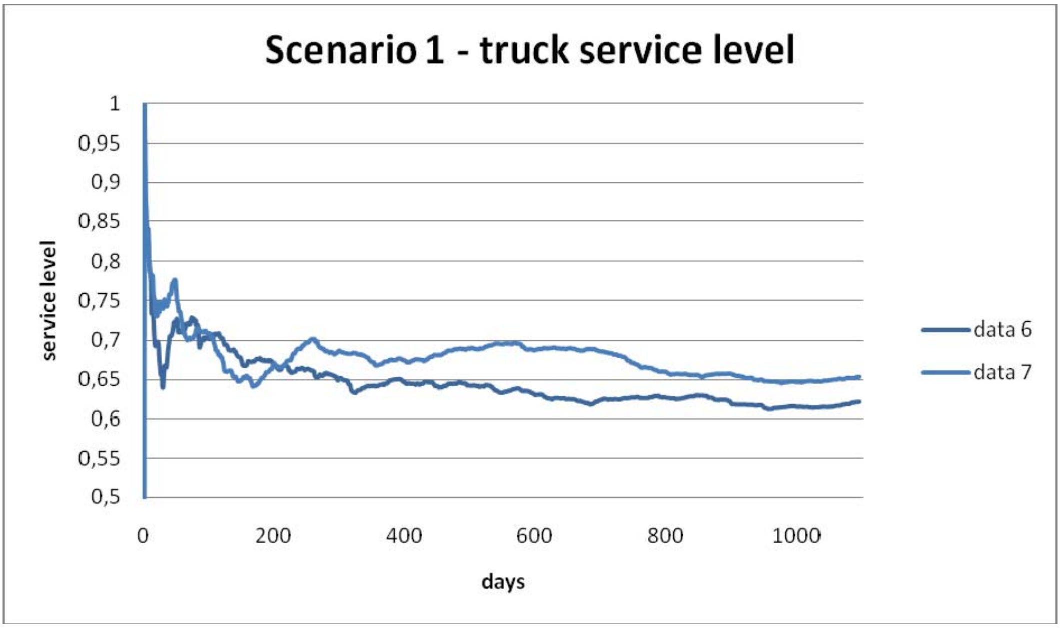



Figure 24 - Service level under high demand

The physical inventory positions both of individual oils and for the system were monitored. The levels from the three initial runs were compared. Both the mean and standard deviations from the three runs were very similar. The mean levels were also stable; no long term trends were visible. A period of fluctuation was visible in the beginning but was connected with the start volumes in the model.

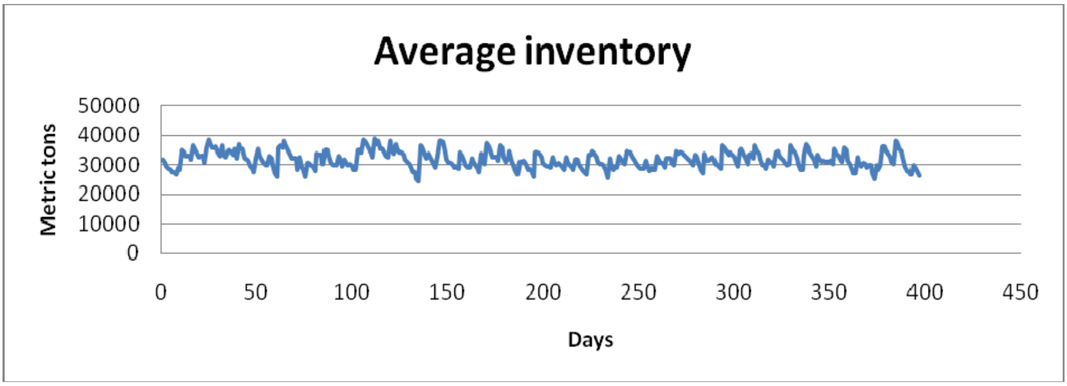



Figure 25 - Average inventory levels

## 6.9 Calibrating the model

### 6.9.1 Issues when setting R and Q

The reordering system for base oils in the simulation model can be seen as a (R, Q)-system with a periodic review policy. The reordering system for blend oils works more like a (s, S)-system with an order-up-to level that is different depending on which tank that is chosen for blending operations. The review time T in the model is one day.

The lead time L differs between oils. In our model all oils that are delivered from Nynäshamn has a stochastic lead time. Lead times depend on whether a boat is available in Nynäshamn or not, when the boat is full enough to leave Nynäshamn and the time it takes to travel to Antwerp. The lead time can be as short as 3-4 days and in worst case closer to two weeks.

### 6.9.2 Setting the reorder point

When setting the reorder point several factors had to be taken into consideration. The first one is the lead time for replenishment orders. The lead time is stochastic with an average of approximately 8 days. In addition to cover these 8 days a safety stock to handle 10 days demand was added. The scenario was then tested and the inventory levels for different oils were plotted, see Figure 26. With the help of these graphs the levels were adjusted to keep the average inventory down. The case in Figure 26 the reorder point is somewhat high, a reduction by 100 tons would be appropriate. This reduction would decrease the average inventory and still be adequate to cover demand. Other factors that were taken in consideration were the size of tanks and appropriate batch sizes. Some oils that were ordered from far away

(Isla, Huston) had higher reorder points and larger batch sizes then necessary. This was decided after discussions with Andreas Jerper. The higher reorder points and larger batch sizes for these oils were to reflect the transportation issues for the oils.

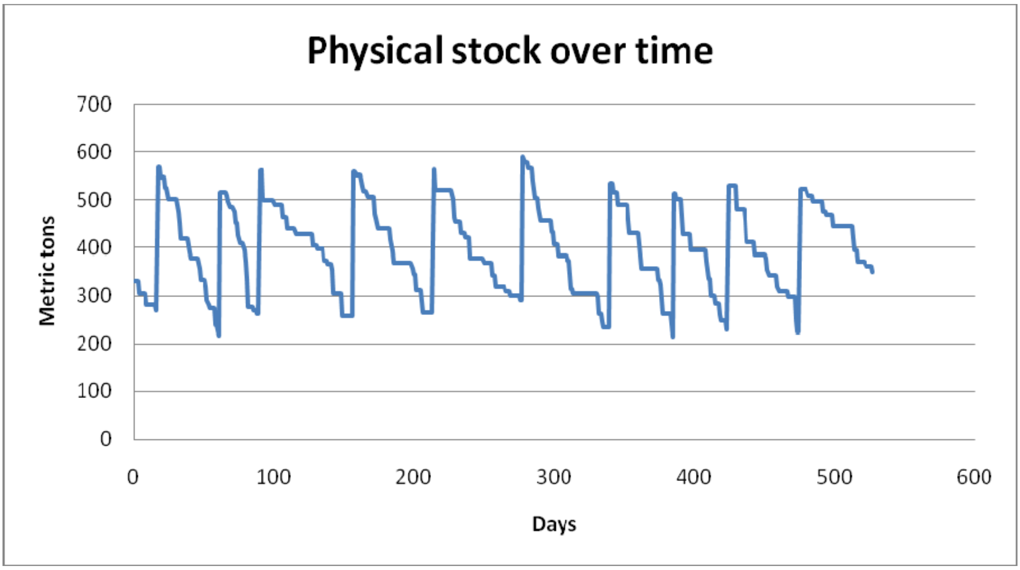



Figure 26 – Example of physical stock level over time

The reorder points for the stored blends are more complex. Since there are several oils that need to be ordered or transferred the average lead times are harder to estimate. Many blended oil also have a quarantine time adding to the complexity. The quarantine time will lead to significantly higher average inventor level since part of the oil will be unavailable. It is also more difficult to evaluate the plots over average inventory levels since they do not separate available volumes from unavailable ones. Another issue with the stored blends is the use of swing tanks. In order to keep the dedicated tank to a minimum, swing tank capacity is needed to make room for blending operations.

The basic setup was to let the reorder point be somewhat lower than the volume of the largest tank the oil was stored in. In some cases this worked fine and in others it was either too low or too high. If the oil was stored in more than 3 tanks the reorder point was set to a number close to half of the total capacity.

## 6.10 Setting the batch size

When setting the batch sizes Q for the base oils the limitations were connected to the reorder point and the tank capacity for each oil. It was essential to have an R + Q that could fit in the dedicated tanks. This was crucial since the swing tanks were mainly for blend and boat orders.

For blends the reorder quantity is set automatically to the size of the tank selected for blending operations. This makes the process realistic as blends are preferably done in the largest available tank which will wary over time.

### 6.10.1 Setting the reorder point modifier

Oils that have no conventional demand but instead are stored for blending purposes were assigned a reorder point modifier. When a specific oil is needed in the blending procedure the model first checks if the volume is available in a single tank. Secondly the model determines if the physical stock minus the demanded volume is larger than the reorder point. By doing so we can assure that the blending operation is not interfering with the capabilities of handling the oils regular demand. For oils that have low conventional demand but frequently is used for blends, the use of only R to determine if the oil is available in enough quantities is no good solution. To improve the model a reorder point modifier was introduced. In the replenishment generator the conventional R is added with the reorder point modifier. If the inventory position falls short of this value a new order is triggered. If an oil for instance have a reorder point of zero but a reorder point modifier of 300 a replenishment order will be triggered if the inventory position is below 300. Still a blending operation is allowed to use the entire volume in Antwerp as long as it is stored in a single tank.

The reorder point modifier was set so that the largest quantity needed for a blend was smaller than the modifier. In this way the blending operation could always acquire the needed oil as long as the volume was available in a single tank.

### 6.10.2 Other issues

An issue that proved very important when setting R and Q was the effect of the large boat orders. Since the boat orders often were large quantity orders they required that large quantities were available at the hub in order to achieve a high service level. In reality the boat orders are planned well in advanced so that the required volumes are available. In our simulation model this was solved by introducing the orders 15 days before they actually arrived at Antwerp (introducing the orders even earlier was tested but had small impacts on the performance). The logic in the model reacts by reserving the requested volume which is the same as lowering the inventory position by the order size. If the new inventory position is below the reorder point a new replenishment order is triggered. Since the lead time for oils is sometimes longer then 15 days (especially for oils requiring quarantine) this had to be considered when setting R and Q.

In order to handle the boat orders in a good way it is preferable to have the reserved oil volume in a single tank. It is therefore preferable to store the oil in at least one tank which is larger then the largest possible boat order. If the oil is also lifted by trucks or in drums it is important that the oil is stored in more then one tank since the tank is reserved for 15 days before the actual order arrives. T

## 6.11 Designing tank setup

When the oils were distributed among the available tanks a number of factors needed to be taken into consideration. These were tank volumes, heating, inline blender capabilities, filling station connections and connections to the drumming station.

First of all, oils requiring heating have to be distributed among the tanks with heating capabilities. Secondly, all oils that where required in inline blending operations was identified. These oils were distributed among tanks connected to the inline blender.

Oils with frequent truck lifts needed to be present at as many filling stations as possible to ensure a high service level. This minimized the risk that an order was not fulfilled because shortage of slots at the filling station.

## 6.12 The 2008 setup

The first step in the simulation part of this thesis was to create a tank setup for 2008. The tanks available in the 2008 budget were already determined. A total tank capacity of 87.385 metric tons was available. This was an increase by 15.000 tons compared to the 2007 setup.

The approached used to create this setup was to first create a base setup using our and the supply teams knowledge of the system. This base setup was then fed into the simulation model and a number of simulation runs were made. By studying the report generated by the model a number of problems were identified. These problems were of five main types.

- To high utilization of certain filling stations
  In order to create an effective setup oils needed to be allocated in such a way so the utilization of the different filling stations was fairly even. In addition oils with high demand should be available at several filling stations in order to be able to handle demand peaks.
- Inadequate tank capacity for certain oils
  In order to maintain a high service level the oils need to be stored in tanks with enough capacity. Since the tank capacity is limited there is a trade of between oils.
- Problems with locked tanks
  Oils with many drum and boat lifts needed to be available in several tanks. This is because frequent lifts will block the tanks for truck lifts.
- Inappropriate reorder points and batch sizes
  Problems with a too low reorder point could result in an inadequate safety stock. A too high reorder point could lead to utilization of swing tank capacity which is better needed elsewhere.
- Inadequate swing tank capacity
  In order to maintain a high service level for the stored blends swing tank capacity is required in order to free up tanks for additional bled operations.

The major problems were addressed by reallocating oils between available tanks and adjusting reorder points and batch sizes. The new improved setup was then fed into the model and new simulation was conducted. This process was repeated in an iterative process until a good setup was identified

### 6.12.1 Simulation process

Each simulation run simulated three years, 1095 days. It would have been desirable o simulate longer time periods but limitation in calculation power limited the number of possible runs (each simulation takes 4-9 hours depending on volumes and number of backorders in the system). Each scenario was executed with three different sets of input data. The data was reused in each comparable scenario to exclude deviation from different sets of demand.

# 7 Scenarios

In this chapter the scenarios created in order to evaluate the Antwerp hub will be described in detail. At first 7 different scenarios were created. During the simulation process it became obvious that additional scenarios were needed. These scenarios were named 8 to 13. The reorder points and batch sizes was not adjusted within each scenario group. This might have a small impact and lower the service levels of scenarios with increased demand compared to adjusting levels according to the higher demand. The reason for this is the extra works associated with modifying these parameters and test them. All scenarios are available in Table 4.

## 7.1 Scenario 1-4

In order to create a point of reference two different scenarios were simulated, called scenario one and two. Scenario one was the tank setup planned for 2007 and scenario two represented the actual tank setup in November 2007. These both scenarios had almost identical total tank capacities but differed in distribution of oils among available tanks (a complete tank list for each scenario can be found in appendix 1A and appendix 1B). The two scenarios were then simulated with the 2007 demand and the 2007 demand with additional 10 %, called scenario 3 and 4.

## 7.2 Scenario 5-7

The setup for 2008 was simulated with three sets of in data. First the 2007 demand was used and then 10% and 20% increase was tested.

## 7.3 Scenarios 8-11

When the demand was increased the boats transporting oils from Nynäshamn to Antwerp was a major bottleneck. In order to test the impact of a demand increase beyond approximately 15% additional boat capacity was added. A new boat with a capacity of 4600 tons with similar travel times was added. This new setup was simulated in four different scenarios called 8 to 11.

## 7.4 Scenarios 12-13

During the simulation process it became obvious that the quarantine times played a key role. In order to find out the impact of reduced quarantine times two additional scenarios was created. The first one reduced the quarantine times with 10% and the second scenario was a reduction with 20%.

**Table 3 - Quarantine times**

| Quarantine time (days) | | | |
|---|---|---|---|
| | quarantine time | quarantine times -10% | quarantine times -20% |
| Nytro 400A/X | 23 | 21 | 19 |
| N Taurus | 10 | 9 | 8 |
| N Libra | 10 | 9 | 8 |
| N Lyra | 23 | 21 | 19 |
| N Gemini X | 23 | 21 | 19 |

**Table 4 - Setups**

| Setups | Demand<br>2007 years demand | Demand +10% | demand +20% | demand +35% |
|---|---|---|---|---|
| Planned setup for 2007 | Scenario1 | Scenario 3 | | |
| actual setup 2007 | Scenario 2 | Scenario 4 | | |
| our proposed setup (2008 tank limitations) | Scenario 5 | Scenario 6 | Scenario 7 | |
| our proposed setup (2008 tank limitations +additional boat 4600 ton) | Scenario 8 | Scenario 9 | Scenario 10 | Scenario 11 |
| our proposed setup (2008 tank limitations + additional boat 4600 tons -10% quarantine times) | | | | Scenario 12 |
| our proposed setup (2008 tank limitations + additional boat 4600 tons -20% quarantine times) | | | | Scenario 13 |

## 7.5 Demand

The simulation was performed with four different levels of demand. 2007 years demand which was collected from historical data. The 10% increase in demand was accomplished by adding 40.000 tons to the total volume. The increase was evenly distributed among the transformer oils, NYTRO 4000A/X, NYTRO Taurus, NYTRO Libra, NYTRO Lyra and NYTRO Gemini X. This figure was set with the help of Anders Nilsson. He thought this increase would be in line with the expected demand for 2008. The 20% increase was created by using the 10% increase and then add an additional 40.000 tons. The increase was evenly spread over all products. The 35 %

increase was accomplished in the same manner but the already increased data was used as a base. The additional increase was evenly distributed among all products. These figures were chosen after discussions with the supply department. The demand was also evenly distributed among the tree demand types.

## 7.6 Setups

Three different setups were used in the simulation phase. The planned setup and actual setup for 2007 was similar in terms of tank capacity. Nevertheless there were major differences between the two setups. The planned setup had a high percentage of swing tanks compared to the actual setup. The actual setup had a larger portion of the tanks dedicated for blended oils while the planned setup had more dedicated capacity for base oils. The 2008 setup hade 15.000 tons additional tank capacity compared to the two previous setups. It also has a high percentage of the total capacity dedicated as swing tanks. To see a complete descriptions of the setups see appendix 1A for the planned setup, appendix 1B for the actual setup and the appendix 1E for the 2008 setup.

**Table 5 - Tank capacities**

| Tank setup | Total tank cap. | Ordinary tank cap. | Swing tank cap. | Swing tank % |
|---|---|---|---|---|
| 2007 budget | 71641 | 63662 | 7979 | 11,1% |
| 2007 actual | 72354 | 68099 | 4255 | 5,9% |
| 2008 setup | 87385 | 73072 | 14313 | 16,4% |

# 8 Results

Each scenario was simulated with three sets of in data and the average results were calculated. The main measurement of the system performance is the truck service level. The service levels of the different scenarios can be found in Table 6 and studied further in Figure 27.

**Table 6 - Results**

| Setups | Demand<br>2007 years demand | Demand +10% | demand +20% | demand +35% |
|---|---|---|---|---|
| Planned setup for 2007 | 73,2% | 63,8% | | |
| actual setup 2007 | 77,0% | 71,9% | | |
| our proposed setup (2008 tank limitations) | 92,0% | 88,8% | 71,5% | |
| our proposed setup (2008 tank limitations +additional boat 4600 ton) | 93,1% | 91,8% | 89,7% | 82,3% |
| our proposed setup (2008 tank limitations + additional boat 4600 tons -10% quarantine times) | | | | 85,9% |
| our proposed setup (2008 tank limitations + additional boat 4600 tons -10% quarantine times) | | | | 87,2% |

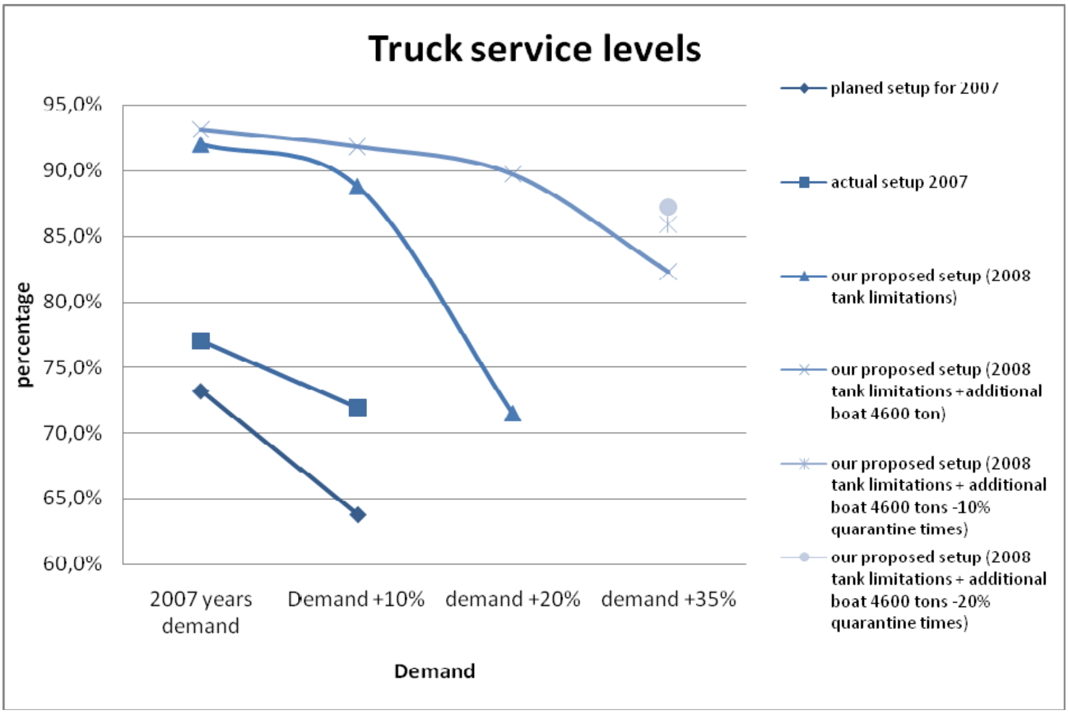



Figure 27 - Results truck service levels

The highest service level was achieved with the 2008 setup with an additional boat and the lowest service level was that of the planned setup 2007 with a 10% increase in volumes. The 2008 setup is a major improvement compared to the two previous setups, but the service level drops significantly when the demand is increased with 20%.

There is also a large difference in service level between the planned and actual setup for 2007. If you study the reports in detail (see appendix 1A-1O) you can see that the actual setup have significantly higher service levels for the transformer oils.

The average inventory levels can be found in

Table 7. The average inventory is very similar for the two first setups. A general conclusion is that the average inventory position drops when demand increases. The effect is small but clearly visible throughout all scenarios. The average inventory for the planned and actual setup 2007 was in line with the average inventory level Nynas encounter today. In the setup for 2008 the average inventory is some 10% higher than for the 2007 setups. When an additional boat is added to the system the inventory levels rises even more.

**Table 7 - Average inventory levels**

| Setups | Demand 2007 years demand | Demand +10% | demand +20% | demand +35% |
|---|---|---|---|---|
| Planned setup for 2007 | 31548 | 31304 | | |
| actual setup 2007 | 31304 | 29476 | | |
| our proposed setup (2008 tank limitations) | 34460 | 33746 | 28302 | |
| our proposed setup (2008 tank limitations +additional boat 4600 ton) | 36528 | 36029 | 36117 | 35328 |
| our proposed setup (2008 tank limitations + additional boat 4600 tons -10% quarantine times) | | | | 35703 |
| our proposed setup (2008 tank limitations + additional boat 4600 tons -10% quarantine times) | | | | 35948 |

## 8.1 Boat filling percentage

When it became obvious that the bottleneck in the system was ship capacity a more thorough study was conducted. This was done in order to find out the relationship between the service levels and the filling percentage of the vessels. In order to minimize the impact of other capacity constraints such as filling station utilization and tank capacity additional capacity was added in all areas. The 2007 demand was used as a reference and then the demand was increased with 5, 10, 15 and 20%. The scenarios was called scenario 14-18. Under each scenario the average ship filling percentage was calculated. The average filling percentage of the ships can be seen in Table 8.

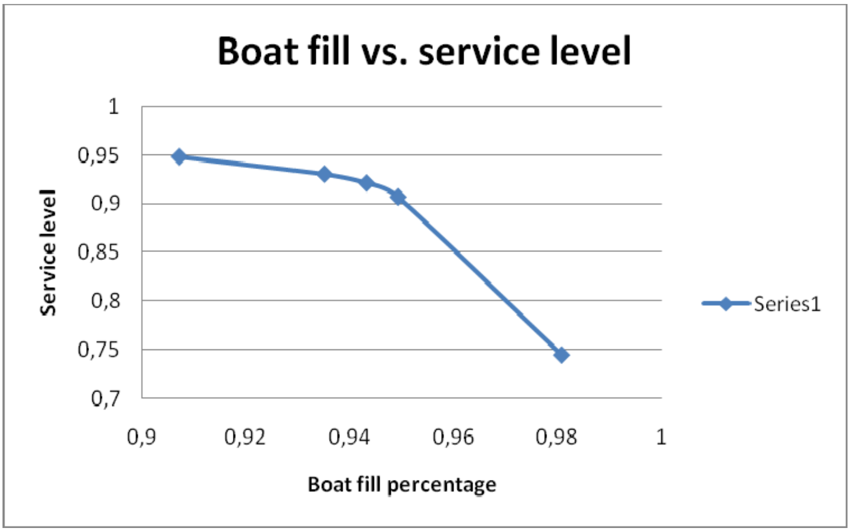



**Figure 28 - Service level vs. boat filling percentage**

**Table 8 - Service levels vs. boat filling percentage**

| | average filling percentage | service level |
|---|---|---|
| 2007 demand | 90,7% | 94,9% |
| +5% | 93,5% | 93,1% |
| +10% | 94,3% | 92,2% |
| +15% | 94,9% | 90,7% |
| +20% | 98,1% | 74,5% |

# 9 Analysis

In the following chapter the results of the simulation will be discussed in detail. In order to follow the discussions it will be helpful to have appendix 1A- 1O at hand.

## 9.1 Scenario 1-4

There were two major differences between the actual setup for 2007 and the planned setup. The planned setup had low dedicated tank capacity for the transformer oils, but large swing tank capacity. The actual setup had a much larger dedicated tank capacity for the transformer oils but less swing tank capacity (see appendix 1B). The low capacity for transformer oils in the planned setup is linked to the change in product slat that occurred 2007. Obviously the planned setup will have problems to attain a high service level when the demand increases, especially since the growth is among the transformer oils. A simple calculation experiment on the Lyra X can illustrate the problems with the planned setup for 2007. A new blend takes approximately 30 days to finish after the reorder point is reached. The reorder point in this case is 600 tons. The new blend is preferably made in a tank with a volume of 740m$^2$ which corresponds to about 662 tons of oil. In cases where the inventory position drops below 600 tons during a blend the smaller tank on 187 m$^2$ (167 tons) will also be used to make blends in. In total approx. 12 blends per year and tank can be made. This means that the maximum amount of Lyra X that can be produced each year is 662*12+167*12=10008 tons. Since the yearly demand for Lyra X under the 2007 years demand +10% is 10429 tons it means that the system cannot handle the volumes. That is the reason why service level sinks so dramatically on these blends. The same goes for Gemini X but since there are boat orders involved in the demand for this oil the calculations are not as trivial as with the Lyra X.

Another issue with the planned setup is the high utilization of filling station 3B which is close to 87%. Such high average utilization means that there will not be enough slots available to cover demand most of the days.

## 9.2 Scenario 5-7

The 2008 setup is a major improvement of the Antwerp facility. The service level for the 2007 demand was 92% for trucks, which can be compared to a 77% service level for the actual setup. The service level for all large volume oils is at least 90%. There are still problems to achieve a high service level for the inline blended oil. The main limitation is a high utilization of the inline blender. The inline blended oils also require the use of more than one tank, this increases the risk that required tanks are locked for other operations.

When volumes are increased by 10% the service level drops to 88,8%. This is still a decent level and significantly higher than the actual setup can perform with the 2007 demand. The transformer oils which are blended in Antwerp suffers most in terms of service levels. This is expected since the increase was distributed among these oils. The oils with high quarantine times namely NYTRO Taurus, NYTRO Lyra and NYTRO 4000A/X suffered more then the rest of the quarantined oils. This was expected since the longer quarantine times make the blending procedure more capacity consuming.

When the demand was increased with 20% the system became unstable. In one of the simulation the backorder stock kept growing throughout the simulation. The boat capacity was a bottleneck and the system lacks the ability to work back earlier periods with high demand. This instability was also visible when you study the average inventory levels. The level dropped to 28.000 tons and is still sinking in the end of the simulation period.

## 9.3 Scenario 8-11

The effects of additional boat capacity are small when demand is at the 2007 level. The service level for the scenario with additional boat capacity is 93,1%, which can be compared with 92% for the original boat capacity. The additional cost of chartering an extra boat is substantial and at this demand the increase in service level is minor.

When demand is increased the positive effects of additional boat capacity is more prominent. As can be seen in Figure 27 the gap between the two curves representing the 2008 setup and the 2008 setup with an extra boat is widening. The marginal effect is quite small but increases as demand goes up. When demand is increased by 20% the system with an additional boat is still stabile and the service level is still almost 90%. However, when demand is increased by 35% the service level drops to 82%. We believe that the decrease in service level could be less significant if the reorder points and batch size where modified. But for the setup to handle an increase of this magnitude and still perform such high service levels is a good testament of the setup effectiveness.

## 9.4 Scenario 12-13

In scenario 12 the quarantine times was reduced with 10%. This was a reduction from 21 to 19 days for the NYTRO Taurus, NYTRO 11GX and the NYTRO 4000A/X and a reduction from 10 to 9 days for the remaining NYTRO grades. No changes were made to the reorder points for the oils in question. If the reorder point were to be altered in accordance with the reduction of quarantine times the effect would undoubtedly be greater. The service level increased to 85,9% from 82,3%. This is a major improvement when you have in mind that the change in quarantine time only affected roughly half the volumes passing through Antwerp each year.

When the quarantine times was reduced with 20% the service level increased to 87,2%. This increase was smaller than expected but we believe the effects would be higher if the reorder points and batch sizes were modified.

The average service levels were slightly higher for these scenarios compared to the scenarios with the original quarantine times. The increase is as expected highest with the quarantined oils.

## 9.5 Scenario 14-18

In these scenarios the effect of additional stress to a bottleneck in the system was examined. The ship capacity, which was the first major capacity constraint, was isolated by increasing all other possible capacity limitations. Tank capacity was increased with almost 50% and the available slots were increased by 500%. The service level of the new system was 94,9% under the 2007 years demand and the average ship filling percentage was 90,7%. As expected the service level was significantly higher than for the original 2008 setup. The main factors preventing the service level from increasing even more was the lock down of tanks as results of boat and drum orders. These capacity constraints were still present because the number of tanks remained constant; only the volume of each tank was increased.

The demand was then increased with 5% evenly over all products and demand types. This modification decreased service level to 93,1% and the ship filling percentage increased to 93,1%. Because the capacity in the system was so high the decline in service level is almost entirely a result of additional stress on the ships. When demand was increased further the decline in service level accelerated. When the average filling percentage of the ships is approaching 100% the service level of the system goes towards 0%. This is because the system’s ability to work back delays is eliminated. Since the demand is stochastic and fluctuate over time, periods with high demand create backorders. Since the capacity roof is reached the system cannot transport enough oil to get the system in balance under periods with lower demand.

It is reasonable to conclude that these effects will be even more visible in reality. In the model all external disturbances such as production problems, weather, boat failures and so forth are removed. If the average filling percentage of the boats reaches a very high level the system will become unstable. In reality chartering additional boat capacity when the need occurs may reduce this effect.

## 9.6 Impacts of quarantine times

There is a large difference in required tank capacity between blends that require quarantine and base oil in order to achieve a certain service level. A simple calculation example will show this difference. Let's say a base oil can handle the demand with a single 1100 ton tank. If no swing tanks are available a blended oil will require 2200 ton capacity in two identical tanks to achieve the same service level. The first tank will be used to hold the ongoing blends under its quarantine time. The second tank will be used to hold completed blends and satisfy customer demand. As soon as a blend is ready it is transferred to the distribution tank and another blending operation is issued. The average inventory for a blended oil will also be significantly higher because of this reasons. The effect can be reduces by using a larger number of smaller tanks but that would increase cost of testing the completed blends. Another way to decrease the required tank capacity is to use swing tanks.

If the quarantine times could be reduced either the service level could be increased or the required tank capacity could be decreased. This could mean substantial savings for Nynas since both the rent for tanks could be lower as could the average inventory levels.

# 10 Final thoughts and conclusions

The complexity of the Antwerp hub was even larger than expected. In the work with this master thesis new important factors were discovered along the way. In order to build a good simulation model they needed to be incorporated. This had the effect that the model became very large and complex. If the model was to be built once again a few smart design changes would make the model run faster. This would not result in different results since we believe that all the important features are present but give the opportunity to simulate longer time periods.

We believe that simulation is a good way to predict the behaviour of a complex system like this. We noticed that it is really hard to foresee the effects of changes like lowering the quarantine times.  The model is not a representation of reality and an increase in service level of 5 % might not result in an equal increase in reality. Instead the model should be used to compare the effects of different changes, like in demand, setup and quarantine times. Used in this way it is a powerful tool used in combination with the knowledge and experience of the supply department.

The model is built in such a way that it should be easy to make changes. This will enable the supply department to adjust the model to new prerequisites. They can move the oils around, add/remove tanks and alter the basic data that is stored in a database. They can also alter and change the demand and generate new sets using the Excel script.  The model could also with some minor changes be used to simulate other depots. It might not be useful if just small changes are to be made but if major changes are to be implemented it will for sure be worthwhile.

We are confident that the results of this master thesis will be useful for Nynas. They might not fully implement our suggested setup for 2008 but they will certainly have the results in mind when working with it. Furthermore Nynas now have a slightly better understanding of how the growing volumes will have for impact on the system. This understanding will give them more time to prepare necessary measures and understand where they will meet capacity constraints first.

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## 11.2 Figures

## 11.3 Tables

# Appendix 1A - Scenario 1

Original 2007 demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 23 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 16 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | | 3 |
| 6 | 111 | 48 | 740 | x | | 2 |
| 7 | 112 | 47 | 741 | x | | 2 |
| 8 | 113 | 9 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 22 | 1110 | x | x | 1 |
| 13 | 124 | 49 | 1110 | x | x | 1 |
| 14 | 204 | 0 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 1 | 1012 | x | | 4 |
| 17 | 210 | 0 | 1020 | x | | 4 |
| 18 | 211 | 49 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 0 | 1019 | x | | 4 |
| 21 | 215 | 16 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 0 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 10 | 2006 | x | | 6 |
| 26 | 333 | 12 | 2007 | | | 6 |
| 27 | 334 | 1 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 47 | 3331 | | | 10 |
| 32 | 412 | 24 | 740 | | | 12 |
| 33 | 441 | 24 | 825 | | | 11 |
| 34 | 442 | 24 | 828 | | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 0 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 46 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 45 | 187 | | x | 16 |
| 43 | 602 | 48 | 188 | | x | 16 |
| 44 | 603 | 5 | 188 | | x | 16 |
| 45 | 604 | 10 | 187 | | x | 16 |
| 46 | 605 | 42 | 186 | | x | 16 |
| 47 | 606 | 12 | 187 | | x | 16 |
| 48 | 607 | 16 | 187 | | x | 16 |
| 49 | 1005 | 21 | 1641 | | | 17 |
| 50 | 1006 | 13 | 1640 | | | 17 |
| 51 | 1012 | 8 | 1638 | | | 18 |
| 52 | 52 | | | | | |
| 53 | 53 | | | | | |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 3 | 4150 | | | 21 |
| 56 | 56 | | | | | |
| 57 | 57 | | | | | |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 61 | | | | | |
| 62 | 62 | | | | | |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 65 | | | | | |
| 66 | 66 | | | | | |
| 67 | 67 | | | | | |
| 68 | 68 | | | | | |
| 69 | 69 | | | | | |
| 70 | 70 | | | | | |
| 71 | 71 | | | | | |
| | | | **71641** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS trucks | boats | drums | AVERAGE TIME IN SYSTEM trucks | boats | drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | 200 | 200 | | x | 3012 | 635 | | 95,3% | | | 1,8 | |
| **NX3020** | 2 | | | | | | | | | | | | |
| **N9** | 3 | 500 | 1500 | 1100 | x | 4150 | 1550 | | | | | | |
| **NS3** | 4 | 250 | 400 | | x | 740 | 377 | 90,4% | | 100,0% | 0,9 | | 1,0 |
| **NS8** | 5 | 1300 | 1500 | | x | 3569 | 2063 | 88,0% | 100,0% | 82,4% | 0,9 | 1,0 | 1,4 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 300 | 300 | | x | 741 | 392 | 92,0% | | | 0,9 | | |
| **S 20** | 8 | 200 | 500 | | x | 1638 | 480 | 97,6% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 300 | | x | 741 | 335 | 91,5% | | 87,8% | 0,9 | | 1,2 |
| **S 100B** | 10 | 800 | 900 | | x | 2193 | 1021 | 61,3% | | 95,0% | 1,5 | | 1,2 |
| **S 150** | 11 | 100 | 500 | | x | 1011 | 336 | 88,6% | | | 1,3 | | |
| **SR 130** | 12 | 400 | 600 | | x | 2194 | 632 | 70,5% | | 100,0% | 1,4 | | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 1640 | 372 | 95,1% | | 100,0% | 0,8 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 1400 | 2000 | | x | 4547 | 1904 | 89,5% | 100,0% | 98,0% | 1,0 | 1,1 | 1,1 |
| **T 110** | 17 | 1700 | 1900 | | x | 4415 | 2303 | 68,8% | 99,7% | 92,0% | 1,3 | 1,1 | 1,2 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 300 | 600 | | x | 1110 | 435 | 86,3% | | 97,3% | 1,0 | | 1,1 |
| **T 4000** | 20 | 100 | 400 | 400 | x | 1110 | 648 | 93,8% | | 92,6% | 0,9 | | 1,2 |
| **S 9** | 21 | | 550 | 750 | x | 1641 | 695 | | | | | | |
| **S 90** | 22 | 350 | 600 | | x | 1110 | 950 | | 77,7% | | | 2,1 | |
| **NFR-40** | 23 | 100 | 250 | 200 | x | 739 | 411 | | | | | | |
| **Star 2** | 24 | 300 | 500 | 900 | x | 2393 | 1431 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 74,4% | | | 1,2 | | |
| **NYTRO 11GX** | 27 | | | | | | | 23,2% | | | 6,2 | | |
| **BNS 20** | 28 | | | | | | | 47,4% | | | 4,2 | | |
| **BNS 4** | 29 | | | | | | | 81,3% | | | 1,0 | | |
| **BNT 9** | 30 | | | | | | | 75,7% | | | 1,1 | | |
| **BST 21** | 31 | | | | | | | 51,3% | | | 4,4 | | |
| **BT 12** | 32 | | | | | | | 65,2% | | | 1,5 | | |
| **BT 10** | 33 | | | | | | | | | | 0,0 | | |
| **NYFLEX 8101** | 34 | | | | | | | 66,8% | | | 1,9 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 50,2% | | | 3,5 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 53,8% | | | 2,0 | | |
| **BT Group 1** | 39 | | | | | | | 58,7% | | | 1,8 | | |
| **BT Group 2** | 40 | | | | | | | 60,8% | | | 1,8 | | |
| **BT 470** | 41 | | | | | | | 61,5% | | | 1,7 | | |
| **NS 100** | 42 | 600 | | | x | 1836 | 878 | 95,7% | 100,0% | 100,0% | 0,8 | 1,1 | 1,1 |
| **NYFROST 32** | 43 | | | | | | | 59,5% | | | 1,9 | | |
| **NYFROS 68** | 44 | | | | | | | 44,7% | | | 2,3 | | |
| **NYTRO 4000A/X** | 45 | 500 | | | x | 927 | 754 | 86,0% | 0,0% | 96,1% | 1,4 | | 1,8 |
| **N Taurus** | 46 | 1600 | | | x | 4010 | 2919 | 64,0% | 71,5% | 80,6% | 4,8 | 4,1 | 3,3 |
| **N Libra** | 47 | 3000 | | | x | 11832 | 4612 | 86,3% | 95,0% | 75,4% | 1,1 | 1,5 | 2,2 |
| **N Lyra X** | 48 | 600 | | | x | 928 | 845 | 68,4% | | 82,7% | 2,5 | | 2,1 |
| **N Gemini X** | 49 | 900 | | | x | 2125 | 1643 | 37,4% | 37,0% | 39,9% | 9,8 | 8,4 | 6,4 |
| **T9** | 50 | 1700 | | | x | 3310 | 2927 | 44,5% | 99,2% | 88,3% | 2,1 | 1,1 | 1,4 |
| | | | | | | | **31548** | **73,2%** | **92,6%** | **80,8%** | 1,9 | 1,8 | 2,2 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 227920 | 51,8% |
| boat volume: | 185535 | 42,1% |
| drum volume: | 26747 | 6,1% |

**Total service level:** **81,88%**

| | | |
|---|---|---|
| **swing tank capacity:** | **7979** | 11,1% |
| **dedicated tank capacity:** | **63662** | 88,9% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 14,3% |
| 2 | 1B | 32,1% |
| 3 | 1C | 19,8% |
| 4 | 2A | 62,8% |
| 5 | 2B | 8,9% |
| 6 | 3B | 86,5% |
| 7 | 3C | 5,2% |
| 8 | 3F | 14,0% |
| 9 | 3H | 22,2% |
| 10 | 3J | 21,1% |
| 11 | 4B | 0,0% |
| 12 | 4E | 0,0% |
| 13 | 5A | 53,5% |
| 14 | 5B | 5,7% |
| 15 | 5C | 58,5% |
| 16 | 6A | 11,9% |
| 17 | 10A | 9,4% |
| 18 | 10B | 0,8% |

# Appendix 1C - Scenario 3

Original +10% demand

## TANK SETUP

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 23 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 16 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | | 3 |
| 6 | 111 | 48 | 740 | x | | 2 |
| 7 | 112 | 47 | 741 | x | | 2 |
| 8 | 113 | 9 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 22 | 1110 | x | x | 1 |
| 13 | 124 | 49 | 1110 | x | x | 1 |
| 14 | 204 | 0 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 1 | 1012 | x | | 4 |
| 17 | 210 | 0 | 1020 | x | | 4 |
| 18 | 211 | 49 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 0 | 1019 | x | | 4 |
| 21 | 215 | 16 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 0 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 10 | 2006 | x | | 6 |
| 26 | 333 | 12 | 2007 | | | 6 |
| 27 | 334 | 1 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 47 | 3331 | | | 10 |
| 32 | 412 | 24 | 740 | | | 12 |
| 33 | 441 | 24 | 825 | | | 11 |
| 34 | 442 | 24 | 828 | | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 0 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 46 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 45 | 187 | | x | 16 |
| 43 | 602 | 48 | 188 | | x | 16 |
| 44 | 603 | 5 | 188 | | x | 16 |
| 45 | 604 | 10 | 187 | | x | 16 |
| 46 | 605 | 42 | 186 | | x | 16 |
| 47 | 606 | 12 | 187 | | x | 16 |
| 48 | 607 | 16 | 187 | | x | 16 |
| 49 | 1005 | 21 | 1641 | | | 17 |
| 50 | 1006 | 13 | 1640 | | | 17 |
| 51 | 1012 | 8 | 1638 | | | 18 |
| 52 | 52 | | | | | |
| 53 | 53 | | | | | |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 3 | 4150 | | | 21 |
| 56 | 56 | | | | | |
| 57 | 57 | | | | | |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 61 | | | | | |
| 62 | 62 | | | | | |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 65 | | | | | |
| 66 | 66 | | | | | |
| 67 | 67 | | | | | |
| 68 | 68 | | | | | |
| 69 | 69 | | | | | |
| 70 | 70 | | | | | |
| 71 | 71 | | | | | |
| | | | **71641** | | | |

## OIL DATA / SERVICE LEVELS / AVERAGE TIME IN SYSTEM

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS trucks | boats | drums | AVERAGE TIME IN SYSTEM trucks | boats | drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | 200 | 200 | | x | 3012 | 676 | | 94,4% | | | 1,8 | |
| **NX3020** | 2 | | | | | | | | | | | | |
| **N9** | 3 | 500 | 1500 | 1100 | x | 4150 | 1466 | | | | | | |
| **NS3** | 4 | 250 | 400 | | x | 740 | 378 | 83,1% | | 87,5% | 1,0 | | 1,2 |
| **NS8** | 5 | 1300 | 1500 | | x | 3569 | 2332 | 79,5% | 100,0% | 83,4% | 1,3 | 1,0 | 1,4 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 300 | 300 | | x | 741 | 397 | 92,4% | | | 0,8 | | |
| **S 20** | 8 | 200 | 500 | | x | 1638 | 476 | 97,4% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 300 | | x | 741 | 325 | 84,3% | | 100,0% | 1,0 | | 1,1 |
| **S 100B** | 10 | 800 | 900 | | x | 2193 | 1027 | 53,9% | | 97,1% | 1,9 | | 1,1 |
| **S 150** | 11 | 100 | 500 | | x | 1011 | 328 | 71,0% | | | 1,9 | | |
| **SR 130** | 12 | 400 | 600 | | x | 2194 | 626 | 59,6% | | 100,0% | 1,9 | | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 1640 | 369 | 93,4% | | 87,5% | 0,8 | | 1,5 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 1400 | 2000 | | x | 4547 | 1851 | 86,7% | 99,7% | 97,5% | 1,0 | 1,2 | 1,1 |
| **T 110** | 17 | 1700 | 1900 | | x | 4415 | 2282 | 58,8% | 99,6% | 91,6% | 1,7 | 1,1 | 1,2 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 300 | 600 | | x | 1110 | 414 | 85,8% | | 96,5% | 1,0 | | 1,2 |
| **T 4000** | 20 | 100 | 400 | 400 | x | 1110 | 651 | 90,8% | | 100,0% | 0,9 | | 1,1 |
| **S 9** | 21 | 0 | 550 | 750 | x | 1641 | 629 | | | | | | |
| **S 90** | 22 | 350 | 600 | | x | 1110 | 900 | | 82,6% | | | 1,9 | |
| **NFR-40** | 23 | 100 | 250 | 200 | x | 739 | 406 | | | | | | |
| **Star 2** | 24 | 300 | 500 | 900 | x | 2393 | 1405 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 74,9% | | | 1,2 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 50,5% | | | 3,4 | | |
| **BNS 4** | 29 | | | | | | | 81,3% | | | 1,0 | | |
| **BNT 9** | 30 | | | | | | | 76,9% | | | 1,2 | | |
| **BST 21** | 31 | | | | | | | 54,3% | | | 3,3 | | |
| **BT 12** | 32 | | | | | | | 63,4% | | | 1,5 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 53,2% | | | 2,8 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 42,2% | | | 3,6 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 52,3% | | | 2,2 | | |
| **BT Group 1** | 39 | | | | | | | 55,7% | | | 2,2 | | |
| **BT Group 2** | 40 | | | | | | | 55,9% | | | 2,1 | | |
| **BT 470** | 41 | | | | | | | 57,1% | | | 2,2 | | |
| **NS 100** | 42 | 600 | | | x | 1836 | 851 | 94,0% | 100,0% | 100,0% | 0,8 | 1,1 | 1,1 |
| **NYFROST 32** | 43 | | | | | | | 51,6% | | | 2,0 | | |
| **NYFROS 68** | 44 | | | | | | | 40,6% | | | 2,4 | | |
| **NYTRO 4000A/X** | 45 | 500 | | | x | 927 | 768 | 77,9% | | 86,8% | 1,7 | | 1,8 |
| **N Taurus** | 46 | 1600 | | | x | 4010 | 2838 | 47,0% | 59,7% | 72,0% | 21,7 | 5,4 | 4,7 |
| **N Libra** | 47 | 3000 | | | x | 11832 | 4537 | 65,2% | 83,9% | 67,5% | 2,1 | 2,1 | 2,8 |
| **N Lyra X** | 48 | 600 | | | x | 928 | 785 | 29,3% | | 55,5% | 8,4 | | 4,2 |
| **N Gemini X** | 49 | 900 | | | x | 2125 | 1658 | 11,1% | 9,0% | 26,1% | 53,3 | 11,8 | 12,7 |
| **T9** | 50 | 1700 | | | x | 3310 | 2930 | 43,5% | 99,4% | 94,8% | 2,3 | 1,1 | 1,2 |
| | | | | | | | **31305** | **63,8%** | **87,6%** | **73,7%** | 5,1 | 2,3 | 3,0 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 238804 | 50,0% |
| boat volume: | 208932 | 43,7% |
| drum volume: | 30122 | 6,3% |

**Total service level:** **74,81%**

| | | |
|---|---|---|
| **swing tank capacity:** | **7979** | 11,1% |
| **dedicated tank capacity:** | **63662** | 88,9% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 12,6% |
| 2 | 1B | 37,6% |
| 3 | 1C | 22,5% |
| 4 | 2A | 62,8% |
| 5 | 2B | 13,0% |
| 6 | 3B | 86,8% |
| 7 | 3C | 4,6% |
| 8 | 3F | 23,6% |
| 9 | 3H | 22,7% |
| 10 | 3J | 19,3% |
| 11 | 4B | 0,0% |
| 12 | 4E | 0,0% |
| 13 | 5A | 56,0% |
| 14 | 5B | 6,5% |
| 15 | 5C | 59,9% |
| 16 | 6A | 14,6% |
| 17 | 10A | 9,1% |
| 18 | 10B | 1,0% |

# Appendix 1B - Scenario 2

Actual 2007 demand

## TANK SETUP

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 9 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 49 | 1110 | x | x | 1 |
| 14 | 204 | 21 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 49 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 9 | 1019 | x | | 4 |
| 21 | 215 | 16 | 1010 | | | 4 |
| 22 | 315 | 9 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 10 | 2006 | x | | 6 |
| 26 | 333 | 12 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 22 | 828 | | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 0 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 0 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | | | | | |
| 53 | 1311 | | | | | |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | | | | | |
| 57 | 57 | | | | | |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 61 | | | | | |
| 62 | 62 | | | | | |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 65 | | | | | |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 67 | | | | | |
| 68 | 68 | | | | | |
| 69 | 69 | | | | | |
| 70 | 70 | | | | | |
| 71 | 71 | | | | | |
| | | | **72354** | | | |

## OIL DATA / SERVICE LEVELS / AVERAGE TIME IN SYSTEM

| | OIL DATA | | | | | | | SERVICE LEVELS | | | AVERAGE TIME IN SYSTEM | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | trucks | boats | drums | trucks | boats | drums |
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 753 | | 74,7% | | | 4,1 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 358 | 94,3% | | 83,3% | 0,8 | | 1,3 |
| **NS8** | 5 | 1000 | 1500 | | x | 4491 | 1397 | 89,7% | 99,7% | 81,4% | 1,0 | 1,1 | 1,4 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 315 | 95,6% | | | 0,8 | | |
| **S 20** | 8 | 200 | 400 | | x | 1454 | 434 | 99,2% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 300 | | x | 2510 | 361 | 95,9% | | 100,0% | 0,8 | | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 3026 | 801 | 91,8% | | 98,5% | 0,9 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 302 | 95,8% | | 0,0% | 0,9 | | 0,0 |
| **SR 130** | 12 | 250 | 600 | | x | 2195 | 484 | 90,2% | | 100,0% | 0,9 | | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 324 | 96,1% | | 100,0% | 0,8 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 1500 | 1800 | | x | 3620 | 1899 | 71,4% | 99,7% | 89,6% | 1,3 | 1,1 | 1,3 |
| **T 110** | 17 | 1600 | 1900 | | x | 4415 | 2097 | 79,9% | 100,0% | 94,9% | 1,1 | 1,1 | 1,2 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 100 | 400 | 300 | x | 1110 | 415 | 87,1% | | 96,7% | 0,9 | | 1,1 |
| **T 4000** | 20 | 50 | 300 | 300 | x | 1110 | 444 | 95,0% | | 92,6% | 0,8 | | 1,2 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1010 | 492 | | | | | | |
| **S 90** | 22 | 0 | 300 | 350 | x | 828 | 721 | | 72,0% | | | 2,9 | |
| **NFR-40** | 23 | 0 | 250 | 200 | x | 1480 | 326 | | | | | | |
| **Star 2** | 24 | 0 | 400 | 1200 | x | 2004 | 1173 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 78,5% | | | 1,2 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 17,8% | | | ### | | |
| **BNS 4** | 29 | | | | | | | 81,7% | | | 1,1 | | |
| **BNT 9** | 30 | | | | | | | 54,8% | | | 1,8 | | |
| **BST 21** | 31 | | | | | | | 25,0% | | | 9,4 | | |
| **BT 12** | 32 | | | | | | | 44,4% | | | 2,3 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 66,0% | | | 1,6 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 30,3% | | | ### | | |
| **NS30 / BNS 30** | 38 | | | | | | | 40,2% | | | 3,0 | | |
| **BT Group 1** | 39 | | | | | | | 59,4% | | | 1,7 | | |
| **BT Group 2** | 40 | | | | | | | 42,9% | | | 2,5 | | |
| **BT 470** | 41 | | | | | | | 56,5% | | | 1,7 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 690 | 94,8% | 97,3% | 97,9% | 0,9 | 1,2 | 1,2 |
| **NYFROST 32** | 43 | | | | | | | 41,3% | | | 2,7 | | |
| **NYFROS 68** | 44 | | | | | | | 38,7% | | | 2,5 | | |
| **NYTRO 4000A/X** | 45 | 400 | | | x | 1480 | 672 | 86,7% | | 92,1% | 1,4 | | 1,7 |
| **N Taurus** | 46 | 3000 | | | x | 7276 | 3797 | 83,5% | 74,5% | 90,5% | 1,8 | 3,4 | 1,7 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5552 | 93,0% | 97,3% | 77,6% | 0,9 | 1,3 | 2,1 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1839 | 99,3% | | 100,0% | 0,8 | | 1,1 |
| **N Gemini X** | 49 | 1600 | | | x | 4122 | 2250 | 71,0% | 67,2% | 59,3% | 2,4 | 4,2 | 3,0 |
| **T9** | 50 | 1700 | | | x | 3497 | 1908 | 49,9% | 78,4% | 70,1% | 5,3 | 2,9 | 2,5 |
| | | | | | | | **29805** | **77,0%** | **89,4%** | **84,8%** | 1,9 | 2,0 | 1,6 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 227920 | 51,8% |
| boat volume: | 185535 | 42,1% |
| drum volume: | 26747 | 6,1% |

**Total service level: 82,72%**

| | | |
|---|---|---|
| **swing tank capacity:** | **4255** | 5,9% |
| **dedicated tank capacity:** | **68099** | 94,1% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 25,6% |
| 2 | 1B | 28,8% |
| 3 | 1C | 7,2% |
| 4 | 2A | 58,4% |
| 5 | 2B | 22,7% |
| 6 | 3B | 64,2% |
| 7 | 3C | 10,8% |
| 8 | 3F | 0,1% |
| 9 | 3H | 26,7% |
| 10 | 3J | 32,4% |
| 11 | 4B | 0,0% |
| 12 | 4E | 0,5% |
| 13 | 5A | 50,5% |
| 14 | 5B | 0,0% |
| 15 | 5C | 60,4% |
| 16 | 6A | 12,7% |
| 17 | 10A | 16,3% |
| 18 | 10B | 7,6% |

# Appendix 1D - Scenario 4

Actual +10% demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 9 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 49 | 1110 | x | x | 1 |
| 14 | 204 | 21 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 49 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 9 | 1019 | x | | 4 |
| 21 | 215 | 16 | 1010 | | | 4 |
| 22 | 315 | 9 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 10 | 2006 | x | | 6 |
| 26 | 333 | 12 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 22 | 828 | | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 0 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 0 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | | | | | |
| 53 | 1311 | | | | | |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | | | | | |
| 57 | 57 | | | | | |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 61 | | | | | |
| 62 | 62 | | | | | |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 65 | | | | | |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 67 | | | | | |
| 68 | 68 | | | | | |
| 69 | 69 | | | | | |
| 70 | 70 | | | | | |
| 71 | 71 | | | | | |
| | | | **72354** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS trucks | SERVICE LEVELS boats | SERVICE LEVELS drums | AVERAGE TIME IN SYSTEM trucks | AVERAGE TIME IN SYSTEM boats | AVERAGE TIME IN SYSTEM drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 792 | | 87,0% | | | 2,6 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 365 | 94,7% | | 100,0% | 0,9 | | 1,1 |
| **NS8** | 5 | 1000 | 1500 | | x | 4491 | 1364 | 90,8% | 99,0% | 83,3% | 0,9 | 1,1 | 1,4 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 318 | 94,9% | | | 0,8 | | |
| **S 20** | 8 | 200 | 400 | | x | 1454 | 448 | 99,0% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 300 | | x | 2510 | 356 | 97,2% | | 100,0% | 0,9 | | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 3026 | 802 | 87,5% | | 100,0% | 0,9 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 333 | 60,1% | | | 1,4 | | |
| **SR 130** | 12 | 250 | 600 | | x | 2195 | 471 | 86,8% | | 96,7% | 1,0 | | 1,2 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 326 | 94,5% | | 83,3% | 0,8 | | 1,9 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 1500 | 1800 | | x | 3620 | 1850 | 64,4% | 99,8% | 90,1% | 1,4 | 1,2 | 1,2 |
| **T 110** | 17 | 1600 | 1900 | | x | 4415 | 2094 | 77,6% | 100,0% | 96,6% | 1,1 | 1,1 | 1,1 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 100 | 400 | 300 | x | 1110 | 415 | 86,9% | | 97,0% | 1,0 | | 1,1 |
| **T 4000** | 20 | 50 | 300 | 300 | x | 1110 | 440 | 91,1% | | 100,0% | 0,9 | | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1010 | 470 | | | | | | |
| **S 90** | 22 | 0 | 300 | 350 | x | 828 | 649 | | 67,9% | | | 2,7 | |
| **NFR-40** | 23 | 0 | 250 | 200 | x | 1480 | 317 | | | | | | |
| **Star 2** | 24 | 0 | 400 | 1200 | x | 2004 | 1129 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 77,4% | | | 1,1 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 16,6% | | | 10,6 | | |
| **BNS 4** | 29 | | | | | | | 78,2% | | | 1,1 | | |
| **BNT 9** | 30 | | | | | | | 47,3% | | | 2,0 | | |
| **BST 21** | 31 | | | | | | | 27,4% | | | 8,2 | | |
| **BT 12** | 32 | | | | | | | 43,0% | | | 2,2 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 57,2% | | | 2,0 | | |
| **NYFLEX 8031** | 35 | | | | | | | 0,0% | | | 0,0 | | |
| **NYFLEX 841** | 36 | | | | | | | 0,0% | | | 0,0 | | |
| **NYTEX 8022** | 37 | | | | | | | 24,4% | | | 9,1 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 36,8% | | | 2,8 | | |
| **BT Group 1** | 39 | | | | | | | 58,4% | | | 1,6 | | |
| **BT Group 2** | 40 | | | | | | | 44,1% | | | 2,3 | | |
| **BT 470** | 41 | | | | | | | 55,9% | | | 1,6 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 660 | 95,3% | 96,7% | 99,4% | 0,8 | 1,1 | 1,1 |
| **NYFROST 32** | 43 | | | | | | | 34,8% | | | 2,5 | | |
| **NYFROS 68** | 44 | | | | | | | 37,5% | | | 2,9 | | |
| **NYTRO 4000A/X** | 45 | 400 | | | x | 1480 | 672 | 75,5% | | 84,5% | 2,6 | | |
| **N Taurus** | 46 | 3000 | | | x | 7276 | 3727 | 69,7% | 67,9% | 82,6% | 5,9 | 4,0 | 2,3 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5411 | 79,0% | 93,3% | 74,3% | 1,5 | 1,5 | 2,3 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1773 | 99,2% | | 99,7% | 0,8 | | 1,1 |
| **N Gemini X** | 49 | 1600 | | | x | 4122 | 2197 | 47,3% | 53,8% | 48,3% | 7,5 | 6,3 | 5,5 |
| **T9** | 50 | 1700 | | | x | 3497 | 2097 | 49,7% | 77,1% | 81,1% | 3,9 | 2,6 | 1,9 |
| | | | | | | | **29476** | **71,9%** | **87,1%** | **82,7%** | 2,8 | 2,3 | 2,0 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 238804 | 50,0% |
| boat volume: | 208932 | 43,7% |
| drum volume: | 30122 | 6,3% |

**Total service level:** **79,26%**

| | | |
|---|---|---|
| **swing tank capacity:** | **4255** | 5,9% |
| **dedicated tank capacity:** | **68099** | 94,1% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 24,7% |
| 2 | 1B | 29,9% |
| 3 | 1C | 7,7% |
| 4 | 2A | 65,6% |
| 5 | 2B | 28,4% |
| 6 | 3B | 66,2% |
| 7 | 3C | 11,7% |
| 8 | 3F | 0,1% |
| 9 | 3H | 27,4% |
| 10 | 3J | 35,9% |
| 11 | 4B | 0,0% |
| 12 | 4E | 0,4% |
| 13 | 5A | 51,5% |
| 14 | 5B | 0,0% |
| 15 | 5C | 60,3% |
| 16 | 6A | 14,6% |
| 17 | 10A | 18,3% |
| 18 | 10B | 10,7% |

# Appendix 1E - Scenario 5

2008 setup 2007 demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | trucks | boats | drums | trucks (avg. time) | boats (avg. time) | drums (avg. time) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 487 | | 100,0% | | | 1,5 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 357 | 95,4% | | 100,0% | 0,8 | | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1521 | 93,7% | 100,0% | 82,7% | 0,9 | 1,1 | 1,3 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 288 | 97,8% | | | 0,8 | | |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 363 | 98,9% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 458 | 98,9% | | 100,0% | 0,8 | | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 667 | 95,9% | | 99,6% | 0,8 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 266 | 97,9% | | | 0,8 | | |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 319 | 92,5% | | 97,8% | 0,9 | | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 277 | 96,3% | | 100,0% | 0,8 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2228 | 90,1% | 100,0% | 97,5% | 0,9 | 1,1 | 1,1 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2376 | 95,0% | 100,0% | 97,3% | 0,8 | 1,1 | 1,1 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 576 | 89,2% | | 96,9% | 0,9 | | 1,1 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 348 | 94,8% | | 100,0% | 0,8 | | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 509 | | | | | | |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1538 | | 95,0% | | | 1,8 | |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 492 | | | | | | |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1309 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 84,5% | | | 1,0 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 75,6% | | | 1,1 | | |
| **BNS 4** | 29 | | | | | | | 94,4% | | | 0,8 | | |
| **BNT 9** | 30 | | | | | | | 88,0% | | | 0,9 | | |
| **BST 21** | 31 | | | | | | | 82,1% | | | 1,0 | | |
| **BT 12** | 32 | | | | | | | 71,0% | | | 1,3 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 57,6% | | | 3,3 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 73,5% | | | 1,1 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 65,3% | | | 1,5 | | |
| **BT Group 1** | 39 | | | | | | | 62,0% | | | 1,6 | | |
| **BT Group 2** | 40 | | | | | | | 72,6% | | | 1,4 | | |
| **BT 470** | 41 | | | | | | | 63,6% | | | 1,6 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 767 | 97,4% | 100,0% | 98,2% | 0,8 | 1,2 | 1,1 |
| **NYFROST 32** | 43 | | | | | | | 61,5% | | | 1,8 | | |
| **NYFROS 68** | 44 | | | | | | | 50,4% | | | 3,2 | | |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 932 | 98,9% | | 100,0% | 0,8 | | 1,1 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 5005 | 94,5% | 92,0% | 97,1% | 1,0 | 1,9 | 1,2 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5600 | 92,8% | 95,6% | 76,7% | 1,0 | 1,4 | 2,1 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1842 | 98,9% | | 100,0% | 0,8 | | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2717 | 87,8% | 85,2% | 68,2% | 1,3 | 2,7 | 2,0 |
| **T9** | 50 | 1900 | | | x | 6245 | 3217 | 97,2% | 99,8% | 91,5% | 0,8 | 1,3 | 1,2 |
| | | | | | | | **34461** | **92,0%** | **97,6%** | **87,8%** | 0,9 | 1,4 | 1,5 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 227920 | 51,8% |
| boat volume: | 185535 | 42,1% |
| drum volume: | 26747 | 6,1% |

**Total service level:** **94,09%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 21,4% |
| 2 | 1B | 31,9% |
| 3 | 1C | 6,1% |
| 4 | 2A | 45,2% |
| 5 | 2B | 21,1% |
| 6 | 3B | 60,8% |
| 7 | 3C | 14,0% |
| 8 | 3F | 5,2% |
| 9 | 3H | 26,6% |
| 10 | 3J | 6,8% |
| 11 | 4B | 3,5% |
| 12 | 4E | 0,4% |
| 13 | 5A | 68,2% |
| 14 | 5B | 13,2% |
| 15 | 5C | 56,9% |
| 16 | 6A | 3,7% |
| 17 | 10A | 24,7% |
| 18 | 10B | 13,3% |
| 19 | 13A | 1,6% |

# Appendix 1F - Scenario 6

2008 setup 10% higher demand

## TANK SETUP

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

## OIL DATA / SERVICE LEVELS / AVERAGE TIME IN SYSTEM

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | Service levels: trucks | Service levels: boats | Service levels: drums | Average time in system: trucks | Average time in system: boats | Average time in system: drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 530 | | 98,4% | | | 1,6 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 361 | 95,2% | | 100,0% | 0,8 | | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1474 | 94,1% | 100,0% | 83,9% | 0,8 | 1,1 | 1,4 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 297 | 96,6% | | | 0,8 | | |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 350 | 99,1% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 463 | 95,5% | | 100,0% | 0,8 | | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 662 | 95,1% | | 98,8% | 0,8 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 328 | 81,7% | | | 1,2 | | |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 316 | 91,5% | | 100,0% | 0,9 | | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 282 | 94,9% | | 100,0% | 0,8 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2210 | 88,9% | 100,0% | 93,1% | 0,9 | 1,1 | 1,2 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2393 | 93,3% | 100,0% | 97,4% | 0,8 | 1,1 | 1,1 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 564 | 87,6% | | 93,3% | 0,9 | | 1,2 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 343 | 95,0% | | 100,0% | 0,8 | | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 461 | | | | | | |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1530 | | 99,1% | | | 1,7 | |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 483 | | | | | | |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1274 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 82,4% | | | 1,0 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 76,7% | | | 1,1 | | |
| **BNS 4** | 29 | | | | | | | 90,2% | | | 0,9 | | |
| **BNT 9** | 30 | | | | | | | 83,4% | | | 1,0 | | |
| **BST 21** | 31 | | | | | | | 80,7% | | | 1,1 | | |
| **BT 12** | 32 | | | | | | | 69,5% | | | 1,3 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 53,3% | | | 2,9 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 73,9% | | | 1,5 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 65,0% | | | 1,5 | | |
| **BT Group 1** | 39 | | | | | | | 58,0% | | | 1,9 | | |
| **BT Group 2** | 40 | | | | | | | 71,5% | | | 1,5 | | |
| **BT 470** | 41 | | | | | | | 54,0% | | | 1,9 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 706 | 96,3% | 100,0% | 99,3% | 0,8 | 1,2 | 1,1 |
| **NYFROST 32** | 43 | | | | | | | 57,2% | | | 1,7 | | |
| **NYFROS 68** | 44 | | | | | | | 54,1% | | | 2,6 | | |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 903 | 94,5% | | 98,5% | 1,0 | | 1,2 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 4808 | 90,9% | 89,2% | 96,7% | 1,6 | 2,2 | 1,5 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5319 | 82,1% | 92,6% | 75,1% | 1,5 | 1,6 | 2,2 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1750 | 97,4% | | 100,0% | 0,8 | | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2705 | 71,4% | 71,7% | 62,5% | 2,9 | 3,6 | 2,5 |
| **T9** | 50 | 1900 | | | x | 6245 | 3234 | 96,5% | 99,4% | 96,7% | 0,8 | 1,3 | 1,1 |
| | | | | | | | **33746** | **88,8%** | **95,9%** | **86,9%** | 1,1 | 1,5 | 1,6 |

| **Sevvice levels** | | |
|---|---|---|
| truck volume: | 238804 | 50,0% |
| boat volume: | 208932 | 43,7% |
| drum volume: | 30122 | 6,3% |

**Total service level: 91,81%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 22,3% |
| 2 | 1B | 32,8% |
| 3 | 1C | 6,4% |
| 4 | 2A | 54,4% |
| 5 | 2B | 26,8% |
| 6 | 3B | 61,0% |
| 7 | 3C | 13,9% |
| 8 | 3F | 8,7% |
| 9 | 3H | 26,5% |
| 10 | 3J | 9,5% |
| 11 | 4B | 2,3% |
| 12 | 4E | 0,5% |
| 13 | 5A | 68,1% |
| 14 | 5B | 14,9% |
| 15 | 5C | 52,5% |
| 16 | 6A | 4,5% |
| 17 | 10A | 27,0% |
| 18 | 10B | 17,9% |
| 19 | 13A | 1,9% |

# Appendix 1G - Scenario 7

2008 setup 20% higher demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | trucks | boats | drums | trucks | boats | drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 569 | | 96,9% | | | 1,7 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 300 | 88,7% | | 100,0% | 1,0 | | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1136 | 82,6% | 94,6% | 77,1% | 1,4 | 1,5 | 1,6 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 292 | 96,4% | | | 0,8 | | |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 366 | 97,9% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 432 | 95,2% | | 100,0% | 0,9 | | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 645 | 89,0% | | 98,4% | 1,0 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 262 | 74,3% | | | 1,2 | | |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 301 | 87,4% | | 97,1% | 1,0 | | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 266 | 90,1% | | 100,0% | 0,9 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 1519 | 68,6% | 88,2% | 87,5% | 2,2 | 1,8 | 1,6 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 1797 | 87,7% | 98,1% | 95,0% | 1,0 | 1,3 | 1,2 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 446 | 84,1% | | 89,5% | 1,1 | | 1,4 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 305 | 89,6% | | 92,3% | 0,9 | | 1,2 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 398 | | | | | | |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1209 | | 76,6% | | | 2,7 | |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 483 | | | | | | |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1274 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 79,8% | | | 1,1 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 56,2% | | | 4,6 | | |
| **BNS 4** | 29 | | | | | | | 84,1% | | | 1,2 | | |
| **BNT 9** | 30 | | | | | | | 75,0% | | | 1,7 | | |
| **BST 21** | 31 | | | | | | | 61,7% | | | 3,2 | | |
| **BT 12** | 32 | | | | | | | 57,5% | | | 2,5 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 48,2% | | | 4,4 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 46,6% | | | 4,5 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 47,2% | | | 3,1 | | |
| **BT Group 1** | 39 | | | | | | | 53,7% | | | 2,2 | | |
| **BT Group 2** | 40 | | | | | | | 58,3% | | | 2,3 | | |
| **BT 470** | 41 | | | | | | | 50,1% | | | 2,3 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 510 | 74,7% | 84,7% | 82,0% | 2,5 | 2,1 | 2,1 |
| **NYFROST 32** | 43 | | | | | | | 43,5% | | | 3,1 | | |
| **NYFROS 68** | 44 | | | | | | | 47,9% | | | 3,4 | | |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 863 | 88,5% | | 95,4% | 1,5 | | 1,5 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 3859 | 65,3% | 70,3% | 77,7% | 8,9 | 4,3 | 3,0 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 4678 | 38,7% | 71,3% | 58,3% | ### | 3,1 | 3,7 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1621 | 92,2% | | 98,2% | 1,0 | | 1,2 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2509 | 52,0% | 47,5% | 53,9% | 6,4 | 6,4 | 3,7 |
| **T9** | 50 | 1900 | | | x | 6245 | 2264 | 81,9% | 89,7% | 85,6% | 2,2 | 2,1 | 1,8 |
| | | | | | | | **28302** | **71,5%** | **83,1%** | **76,9%** | 3,7 | 2,6 | 2,4 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 262789 | 50,0% |
| boat volume: | 229825 | 43,7% |
| drum volume: | 33124 | 6,3% |

**Total service level:** **76,89%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 24,0% |
| 2 | 1B | 42,5% |
| 3 | 1C | 6,7% |
| 4 | 2A | 57,5% |
| 5 | 2B | 24,5% |
| 6 | 3B | 59,0% |
| 7 | 3C | 12,2% |
| 8 | 3F | 14,2% |
| 9 | 3H | 28,1% |
| 10 | 3J | 19,1% |
| 11 | 4B | 7,2% |
| 12 | 4E | 0,5% |
| 13 | 5A | 68,3% |
| 14 | 5B | 15,8% |
| 15 | 5C | 49,5% |
| 16 | 6A | 9,3% |
| 17 | 10A | 28,1% |
| 18 | 10B | 18,2% |
| 19 | 13A | 5,6% |

# Appendix 1H - Scenario 8

2008 setup+boat 2007 demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | trucks (service level) | boats (service level) | drums (service level) | trucks (avg. time) | boats (avg. time) | drums (avg. time) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 500 | | 100,0% | | | 1,6 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 368 | 96,0% | | 100,0% | 0,8 | | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1654 | 95,1% | 100,0% | 83,9% | 0,8 | 1,0 | 1,3 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 286 | 96,1% | | | 0,8 | | |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 358 | 98,4% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 453 | 98,3% | | 100,0% | 0,8 | | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 667 | 96,7% | | 99,5% | 0,8 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 278 | 93,0% | | | 0,8 | | |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 318 | 92,2% | | 96,7% | 0,9 | | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 281 | 96,1% | | 100,0% | 0,8 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2472 | 91,7% | 100,0% | 97,4% | 0,9 | 1,1 | 1,1 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2594 | 94,9% | 100,0% | 98,0% | 0,8 | 1,0 | 1,1 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 598 | 89,4% | | 93,9% | 0,9 | | 1,2 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 353 | 96,1% | | 100,0% | 0,8 | | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 518 | | | | | | |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1830 | | 98,8% | | | 1,7 | |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 486 | | | | | | |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1294 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 84,4% | | | 1,0 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 76,8% | | | 1,1 | | |
| **BNS 4** | 29 | | | | | | | 92,8% | | | 0,9 | | |
| **BNT 9** | 30 | | | | | | | 91,7% | | | 0,8 | | |
| **BST 21** | 31 | | | | | | | 83,2% | | | 1,0 | | |
| **BT 12** | 32 | | | | | | | 69,8% | | | 1,3 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 66,0% | | | 1,7 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 79,4% | | | 1,2 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 63,2% | | | 1,4 | | |
| **BT Group 1** | 39 | | | | | | | 66,2% | | | 1,3 | | |
| **BT Group 2** | 40 | | | | | | | 73,4% | | | 1,2 | | |
| **BT 470** | 41 | | | | | | | 61,8% | | | 1,4 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 797 | 97,9% | 100,0% | 99,0% | 0,8 | 1,1 | 1,2 |
| **NYFROST 32** | 43 | | | | | | | 62,9% | | | 1,6 | | |
| **NYFROS 68** | 44 | | | | | | | 51,5% | | | 2,6 | | |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 941 | 98,5% | | 100,0% | 0,8 | | 1,1 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 5087 | 95,1% | 95,8% | 97,3% | 0,9 | 1,6 | 1,2 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 6046 | 97,6% | 99,3% | 77,8% | 0,8 | 1,2 | 2,1 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1858 | 98,9% | | 100,0% | 0,8 | | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2853 | 92,0% | 89,3% | 68,2% | 1,0 | 1,9 | 1,8 |
| **T9** | 50 | 1900 | | | x | 6245 | 3638 | 97,1% | 99,7% | 90,7% | 0,8 | 1,3 | 1,2 |
| | | | | | | | **36529** | **93,1%** | **98,9%** | **88,3%** | 0,9 | 1,3 | 1,4 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 227920 | 51,8% |
| boat volume: | 185535 | 42,1% |
| drum volume: | 26747 | 6,1% |

**Total service level:** **95,29%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 22,6% |
| 2 | 1B | 29,0% |
| 3 | 1C | 6,3% |
| 4 | 2A | 44,1% |
| 5 | 2B | 20,9% |
| 6 | 3B | 59,3% |
| 7 | 3C | 8,5% |
| 8 | 3F | 6,4% |
| 9 | 3H | 26,5% |
| 10 | 3J | 13,8% |
| 11 | 4B | 5,1% |
| 12 | 4E | 0,4% |
| 13 | 5A | 69,5% |
| 14 | 5B | 12,4% |
| 15 | 5C | 59,2% |
| 16 | 6A | 3,3% |
| 17 | 10A | 22,5% |
| 18 | 10B | 13,5% |
| 19 | 13A | 1,2% |

# Appendix 1I - Scenario 9

2008 setup+boat +10% higher demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | Service levels: trucks | Service levels: boats | Service levels: drums | Avg. time: trucks | Avg. time: boats | Avg. time: drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 648 | | 99,1% | | | 1,6 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 365 | 95,1% | | 100,0% | 0,8 | | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1636 | 95,1% | 100,0% | 84,1% | 0,8 | 1,0 | 1,3 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 301 | 98,7% | | | 0,8 | | |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 366 | 97,8% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 470 | 94,6% | | 100,0% | 0,8 | | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 667 | 96,7% | | 99,5% | 0,8 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 334 | 91,4% | | | 0,9 | | |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 322 | 91,7% | | 92,3% | 0,9 | | 1,3 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 281 | 96,2% | | 100,0% | 0,8 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2495 | 90,7% | 100,0% | 94,7% | 0,9 | 1,1 | 1,2 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2605 | 94,7% | 100,0% | 96,5% | 0,8 | 1,1 | 1,2 |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 590 | 89,7% | | 97,2% | 0,9 | | 1,1 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 347 | 97,3% | | 96,2% | 0,8 | | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 505 | | | | | | |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1542 | | 98,5% | | | 1,9 | |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 484 | | | | | | |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1270 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 85,6% | | | 1,0 | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | 76,3% | | | 1,1 | | |
| **BNS 4** | 29 | | | | | | | 91,3% | | | 0,9 | | |
| **BNT 9** | 30 | | | | | | | 93,7% | | | 0,8 | | |
| **BST 21** | 31 | | | | | | | 81,0% | | | 1,0 | | |
| **BT 12** | 32 | | | | | | | 69,8% | | | 1,3 | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | 64,4% | | | 2,2 | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | 75,0% | | | 1,1 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 65,2% | | | 1,4 | | |
| **BT Group 1** | 39 | | | | | | | 60,3% | | | 1,6 | | |
| **BT Group 2** | 40 | | | | | | | 74,2% | | | 1,3 | | |
| **BT 470** | 41 | | | | | | | 63,1% | | | 1,6 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 773 | 97,7% | 100,0% | 100,0% | 0,8 | 1,0 | 1,1 |
| **NYFROST 32** | 43 | | | | | | | 66,3% | | | 1,7 | | |
| **NYFROS 68** | 44 | | | | | | | 57,9% | | | 2,5 | | |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 913 | 97,7% | | 100,0% | 0,8 | | 1,1 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 4943 | 91,2% | 91,5% | 96,2% | 1,4 | 1,5 | 1,3 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5973 | 93,4% | 99,1% | 76,9% | 0,9 | 1,2 | 2,2 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1791 | 98,8% | | 100,0% | 0,8 | | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2852 | 79,1% | 76,8% | 63,9% | 2,0 | 3,3 | 2,4 |
| **T9** | 50 | 1900 | | | x | 6245 | 3555 | 97,6% | 99,1% | 96,1% | 0,8 | 1,3 | 1,1 |
| | | | | | | | **36029** | **91,8%** | **97,3%** | **87,6%** | 0,96 | 1,4 | 1,5 |

| **Sevvice levels** | | |
|---|---|---|
| truck volume: | 238804 | 50,0% |
| boat volume: | 208932 | 43,7% |
| drum volume: | 30122 | 6,3% |

**Total service level:** **93,95%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 23,1% |
| 2 | 1B | 29,1% |
| 3 | 1C | 6,1% |
| 4 | 2A | 48,6% |
| 5 | 2B | 27,0% |
| 6 | 3B | 61,4% |
| 7 | 3C | 11,1% |
| 8 | 3F | 8,2% |
| 9 | 3H | 26,1% |
| 10 | 3J | 13,2% |
| 11 | 4B | 3,8% |
| 12 | 4E | 0,4% |
| 13 | 5A | 69,8% |
| 14 | 5B | 14,4% |
| 15 | 5C | 57,7% |
| 16 | 6A | 3,5% |
| 17 | 10A | 26,1% |
| 18 | 10B | 17,9% |
| 19 | 13A | 5,1% |

# Appendix 1J - Scenario 10

2008 setup+boat +20% higher demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 4 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | trucks | boats | drums | trucks | boats | drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 557 | 0,0% | 97,3% | 0,0% | 0,0 | 1,7 | 0,0 |
| **N9** | 3 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **NS3** | 4 | 250 | 380 | | x | 740 | 364 | 94,9% | 0,0% | 100,0% | 0,8 | 0,0 | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1635 | 93,8% | 100,0% | 83,4% | 0,8 | 1,1 | 1,3 |
| | 6 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 286 | 97,1% | 0,0% | 0,0% | 0,8 | 0,0 | 0,0 |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 337 | 99,7% | 0,0% | 0,0% | 0,7 | 0,0 | 0,0 |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 440 | 98,8% | 0,0% | 100,0% | 0,8 | 0,0 | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 639 | 92,3% | 0,0% | 99,0% | 0,9 | 0,0 | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 301 | 86,5% | 0,0% | 0,0% | 0,9 | 0,0 | 0,0 |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 303 | 89,3% | 0,0% | 95,7% | 0,9 | 0,0 | 1,2 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 269 | 93,6% | 0,0% | 100,0% | 0,9 | 0,0 | 1,1 |
| | 14 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| | 15 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2452 | 87,9% | 100,0% | 96,1% | 0,9 | 1,1 | 1,2 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2534 | 93,6% | 99,7% | 96,5% | 0,8 | 1,1 | 1,1 |
| **T 300** | 18 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 585 | 87,3% | 0,0% | 94,4% | 0,9 | 0,0 | 1,2 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 347 | 94,7% | 0,0% | 87,0% | 0,8 | 0,0 | 1,2 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 494 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1918 | 0,0% | 99,0% | 0,0% | 0,0 | 1,7 | 0,0 |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 486 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1267 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **YuBase 3** | 25 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **BS 14B** | 26 | | | | | | 0 | 81,8% | 0,0% | 0,0% | 1,0 | 0,0 | 0,0 |
| **NYTRO 11GX** | 27 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **BNS 20** | 28 | | | | | | 0 | 75,9% | 0,0% | 0,0% | 1,1 | 0,0 | 0,0 |
| **BNS 4** | 29 | | | | | | 0 | 91,0% | 0,0% | 0,0% | 0,9 | 0,0 | 0,0 |
| **BNT 9** | 30 | | | | | | 0 | 82,4% | 0,0% | 0,0% | 1,0 | 0,0 | 0,0 |
| **BST 21** | 31 | | | | | | 0 | 78,6% | 0,0% | 0,0% | 1,1 | 0,0 | 0,0 |
| **BT 12** | 32 | | | | | | 0 | 66,5% | 0,0% | 0,0% | 1,4 | 0,0 | 0,0 |
| **BT 10** | 33 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **NYFLEX 8101** | 34 | | | | | | 0 | 64,6% | 0,0% | 0,0% | 2,4 | 0,0 | 0,0 |
| **NYFLEX 8031** | 35 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **NYFLEX 841** | 36 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0,0 | 0,0 | 0,0 |
| **NYTEX 8022** | 37 | | | | | | 0 | 70,3% | 0,0% | 0,0% | 1,4 | 0,0 | 0,0 |
| **NS30 / BNS 30** | 38 | | | | | | 0 | 63,3% | 0,0% | 0,0% | 1,4 | 0,0 | 0,0 |
| **BT Group 1** | 39 | | | | | | 0 | 60,5% | 0,0% | 0,0% | 1,5 | 0,0 | 0,0 |
| **BT Group 2** | 40 | | | | | | 0 | 70,1% | 0,0% | 0,0% | 1,3 | 0,0 | 0,0 |
| **BT 470** | 41 | | | | | | 0 | 57,0% | 0,0% | 0,0% | 1,7 | 0,0 | 0,0 |
| **NS 100** | 42 | 400 | | | x | 1837 | 773 | 97,3% | 100,0% | 98,9% | 0,8 | 1,0 | 1,1 |
| **NYFROST 32** | 43 | | | | | | 0 | 53,6% | 0,0% | 0,0% | 1,6 | 0,0 | 0,0 |
| **NYFROS 68** | 44 | | | | | | 0 | 48,4% | 0,0% | 0,0% | 2,5 | 0,0 | 0,0 |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 921 | 94,8% | 0,0% | 99,4% | 0,9 | 0,0 | 1,1 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 5028 | 94,1% | 95,1% | 97,1% | 0,9 | 1,7 | 1,2 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5972 | 87,5% | 95,9% | 76,4% | 1,2 | 1,4 | 2,0 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1819 | 96,7% | 0,0% | 99,9% | 0,8 | 0,0 | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2884 | 78,2% | 80,0% | 64,2% | 1,7 | 2,9 | 2,3 |
| **T9** | 50 | 1900 | | | x | 6245 | 3506 | 97,1% | 100,0% | 94,8% | 0,8 | 1,3 | 1,2 |
| | | | | | | | **36117** | **89,7%** | **97,3%** | **87,4%** | 1 | 1,4 | 1,5 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 262789 | 50,0% |
| boat volume: | 229825 | 43,7% |
| drum volume: | 33124 | 6,3% |

**Total service level: 92,91%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 25,0% |
| 2 | 1B | 35,6% |
| 3 | 1C | 6,2% |
| 4 | 2A | 57,7% |
| 5 | 2B | 30,5% |
| 6 | 3B | 65,8% |
| 7 | 3C | 12,7% |
| 8 | 3F | 10,7% |
| 9 | 3H | 29,2% |
| 10 | 3J | 11,7% |
| 11 | 4B | 4,5% |
| 12 | 4E | 0,6% |
| 13 | 5A | 72,8% |
| 14 | 5B | 16,0% |
| 15 | 5C | 58,9% |
| 16 | 6A | 4,6% |
| 17 | 10A | 28,6% |
| 18 | 10B | 18,6% |
| 19 | 13A | 4,0% |

# Appendix 1K - Scenario 11

2008 setup+boat +35% higher demand

**TANK SETUP**

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

**OIL DATA** / **SERVICE LEVELS** / **AVERAGE TIME IN SYSTEM**

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS trucks | SERVICE LEVELS boats | SERVICE LEVELS drums | AVERAGE TIME IN SYSTEM trucks | AVERAGE TIME IN SYSTEM boats | AVERAGE TIME IN SYSTEM drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 564 | | 97,7% | | | 1,6 | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | 355 | 91,6% | | 100,0% | 0,9 | | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1602 | 89,1% | 100,0% | 85,0% | 0,9 | 1,1 | 1,3 |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 287 | 95,9% | | | 0,8 | | |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 344 | 98,8% | | | 0,8 | | |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 425 | 91,8% | | 91,7% | 0,8 | | 1,2 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 577 | 84,9% | | 98,7% | 1,0 | | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 333 | 76,7% | | | 1,1 | | |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 284 | 84,0% | | 93,0% | 1,0 | | 1,2 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 243 | 90,0% | | 100,0% | 0,9 | | 1,1 |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2411 | 77,6% | 100,0% | 96,6% | 1,1 | 1,2 | 1,2 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2496 | 90,2% | 100,0% | 96,4% | 0,9 | 1,1 | 1,1 |
| **T 300** | 18 | | | | | | 0 | | | | | | |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 561 | 83,8% | | 95,2% | 1,0 | | 1,2 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 341 | 86,4% | | 92,3% | 1,0 | | 1,2 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 471 | | | | | | |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1728 | | 95,1% | 0,0% | | 1,8 | 0,0 |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 471 | | | | | | |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1219 | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | 79,8% | | | 1,1 | | |
| **NYTRO 11GX** | 27 | | | | | | | 0,0% | | | 0,0 | | |
| **BNS 20** | 28 | | | | | | | 73,3% | | | 1,2 | | |
| **BNS 4** | 29 | | | | | | | 88,7% | | | 0,9 | | |
| **BNT 9** | 30 | | | | | | | 79,5% | | | 1,0 | | |
| **BST 21** | 31 | | | | | | | 75,5% | | | 1,1 | | |
| **BT 12** | 32 | | | | | | | 65,3% | | | 1,4 | | |
| **BT 10** | 33 | | | | | | | 0,0% | | | 0,0 | | |
| **NYFLEX 8101** | 34 | | | | | | | 48,0% | | | 3,1 | | |
| **NYFLEX 8031** | 35 | | | | | | | 0,0% | | | 0,0 | | |
| **NYFLEX 841** | 36 | | | | | | | 0,0% | | | 0,0 | | |
| **NYTEX 8022** | 37 | | | | | | | 69,7% | | | 1,4 | | |
| **NS30 / BNS 30** | 38 | | | | | | | 57,7% | | | 1,7 | | |
| **BT Group 1** | 39 | | | | | | | 57,1% | | | 1,7 | | |
| **BT Group 2** | 40 | | | | | | | 66,6% | | | 1,5 | | |
| **BT 470** | 41 | | | | | | | 58,9% | | | 1,6 | | |
| **NS 100** | 42 | 400 | | | x | 1837 | 783 | 94,9% | 100,0% | 97,8% | 0,8 | 1,1 | 1,2 |
| **NYFROST 32** | 43 | | | | | | 0 | 52,1% | | | 2,4 | | |
| **NYFROS 68** | 44 | | | | | | 0 | 39,4% | | 0,0% | 4,5 | | |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 912 | 90,0% | | 97,3% | 1,0 | | 1,2 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 4730 | 71,8% | 82,2% | 83,1% | 6,1 | 3,0 | 2,4 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5916 | 76,8% | 93,9% | 77,0% | 1,5 | 1,5 | 2,2 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1776 | 95,0% | | 98,7% | 0,9 | | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2954 | 59,0% | 65,0% | 60,4% | 3,2 | 4,3 | 2,9 |
| **T9** | 50 | 1900 | | | x | 6245 | 3544 | 95,3% | 99,7% | 94,1% | 0,8 | 1,3 | 1,2 |
| | | | | | | | **35328** | **82,3%** | **94,5%** | **85,3%** | 1,5 | 1,7 | 1,7 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 297011 | 50,0% |
| boat volume: | 259702 | 43,7% |
| drum volume: | 37441 | 6,3% |

**Total service level:** **87,82%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 29,4% |
| 2 | 1B | 43,6% |
| 3 | 1C | 7,5% |
| 4 | 2A | 68,8% |
| 5 | 2B | 36,1% |
| 6 | 3B | 68,9% |
| 7 | 3C | 12,5% |
| 8 | 3F | 12,0% |
| 9 | 3H | 32,1% |
| 10 | 3J | 18,8% |
| 11 | 4B | 8,0% |
| 12 | 4E | 0,7% |
| 13 | 5A | 79,2% |
| 14 | 5B | 20,7% |
| 15 | 5C | 59,4% |
| 16 | 6A | 7,0% |
| 17 | 10A | 29,2% |
| 18 | 10B | 20,5% |
| 19 | 13A | 5,0% |

# Appendix 1L - Scenario 12

2008 setup+boat +35% higher demand -10% quarantine

## TANK SETUP

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

## OIL DATA / SERVICE LEVELS / AVERAGE TIME IN SYSTEM

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS trucks | SERVICE LEVELS boats | SERVICE LEVELS drums | AVERAGE TIME IN SYSTEM trucks | AVERAGE TIME IN SYSTEM boats | AVERAGE TIME IN SYSTEM drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 604 | 0,0% | 100,0% | 0,0% | 0 | 1,6 | 0,0 |
| **N9** | 3 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NS3** | 4 | 250 | 380 | | x | 740 | 358 | 91,2% | 0,0% | 100,0% | 0,9 | 0 | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1588 | 87,3% | 100,0% | 83,9% | 1 | 1,1 | 1,3 |
| | 6 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 288 | 97,5% | 0,0% | 0,0% | 0,8 | 0 | 0,0 |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 345 | 98,9% | 0,0% | 0,0% | 0,8 | 0 | 0,0 |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 421 | 91,3% | 0,0% | 83,3% | 0,8 | 0 | 1,3 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 566 | 86,0% | 0,0% | 96,7% | 1,1 | 0 | 1,2 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 296 | 68,8% | 0,0% | 0,0% | 1,1 | 0 | 0,0 |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 283 | 82,9% | 0,0% | 100,0% | 1 | 0 | 1,1 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 252 | 90,6% | 0,0% | 100,0% | 0,9 | 0 | 1,1 |
| | 14 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| | 15 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2453 | 77,0% | 100,0% | 93,6% | 1,1 | 1,1 | 1,2 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2506 | 93,3% | 100,0% | 96,9% | 0,8 | 1,1 | 1,1 |
| **T 300** | 18 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 567 | 85,1% | 0,0% | 100,0% | 1 | 0 | 1,1 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 340 | 95,6% | 0,0% | 100,0% | 0,8 | 0 | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 449 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1616 | 0,0% | 97,2% | 0,0% | 0 | 1,9 | 0,0 |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 480 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1223 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **YuBase 3** | 25 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **BS 14B** | 26 | | | | | | 0 | 78,1% | 0,0% | 0,0% | 1,1 | 0 | 0,0 |
| **NYTRO 11GX** | 27 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **BNS 20** | 28 | | | | | | 0 | 75,3% | 0,0% | 0,0% | 1,1 | 0 | 0,0 |
| **BNS 4** | 29 | | | | | | 0 | 85,4% | 0,0% | 0,0% | 0,9 | 0 | 0,0 |
| **BNT 9** | 30 | | | | | | 0 | 81,8% | 0,0% | 0,0% | 1 | 0 | 0,0 |
| **BST 21** | 31 | | | | | | 0 | 81,6% | 0,0% | 0,0% | 1 | 0 | 0,0 |
| **BT 12** | 32 | | | | | | 0 | 66,8% | 0,0% | 0,0% | 1,4 | 0 | 0,0 |
| **BT 10** | 33 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYFLEX 8101** | 34 | | | | | | 0 | 63,8% | 0,0% | 0,0% | 2,1 | 0 | 0,0 |
| **NYFLEX 8031** | 35 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYFLEX 841** | 36 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYTEX 8022** | 37 | | | | | | 0 | 80,0% | 0,0% | 0,0% | 1,2 | 0 | 0,0 |
| **NS30 / BNS 30** | 38 | | | | | | 0 | 59,2% | 0,0% | 0,0% | 1,5 | 0 | 0,0 |
| **BT Group 1** | 39 | | | | | | 0 | 59,2% | 0,0% | 0,0% | 1,6 | 0 | 0,0 |
| **BT Group 2** | 40 | | | | | | 0 | 72,6% | 0,0% | 0,0% | 1,2 | 0 | 0,0 |
| **BT 470** | 41 | | | | | | 0 | 57,6% | 0,0% | 0,0% | 1,6 | 0 | 0,0 |
| **NS 100** | 42 | 400 | | | x | 1837 | 774 | 95,9% | 100,0% | 98,6% | 0,8 | 1 | 1,1 |
| **NYFROST 32** | 43 | | | | | | 0 | 49,1% | 0,0% | 0,0% | 2,9 | 0 | 0,0 |
| **NYFROS 68** | 44 | | | | | | 0 | 38,7% | 0,0% | 0,0% | 4,2 | 0 | 0,0 |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 897 | 89,5% | 0,0% | 98,3% | 1 | 0 | 1,2 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 5481 | 95,8% | 98,6% | 98,5% | 0,8 | 1,5 | 1,1 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5852 | 85,1% | 97,0% | 77,2% | 1,1 | 1,3 | 2,1 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1764 | 97,2% | 0,0% | 99,0% | 0,8 | 0 | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2909 | 59,7% | 64,9% | 66,7% | 3 | 3,6 | 2,3 |
| **T9** | 50 | 1900 | | | x | 6245 | 3393 | 97,7% | 99,5% | 92,3% | 0,8 | 1,3 | 1,2 |
| | | | | | | | **35704** | **85,9%** | **97,0%** | **88,2%** | 1,1 | 1,4 | 1,9 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 297011 | 50,0% |
| boat volume: | 259702 | 43,7% |
| drum volume: | 37441 | 6,3% |

**Total service level:** **90,91%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 29,8% |
| 2 | 1B | 44,7% |
| 3 | 1C | 7,6% |
| 4 | 2A | 67,9% |
| 5 | 2B | 38,0% |
| 6 | 3B | 69,4% |
| 7 | 3C | 14,9% |
| 8 | 3F | 5,0% |
| 9 | 3H | 31,3% |
| 10 | 3J | 12,6% |
| 11 | 4B | 9,7% |
| 12 | 4E | 0,5% |
| 13 | 5A | 79,6% |
| 14 | 5B | 22,1% |
| 15 | 5C | 59,8% |
| 16 | 6A | 6,5% |
| 17 | 10A | 29,6% |
| 18 | 10B | 22,7% |
| 19 | 13A | 6,6% |

# Appendix 1M - Scenario 13

2008 setup+boat +35% higher demand -20% quarantine

## TANK SETUP

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

## OIL DATA / SERVICE LEVELS / AVERAGE TIME IN SYSTEM

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS trucks | boats | drums | AVERAGE TIME IN SYSTEM trucks | boats | drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 712 | 0,0% | 98,6% | 0,0% | 0 | 1,6 | 0,0 |
| **N9** | 3 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NS3** | 4 | 250 | 380 | | x | 740 | 357 | 92,9% | 0,0% | 100,0% | 0,84 | 0 | 1,1 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1548 | 90,1% | 100,0% | 84,6% | 0,9 | 1,1 | 1,3 |
| | 6 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 288 | 93,8% | 0,0% | 0,0% | 0,81 | 0 | 0,0 |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 344 | 100,0% | 0,0% | 0,0% | 0,74 | 0 | 0,0 |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 423 | 91,3% | 0,0% | 83,3% | 0,92 | 0 | 1,3 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 564 | 86,8% | 0,0% | 98,3% | 1,01 | 0 | 1,1 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 295 | 93,8% | 0,0% | 0,0% | 0,81 | 0 | 0,0 |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 283 | 83,7% | 0,0% | 92,3% | 1,05 | 0 | 1,2 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 252 | 91,2% | 0,0% | 100,0% | 0,91 | 0 | 1,1 |
| | 14 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| | 15 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2428 | 77,8% | 100,0% | 92,7% | 1,08 | 1,1 | 1,2 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2470 | 90,7% | 100,0% | 98,5% | 0,86 | 1 | 1,1 |
| **T 300** | 18 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 568 | 83,9% | 0,0% | 100,0% | 0,98 | 0 | 1,1 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 336 | 92,6% | 0,0% | 100,0% | 0,9 | 0 | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 471 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1688 | 0,0% | 94,4% | 0,0% | 0 | 1,8 | 0,0 |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 479 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1237 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **YuBase 3** | 25 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **BS 14B** | 26 | | | | | | 0 | 78,5% | 0,0% | 0,0% | 1,06 | 0 | 0,0 |
| **NYTRO 11GX** | 27 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **BNS 20** | 28 | | | | | | 0 | 71,8% | 0,0% | 0,0% | 1,22 | 0 | 0,0 |
| **BNS 4** | 29 | | | | | | 0 | 87,9% | 0,0% | 0,0% | 0,9 | 0 | 0,0 |
| **BNT 9** | 30 | | | | | | 0 | 75,0% | 0,0% | 0,0% | 1,16 | 0 | 0,0 |
| **BST 21** | 31 | | | | | | 0 | 77,4% | 0,0% | 0,0% | 1,07 | 0 | 0,0 |
| **BT 12** | 32 | | | | | | 0 | 66,8% | 0,0% | 0,0% | 1,36 | 0 | 0,0 |
| **BT 10** | 33 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYFLEX 8101** | 34 | | | | | | 0 | 57,4% | 0,0% | 0,0% | 2,03 | 0 | 0,0 |
| **NYFLEX 8031** | 35 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYFLEX 841** | 36 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYTEX 8022** | 37 | | | | | | 0 | 70,0% | 0,0% | 0,0% | 1,78 | 0 | 0,0 |
| **NS30 / BNS 30** | 38 | | | | | | 0 | 66,7% | 0,0% | 0,0% | 1,35 | 0 | 0,0 |
| **BT Group 1** | 39 | | | | | | 0 | 59,6% | 0,0% | 0,0% | 1,62 | 0 | 0,0 |
| **BT Group 2** | 40 | | | | | | 0 | 66,4% | 0,0% | 0,0% | 1,47 | 0 | 0,0 |
| **BT 470** | 41 | | | | | | 0 | 53,6% | 0,0% | 0,0% | 1,85 | 0 | 0,0 |
| **NS 100** | 42 | 400 | | | x | 1837 | 737 | 96,7% | 100,0% | 100,0% | 0,79 | 1 | 1,1 |
| **NYFROST 32** | 43 | | | | | | 0 | 49,1% | 0,0% | 0,0% | 3,01 | 0 | 0,0 |
| **NYFROS 68** | 44 | | | | | | 0 | 35,5% | 0,0% | 0,0% | 2,98 | 0 | 0,0 |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 904 | 95,8% | 0,0% | 100,0% | 0,8 | 0 | 1,1 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 5444 | 94,9% | 99,3% | 99,1% | 0,85 | 1,4 | 1,1 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5927 | 91,6% | 98,5% | 78,7% | 0,9 | 1,3 | 2,0 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1787 | 96,5% | 0,0% | 99,7% | 0,81 | 0 | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2852 | 72,5% | 81,1% | 72,9% | 1,77 | 2,3 | 1,9 |
| **T9** | 50 | 1900 | | | x | 6245 | 3554 | 96,4% | 100,0% | 92,3% | 0,8 | 1,3 | 1,2 |
| | | | | | | | **35949** | **87,2%** | **98,2%** | **89,3%** | 0,98 | 1,30 | 1,41 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 297011 | 50,0% |
| boat volume: | 259702 | 43,7% |
| drum volume: | 37441 | 6,3% |

**Total service level:** **92,16%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 30,0% |
| 2 | 1B | 40,9% |
| 3 | 1C | 6,8% |
| 4 | 2A | 66,1% |
| 5 | 2B | 40,1% |
| 6 | 3B | 68,5% |
| 7 | 3C | 13,2% |
| 8 | 3F | 4,1% |
| 9 | 3H | 30,7% |
| 10 | 3J | 15,8% |
| 11 | 4B | 10,2% |
| 12 | 4E | 0,6% |
| 13 | 5A | 79,9% |
| 14 | 5B | 21,1% |
| 15 | 5C | 60,3% |
| 16 | 6A | 5,6% |
| 17 | 10A | 32,1% |
| 18 | 10B | 22,2% |
| 19 | 13A | 10,3% |

# Appendix 1N - Scenario 14

2008 setup+boat +35% higher demand -30% quarantine

## TANK SETUP

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | **87385** | | | |

## OIL DATA / SERVICE LEVELS / AVERAGE TIME IN SYSTEM

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS trucks | boats | drums | AVERAGE TIME IN SYSTEM trucks | boats | drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NX3020** | 2 | 0 | 600 | | x | 825 | 573 | 0,0% | 100,0% | 0,0% | 0 | 1,5 | 0,0 |
| **N9** | 3 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NS3** | 4 | 250 | 380 | | x | 740 | 354 | 92,6% | 0,0% | 75,0% | 0,86 | 0 | 2,0 |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | 1598 | 91,4% | 100,0% | 84,7% | 0,89 | 1,1 | 1,3 |
| | 6 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | 288 | 97,5% | 0,0% | 0,0% | 0,77 | 0 | 0,0 |
| **S 20** | 8 | 100 | 250 | | x | 1454 | 344 | 98,9% | 0,0% | 0,0% | 0,76 | 0 | 0,0 |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | 419 | 95,7% | 0,0% | 100,0% | 0,79 | 0 | 1,1 |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | 562 | 87,8% | 0,0% | 97,5% | 0,96 | 0 | 1,2 |
| **S 150** | 11 | 50 | 500 | | x | 1011 | 295 | 93,8% | 0,0% | 0,0% | 0,81 | 0 | 0,0 |
| **SR 130** | 12 | 250 | 400 | | x | 926 | 282 | 84,6% | 0,0% | 92,3% | 1,01 | 0 | 1,2 |
| **T 4** | 13 | 200 | 400 | | x | 739 | 252 | 90,7% | 0,0% | 100,0% | 0,93 | 0 | 1,1 |
| | 14 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| | 15 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | 2423 | 79,6% | 100,0% | 95,4% | 1,06 | 1,1 | 1,2 |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | 2475 | 92,1% | 100,0% | 93,8% | 0,85 | 1 | 1,2 |
| **T 300** | 18 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | 562 | 84,6% | 0,0% | 90,6% | 0,97 | 0 | 1,2 |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | 335 | 94,1% | 0,0% | 100,0% | 0,83 | 0 | 1,1 |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | 476 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | 1684 | 0,0% | 91,7% | 0,0% | 0 | 1,8 | 0,0 |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | 473 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | 1244 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **YuBase 3** | 25 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **BS 14B** | 26 | | | | | | 0 | 78,9% | 0,0% | 0,0% | 1,08 | 0 | 0,0 |
| **NYTRO 11GX** | 27 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **BNS 20** | 28 | | | | | | 0 | 70,6% | 0,0% | 0,0% | 1,28 | 0 | 0,0 |
| **BNS 4** | 29 | | | | | | 0 | 82,2% | 0,0% | 0,0% | 1,01 | 0 | 0,0 |
| **BNT 9** | 30 | | | | | | 0 | 79,5% | 0,0% | 0,0% | 1,07 | 0 | 0,0 |
| **BST 21** | 31 | | | | | | 0 | 75,3% | 0,0% | 0,0% | 1,12 | 0 | 0,0 |
| **BT 12** | 32 | | | | | | 0 | 66,7% | 0,0% | 0,0% | 1,4 | 0 | 0,0 |
| **BT 10** | 33 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYFLEX 8101** | 34 | | | | | | 0 | 51,1% | 0,0% | 0,0% | 2,6 | 0 | 0,0 |
| **NYFLEX 8031** | 35 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYFLEX 841** | 36 | | | | | | 0 | 0,0% | 0,0% | 0,0% | 0 | 0 | 0,0 |
| **NYTEX 8022** | 37 | | | | | | 0 | 80,0% | 0,0% | 0,0% | 1,35 | 0 | 0,0 |
| **NS30 / BNS 30** | 38 | | | | | | 0 | 61,8% | 0,0% | 0,0% | 1,62 | 0 | 0,0 |
| **BT Group 1** | 39 | | | | | | 0 | 55,8% | 0,0% | 0,0% | 1,78 | 0 | 0,0 |
| **BT Group 2** | 40 | | | | | | 0 | 66,8% | 0,0% | 0,0% | 1,51 | 0 | 0,0 |
| **BT 470** | 41 | | | | | | 0 | 55,8% | 0,0% | 0,0% | 1,73 | 0 | 0,0 |
| **NS 100** | 42 | 400 | | | x | 1837 | 759 | 98,2% | 100,0% | 100,0% | 0,77 | 1 | 1,1 |
| **NYFROST 32** | 43 | | | | | | 0 | 54,4% | 0,0% | 0,0% | 2,42 | 0 | 0,0 |
| **NYFROS 68** | 44 | | | | | | 0 | 46,8% | 0,0% | 0,0% | 3,99 | 0 | 0,0 |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | 900 | 96,4% | 0,0% | 100,0% | 0,79 | 0 | 1,1 |
| **N Taurus** | 46 | 3500 | | | x | 7276 | 4664 | 89,8% | 95,7% | 95,9% | 1,09 | 1,5 | 1,3 |
| **N Libra** | 47 | 4000 | | | x | 13112 | 5716 | 90,4% | 99,5% | 77,0% | 1,01 | 1,2 | 2,1 |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | 1756 | 98,6% | 0,0% | 100,0% | 0,76 | 0 | 1,1 |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | 2877 | 80,4% | 86,5% | 75,7% | 1,26 | 2 | 1,7 |
| **T9** | 50 | 1900 | | | x | 6245 | 3285 | 95,6% | 98,0% | 90,9% | 0,83 | 1,4 | 1,2 |
| | | | | | | | **34599** | **87,6%** | **98,0%** | **88,4%** | 1,00 | 1,30 | 1,43 |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 297011 | 50,0% |
| boat volume: | 259702 | 43,7% |
| drum volume: | 37441 | 6,3% |

**Total service level:** **92,17%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | | |
|---|---|---|
| 1 | 1A | 29,3% |
| 2 | 1B | 43,5% |
| 3 | 1C | 7,9% |
| 4 | 2A | 65,8% |
| 5 | 2B | 39,1% |
| 6 | 3B | 69,1% |
| 7 | 3C | 6,4% |
| 8 | 3F | 11,1% |
| 9 | 3H | 31,5% |
| 10 | 3J | 13,4% |
| 11 | 4B | 16,1% |
| 12 | 4E | 0,4% |
| 13 | 5A | 79,0% |
| 14 | 5B | 21,8% |
| 15 | 5C | 59,1% |
| 16 | 6A | 7,2% |
| 17 | 10A | 28,4% |
| 18 | 10B | 21,5% |
| 19 | 13A | 8,3% |

# Appendix 1O - Scenario 15

2008 setup+boat +35% higher demand -+5,7% tankvolumes

## TANK SETUP

| | tank nbr | oil | capacity | inline blender | connected to drumming | connected to fillingstation |
|---|---|---|---|---|---|---|
| 1 | 101 | 5 | 739 | x | x | 2 |
| 2 | 102 | 13 | 739 | x | x | 2 |
| 3 | 103 | 4 | 740 | x | x | 2 |
| 4 | 104 | 23 | 740 | x | x | 3 |
| 5 | 105 | 45 | 740 | x | x | 3 |
| 6 | 111 | 45 | 740 | x | x | 2 |
| 7 | 112 | 8 | 741 | x | | 2 |
| 8 | 113 | 50 | 741 | x | x | 2 |
| 9 | 114 | 7 | 741 | x | x | 3 |
| 10 | 121 | 20 | 1110 | x | x | 1 |
| 11 | 122 | 19 | 1110 | x | x | 1 |
| 12 | 123 | 5 | 1110 | x | x | 1 |
| 13 | 124 | 9 | 1110 | x | x | 1 |
| 14 | 204 | 49 | 1010 | | | 4 |
| 15 | 205 | 47 | 998 | | | 5 |
| 16 | 209 | 16 | 1012 | x | | 4 |
| 17 | 210 | 10 | 1020 | x | x | 4 |
| 18 | 211 | 47 | 1015 | | | 4 |
| 19 | 213 | 11 | 1011 | | | 4 |
| 20 | 214 | 21 | 1019 | x | | 4 |
| 21 | 215 | 49 | 1010 | | | 4 |
| 22 | 315 | 0 | 750 | x | | 8 |
| 23 | 322 | 46 | 3442 | | | 6 |
| 24 | 323 | 17 | 3320 | | | 6 |
| 25 | 332 | 22 | 2006 | x | | 6 |
| 26 | 333 | 50 | 2007 | | | 6 |
| 27 | 334 | 49 | 2000 | | | 9 |
| 28 | 342 | 46 | 2006 | | | 7 |
| 29 | 344 | 42 | 824 | | | 9 |
| 30 | 345 | 42 | 826 | | | 9 |
| 31 | 352 | 0 | 3331 | | | 10 |
| 32 | 412 | 23 | 740 | | | 12 |
| 33 | 441 | 2 | 825 | | | 11 |
| 34 | 442 | 0 | 828 | x | | 11 |
| 35 | 541 | 5 | 2642 | x | | 13 |
| 36 | 542 | 12 | 738 | x | | 13 |
| 37 | 543 | 17 | 1095 | x | x | 13 |
| 38 | 544 | 50 | 3310 | x | | 13 |
| 39 | 563 | 24 | 2004 | | x | 14 |
| 40 | 571 | 47 | 2615 | x | x | 15 |
| 41 | 576 | 16 | 2610 | x | x | 15 |
| 42 | 601 | 42 | 187 | | x | 16 |
| 43 | 602 | 12 | 188 | | x | 16 |
| 44 | 603 | 46 | 188 | | x | 16 |
| 45 | 604 | 47 | 187 | | x | 16 |
| 46 | 605 | 49 | 186 | | x | 16 |
| 47 | 606 | 48 | 187 | | x | 16 |
| 48 | 607 | 50 | 187 | | x | 16 |
| 49 | 1005 | 48 | 1641 | | | 17 |
| 50 | 1006 | 46 | 1640 | | | 17 |
| 51 | 1012 | 48 | 1638 | | | 18 |
| 52 | 1310 | 0 | 1650 | x | | 19 |
| 53 | 1311 | 0 | 1650 | x | | 19 |
| 54 | 1301 | 47 | 4147 | | | 21 |
| 55 | 1302 | 47 | 4150 | | | 21 |
| 56 | 56 | 16 | 1100 | | | 13 |
| 57 | 555 | 17 | 1042 | | | 14 |
| 58 | 58 | | | | | |
| 59 | 59 | | | | | |
| 60 | 60 | | | | | |
| 61 | 1104 | 0 | 1156 | | | 7 |
| 62 | 700 | 0 | 1640 | | | 8 |
| 63 | 63 | | | | | |
| 64 | 64 | | | | | |
| 65 | 1105 | 0 | 1658 | | | 11 |
| 66 | 401 | 8 | 713 | | | 12 |
| 67 | 1109 | 10 | 1650 | | | 17 |
| 68 | 1201 | 49 | 1650 | | | 18 |
| 69 | 1312 | 0 | 1650 | | | 19 |
| 70 | 608 | 5 | 185 | | x | 16 |
| 71 | 71 | | | | | |
| | | | 87385 | | | |

## OIL DATA

| | oil nbr | reorder point | batch size | reorder pint modifier | stored oils | tank capacity | average inventory | SERVICE LEVELS: trucks | boats | drums | AVERAGE TIME IN SYSTEM: trucks | boats | drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NX3030** | 1 | | | | | | | | | | | | |
| **NX3020** | 2 | 0 | 600 | | x | 825 | | | | | | | |
| **N9** | 3 | | | | | | | | | | | | |
| **NS3** | 4 | 250 | 380 | | x | 740 | | | | | | | |
| **NS8** | 5 | 1200 | 1500 | | x | 4676 | | | | | | | |
| | 6 | | | | | | | | | | | | |
| **S 8.5** | 7 | 200 | 350 | | x | 741 | | | | | | | |
| **S 20** | 8 | 100 | 250 | | x | 1454 | | | | | | | |
| **S 25B** | 9 | 300 | 650 | | x | 1110 | | | | | | | |
| **S 100B** | 10 | 600 | 900 | | x | 2670 | | | | | | | |
| **S 150** | 11 | 50 | 500 | | x | 1011 | | | | | | | |
| **SR 130** | 12 | 250 | 400 | | x | 926 | | | | | | | |
| **T 4** | 13 | 200 | 400 | | x | 739 | | | | | | | |
| | 14 | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | |
| **T 22** | 16 | 2000 | 1800 | | x | 4722 | | | | | | | |
| **T 110** | 17 | 1900 | 1900 | | x | 5457 | | | | | | | |
| **T 300** | 18 | | | | | | | | | | | | |
| **T 400** | 19 | 200 | 500 | 300 | x | 1110 | | | | | | | |
| **T 4000** | 20 | 50 | 300 | 200 | x | 1110 | | | | | | | |
| **S 9** | 21 | 0 | 100 | 650 | x | 1019 | | | | | | | |
| **S 90** | 22 | 100 | 600 | 1000 | x | 2006 | | | | | | | |
| **NFR-40** | 23 | 0 | 600 | 200 | x | 1480 | | | | | | | |
| **Star 2** | 24 | 0 | 650 | 1200 | x | 2004 | | | | | | | |
| **YuBase 3** | 25 | | | | | | | | | | | | |
| **BS 14B** | 26 | | | | | | | | | | | | |
| **NYTRO 11GX** | 27 | | | | | | | | | | | | |
| **BNS 20** | 28 | | | | | | | | | | | | |
| **BNS 4** | 29 | | | | | | | | | | | | |
| **BNT 9** | 30 | | | | | | | | | | | | |
| **BST 21** | 31 | | | | | | | | | | | | |
| **BT 12** | 32 | | | | | | | | | | | | |
| **BT 10** | 33 | | | | | | | | | | | | |
| **NYFLEX 8101** | 34 | | | | | | | | | | | | |
| **NYFLEX 8031** | 35 | | | | | | | | | | | | |
| **NYFLEX 841** | 36 | | | | | | | | | | | | |
| **NYTEX 8022** | 37 | | | | | | | | | | | | |
| **NS30 / BNS 30** | 38 | | | | | | | | | | | | |
| **BT Group 1** | 39 | | | | | | | | | | | | |
| **BT Group 2** | 40 | | | | | | | | | | | | |
| **BT 470** | 41 | | | | | | | | | | | | |
| **NS 100** | 42 | 400 | | | x | 1837 | | | | | | | |
| **NYFROST 32** | 43 | | | | | | | | | | | | |
| **NYFROS 68** | 44 | | | | | | | | | | | | |
| **NYTRO 4000A/X** | 45 | 650 | | | x | 1480 | | | | | | | |
| **N Taurus** | 46 | 3500 | | | x | 7276 | | | | | | | |
| **N Libra** | 47 | 4000 | | | x | 13112 | | | | | | | |
| **N Lyra X** | 48 | 1300 | | | x | 3466 | | | | | | | |
| **N Gemini X** | 49 | 2000 | | | x | 5856 | | | | | | | |
| **T9** | 50 | 1900 | | | x | 6245 | | | | | | | |
| | | | | | | | **0** | | | | | | |

**Sevvice levels**

| | | |
|---|---|---|
| truck volume: | 297011 | 50,0% |
| boat volume: | 259702 | 43,7% |
| drum volume: | 37441 | 6,3% |

**Total service level: 0,00%**

| | | |
|---|---|---|
| **swing tank capacity:** | **14313** | 16,4% |
| **dedicated tank capacity:** | **73072** | 83,6% |

**filling station utilization**

| | |
|---|---|
| 1 | 1A |
| 2 | 1B |
| 3 | 1C |
| 4 | 2A |
| 5 | 2B |
| 6 | 3B |
| 7 | 3C |
| 8 | 3F |
| 9 | 3H |
| 10 | 3J |
| 11 | 4B |
| 12 | 4E |
| 13 | 5A |
| 14 | 5B |
| 15 | 5C |
| 16 | 6A |
| 17 | 10A |
| 18 | 10B |
| 19 | 13A |

# Appendix 2 - Equipment list Antwerp

| tank number in simulation | loading station nbr in simulation | tank number | diameter | height | 100% capacity (l) | tank material | max pump capacity | pump type | drumming | blender | waterdrain | air blow | heating coils | product filter | insulation | loading | loading station nbr in simulation | loading station | quay connection | quay line | RTC IN | RTC OUT | TT IN | TT OUT | invenory measurement | truck loading principle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 101 | 8.5 | 13 | 739,223 | mild steel | 200 | centrifugal | yes | yes | - | yes | yes | - | - | bottom | 2 | 1B | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 2 | 2 | 102 | 8.5 | 13 | 739,671 | mild steel | 200 | centrifugal | yes | yes | - | yes | yes | - | - | bottom | 2 | 1B | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 3 | 2 | 103 | 8.5 | 13 | 740,245 | mild steel | 200 | centrifugal | yes | yes | - | - | - | - | - | bottom | 2 | 1B | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 4 | 3 | 104 | 8.5 | 13 | 740,266 | mild steel | 200 | centrifugal | yes | yes | - | - | - | yes | - | bottom | 3 | 1C | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 5 | 3 | 105 | 8.5 | 13 | 740,707 | mild steel | 200 | centrifugal | yes | yes | - | - | - | - | - | bottom | 3 | 1C | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 6 | 2 | 111 | 8.5 | 13 | 739,854 | mild steel | 150 | pos.displ. | yes | yes | - | - | - | yes | - | bottom | 2 | 1B | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 7 | 2 | 112 | 8.5 | 13 | 741,024 | mild steel | 150 | pos.displ. | yes | yes | - | - | - | - | - | bottom | 2 | 1B | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 8 | 2 | 113 | 8.5 | 13 | 740,962 | mild steel | 150 | pos.displ. | yes | yes | - | - | - | - | - | bottom | 2 | 1B | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 9 | 3 | 114 | 8.5 | 13 | 740,858 | mild steel | 150 | pos.displ. | yes | yes | - | - | - | - | - | bottom | 3 | 1C | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 10 | 1 | 121 | 10.4 | 13 | 1,108,441 | mild steel | 220 | pos.displ. | yes | yes | - | - | yes | - | w + r | bottom | 1 | 1A | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 11 | 1 | 122 | 10.4 | 13 | 1,106,410 | mild steel | 220 | pos.displ. | yes | yes | - | - | yes | - | w | bottom | 1 | 1A | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 12 | 1 | 123 | 10.4 | 13 | 1,109,044 | mild steel | 250 | centrifugal | yes | yes | - | - | - | - | - | bottom | 1 | 1A | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 13 | 1 | 124 | 10.4 | 13 | 1,108,281 | mild steel | 250 | centrifugal | yes | yes | - | - | - | - | - | bottom | 1 | 1A | S1 | Yes | No | No | Yes | Yes | radar | tank level |
| 14 | 4 | 204 | 10.1 | 12.7 | 1,011,669 | mild steel | 55 | membrane | - | - | yes | - | yes | - | w + r | bottom | 4 | 2A | S2 | Yes | No | No | Yes | Yes | servo | weight bridge |
| 15 | 5 | 205 | 10,1 | 12,7 | 997,670 | mild steel | 115 | pos.displ. | - | - | - | - | yes | - | w + r | bottom | 5 | 2B | S2 | Yes | No | No | Yes | Yes | servo | tank level |
| 16 | 4 | 209 | 10,1 | 12,7 | 1,011,792 | mild steel | 150 | pos.displ. | - | - | - | - | yes | yes | w + r | top+bottom | 4 | 2A | S2 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 17 | 4 | 210 | 10.1 | 12.7 | 1,019,667 | mild steel | 110 | pos.displ. | - | - | - | - | yes | - | w + r | top+bottom | 4 | 2A | S2 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 18 | 4 | 211 | 10,1 | 12,7 | 1,015,206 | mild steel | 126 | pos.displ. | - | - | - | - | yes | - | w + r | bottom | 4 | 2A | S2 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 19 | 4 | 213 | 10,1 | 12,7 | 1,011,095 | mild steel | 120 | pos.displ. | - | - | - | - | yes | yes | w + r | top+bottom | 4 | 2A | S2 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 20 | 4 | 214 | 10,1 | 12,7 | 1,018,980 | mild steel | 120 | pos.displ. | - | - | - | - | yes | yes | w + r | bottom | 4 | 2A | S2 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 21 | 4 | 215 | 10,1 | 12,7 | 1,010,301 | mild steel | 115 | pos.displ. | - | - | - | - | yes | yes | w + r | top+bottom | 4 | 2A | S2 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 22 | 8 | 315 | 8.5 | 13.4 | 749,525 | stainless steel | 55 | membrane | - | - | - | - | yes | - | w + r | bottom | 7 | 3F | S4 | Yes | No | No | Yes | Yes | radar | tank level |
| 23 | 6 | 322 | 18 | 13,7 | 3,442,873 | mild steel | 380 | pos.displ. | - | - | yes | yes | yes | yes | w | bottom | 5 | 3B | S3 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 24 | 6 | 323 | 18 | 13 | 3,319,707 | mild steel | 380 | pos.displ. | - | - | yes | - | yes | - | w + r | bottom | 5 | 3B | S3 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 25 | 6 | 332 | 14 | 13 | 2,006,113 | mild steel | 378 | pos.displ. | - | - | yes | - | yes | - | w + r | bottom | 5 | 3B | S3 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 26 | 6 | 333 | 14 | 13 | 2,007,042 | mild steel | 300 | pos.displ. | - | - | yes | - | yes | - | w + r | bottom | 5 | 3B | S3 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 27 | 9 | 334 | 14 | 13 | 2,000,504 | mild steel | 250 | centrifugal | | - | - | - | yes | - | - | bottom | 8 | 3H | S3 | Yes | No | No | Yes | Yes | servo | MDM |
| 28 | 7 | 342 | 16 | 13 | 2,006,113 | mild steel | 250 | centrifugal | - | - | yes | yes | yes | yes | - | bottom | 6 | 3C | S4 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 29 | 9 | 344 | 9 | 13.3 | 823,946 | mild steel | 175 | pos.displ. | - | - | - | - | yes | - | w | bottom | 8 | 3H | S3 | Combi | No | Yes | Yes | Yes | radar | tank level |
| 30 | 9 | 345 | 9.1 | 13.3 | 825,752 | mild steel | 180 | pos.displ. | - | - | yes | - | yes | - | w | bottom | 8 | 3H | S3 | Combi | No | No | Yes | Yes | radar | tank level |
| 31 | 10 | 352 | 18 | 13.2 | 3,330,382 | mild steel | 168 | pos.displ. | - | - | yes | - | yes | - | w | bottom | 9 | 3J | S3 | Yes | No | Yes | Yes | Yes | servo | tank level |
| 32 | 12 | 412 | 8.5 | 13.3 | 740,053 | mild steel | 125 | pos.displ. | - | - | - | - | yes | - | w + r | bottom | 11 | 4E | S4 | Yes | No | No | Yes | Yes | servo | tank level |
| 33 | 11 | 441 | 9 | 13.3 | 825,496 | mild steel | 45 | pos.displ. | - | - | - | - | yes | - | w 3/4 | bottom | 10 | 4B | S5 | Combi | No | No | Yes | Yes | servo | tank level |
| 34 | 11 | 442 | 9 | 13.3 | 827,645 | mild steel | 45 | pos.displ. | - | - | - | - | yes | - | w 3/4 | bottom | 10 | 4B | S5 | Combi | No | No | Yes | Yes | servo | tank level |
| 35 | 13 | 541 | 16 | 13 | 2,642,125 | mild steel | 350 | centrifugal | yes | yes | yes | - | - | yes | - | bottom | 12 | 5A | S1 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 36 | 13 | 542 | 8.5 | 13 | 738,039 | mild steel | 55 | membrane | - | - | yes | - | yes | - | - | bottom | 12 | 5A | S1 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 37 | 13 | 543 | 10,4 | 13 | 1,094,540 | mild steel | 279 | pos.displ. | yes | yes | - | yes | yes | yes | w + r | bottom | 12 | 5A | S1 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 38 | 13 | 544 | 18 | 13 | 3,309,302 | mild steel | 300 | centrifugal | yes | yes | yes | - | - | yes | - | bottom | 12 | 5A | S1 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 39 | 14 | 563 | 14 | 13 | 2,004,091 | mild steel | 120 | pos.displ. | yes | - | - | - | - | yes | - | bottom | 13 | 5B | S2 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 40 | 15 | 571 | 16 | 13 | 2,614,517 | mild steel | 300 | centrifugal | yes | yes | yes | yes | yes | yes | - | bottom | 14 | 5C | S1 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 41 | 15 | 576 | 16 | 13 | 2,610,412 | mild steel | 240 | pos.displ. | yes | yes | yes | - | yes | yes | w + r | bottom | 14 | 5C | S1 | Yes | No | Yes | Yes | Yes | radar | tank level |
| 42 | 16 | 601 | 6 | 6,5 | 187,162 | mild steel | 120 | pos.displ. | yes | - | - | - | yes | tp 6 | - | bottom | 15 | 6A | - | No | No | No | Yes | Yes | radar | tank level |
| 43 | 16 | 602 | 6 | 6,5 | 188,241 | mild steel | 55 | membrane | yes | - | - | - | yes | tp 6 | - | bottom | 15 | 6A | - | No | No | No | Yes | Yes | radar | tank level |
| 44 | 16 | 603 | 6 | 6,5 | 187,630 | mild steel | 120 | pos.displ. | yes | - | - | - | yes | tp 6 | - | bottom | 15 | 6A | - | No | No | No | Yes | Yes | radar | tank level |
| 45 | 16 | 604 | 6 | 6,5 | 187,066 | mild steel | 55 | membrane | yes | - | - | - | yes | tp 6 | - | bottom | 15 | 6A | - | No | No | No | Yes | Yes | radar | tank level |
| 46 | 16 | 605 | 6 | 6,5 | 186,208 | mild steel | 120 | pos.displ. | yes | - | - | - | yes | tp 6 | - | bottom | 15 | 6A | - | No | No | No | Yes | Yes | radar | tank level |
| 47 | 16 | 606 | 6 | 6,5 | 186,995 | mild steel | 55 | membrane | yes | - | - | - | yes | tp 6 | - | bottom | 15 | 6A | - | No | No | No | Yes | Yes | radar | tank level |
| 48 | 16 | 607 | 6 | 6.9 | 186,873 | mild steel | 120 | pos.displ. | yes | - | - | - | yes | tp 6 | - | bottom | 15 | 6A | - | No | No | No | Yes | Yes | radar | tank level |
| 49 | 17 | 1005 | 12 | 14,5 | 1,641,097 | mild steel | 200 | centrifugal | - | - | - | - | - | - | - | top | 17 | 10A | S6 | Yes | No | Yes | No | Yes | servo | weight bridge |
| 50 | 17 | 1006 | 12 | 14,5 | 1,639,680 | mild steel | 200 | centrifugal | - | - | - | - | - | - | - | top | 17 | 10A | S6 | Yes | No | Yes | No | Yes | servo | weight bridge |
| 51 | 18 | 1012 | 12 | 14,5 | 1,638,007 | mild steel | 200 | centrifugal | - | - | - | - | - | - | w + r | top | 18 | 10B | S6 | Yes | No | Yes | No | Yes | servo | weight bridge |
| 52 | 19 | 1104 | 10.5 | 14.5 | 1,256,252 | mild steel | 200 | centrifugal | - | - | - | - | yes | yes | - | top+bottom | 19 | 11A | S7 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 53 | 19 | 1105 | 10.5 | 14.5 | 1,258,140 | mild steel | 200 | centrifugal | - | - | - | yes | - | yes | - | top+bottom | 19 | 11A | S7 | Yes | No | Yes | Yes | Yes | servo | weight bridge |
| 54 | | 1301 | 19 | 14,5 | 4,147,157 | mild steel | 350 | centrifugal | - | - | yes | yes | - | - | - | no | | No | S9 | Yes | No | No | No | No | | No |
| 55 | | 1302 | 19 | 14,5 | 4,150,726 | mild steel | | same as 1301 | - | - | yes | yes | - | - | - | no | | No | S9 | Yes | No | No | No | No | radar | No |

tp6 = one mobile filter used for all tanks
w = wall insulation
r = roof insulation