Constructing Vasilievsky Island

Creating the planning of the reclamation of an island at the coast of St Petersburg

<u>Final Report Internship:</u>
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Preface

First of all I would like to thank Witteveen+Bos for the opportunity to do my internship at their company. My intention was to do the internship in the Netherlands at the office in Deventer, the possibility to go abroad and to fulfil my assignment in St Petersburg was a pleasant surprise. I know I have learned more being abroad than I would have done in the Netherlands. Working and living in a city with such great and rich history in the biggest country in the world has enriched my life and I know now much more about the history of the Russian Federation and St Petersburg. Off course I now also know more about the work sphere at Witteveen+Bos in general and in Russia in particular.

I have done several assignments for Witteveen+Bos. Creating the planning of their main project in Russia was off course my main assignment and I have spent most of my time on this project. Next to this I was not bored doing nothing, more ambitious projects were ongoing in Russia and I have done small assignments for these projects as well. First of all I translated and analysed ground research for another reclamation project more to the south of Russia. Just before I went back to the Netherlands this assignment was also given to Witteveen+Bos. For the project of Vasilievsky Island I did also some other research and analysis to see how the project would change if other sandpits and borrow areas were taken into account. The effects of the change in borrow areas were translated into the planning of the project as well, as this information was unfortunately not realistic enough this is not taken into account in this assignment. Furthermore I started to make the planning of another huge and ambitious reclamation project in the south of Russia.

I would very much like to thank my supervisor at Witteveen+Bos Russia, Arnoud Joling. I really did not know what to expect from the company and especially not from the country. Arnoud had some nice tips and arranged a perfect apartment to make me feel like home. I also like to thank my colleague Erik Schulte Fischendick for his help in finding a way in the city. Also the other colleagues who came to work (several days) in St Petersburg have made my stay abroad interesting and pleasant. Thank you all!

Glossary

Abbreviation	*Meaning*	*Remark*
W+B	Witteveen+Bos	Dutch engineering consultant company
LMP	Lenmorniiproekt	Russian engineering consultant company
TN	Terra Nova	Russian client for whom the task is to be done
[1]	Reference 1	References can be found in the last chapter ‘References’
ha	Hectare	1 ha = 100x100m = 10.000 m^2

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Introduction

Description of the company Witteveen+Bos

Witteveen+Bos is a Dutch engineering consultant company. Perhaps the best way to describe the company is by using the description of the company from its own website [12]:
'Witteveen+Bos provides consultancy and engineering services for projects in the following areas: water, infrastructure, environment and economics. A multidisciplinary project approach characterises our way of working. Our clients are governmental, commercial, and industrial, including various types of joint ventures and public private partnerships. We serve them from eight offices in the Netherlands and four offices abroad.'

W+B's head quarter is in Deventer, the Netherlands. In 2007 a new office has been opened abroad in Saint Petersburg, Russia. Furthermore, W+B has been given the assignment to create the technical design of the extension of Vasilievsky Island; this is one of the many islands of Saint Petersburg.

Description of the project of Witteveen+Bos in St Petersburg

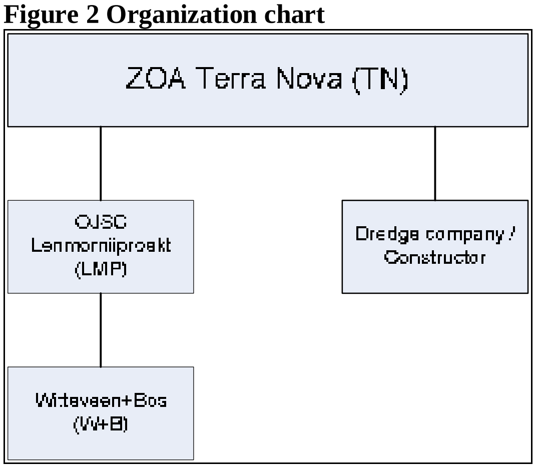
The island Vasilievsky lies at the end of the Neva River and is the end of the city, where the city meets the Finish Gulf. This island has to be extended with approximately 477 ha of new land on the Westside (seaward end). An architectural design has been made; goal for W+B is to give an advice on how it should be reclaimed. In Figure 1 the centre of Saint Petersburg is visible, in the middle of the picture the island Vasilievsky and in green the project area.

Figure 1 Saint Petersburg, the island Vasilievsky and the project area

Organization of the project

A Russian engineering company, OJSC Lenmorniiproekt (LMP), is designing the works that have to be done in order to create the island. LMP sub-contracted Witteveen+Bos (W+B) for certain design activities and assistance. This design will be made together and handed over to the Russian client, ZOA Terra Nova, who will on their hand search for a dredge company or a constructer to actually construct the island. In Figure 2 the organization chart is given.

Figure 2 Organization chart



Personal goal and research question

Personal goal of the internship

To learn to work within project teams, work on a project with multiple persons, working together, create solutions for problems together. Furthermore, I would like to know how to create a construction process in general and more specifically how to make the planning of a big project.

The next objective has been stated:

'The target of this research is to deliver a contribution to the design of the reclamation on the west end of the Island Vasilievsky, St Petersburg, Russian Federation. This can be arranged by creating the planning for the construction period.'

This results in the following research question

'Which parts contribute to the design of the extension of the Island Vasilievsky, how should they be attached to each other and in what order should the island and the different parts be constructed?'

Questions that can be drawn from this research question

- What are the different parts of the construction process?
- Are there parts that do not ligature with designing an island in Russia?
- Which parts of the construction phase of the island are critical parts and are responsible for finishing the job on time or not?
- What are the possible risks that might have an (large) influence the duration and the costs of the project?

Chapter 1 **Construction planning Vasilievsky Island**

In Appendix I Making a construction planning a general description is given of a construction process and mainly how to realize a planning. Planning is a part of a construction process; for this assignment the planning will be made for this particular project: creating Vasilievsky Island.

First it is good to know what type of planning this project concerns. Because W+B is making an advice for designing the island, the planning is supposed to be for the construction phase and not for the design phase. This planning might later be used by contractors who will build the island.

Because the client has given a deadline for different phases of realizing the island, the total duration of different parts of the project have already been defined, therefore this is a task driven planning. Critical path scheduling will be used to see which parts of the construction are critical and will delay the total project if they are delayed themselves.
The quantity of detail needed in this project is not defined; it should be accurate enough to see what has to be done in certain parts of the year. The different phases of the project all have their deadline in certain years. This means the detail of different phases is in months, the detail of the activities and work tasks within these phases should have a detail up to weeks. The contractor might later use his own planning on a day to day basis.

1.1 **Choose construction method and techniques**

Considering the fact that in this case land reclamation is the main subject, it is important to know what kind of sand will be used, what the characteristics are and where it can be dredged. This all might influence the time of dredging, transporting and dumping the sand, compaction time. Different means of dredging depend on the size of the material (sand), the depth of the excavation pit, the distance to the reclamation area, certain barriers which are in the direct surroundings of the reclamation area. Most of these parameters are also needed to define the means of transport and the delivery of the sand on the site. All these factors influence the duration and costs of the project.

Most probable the sand will be delivered via barges, so a temporary quay has to be made in order to make it possible to deliver the sand and pump it via a pipeline to the reclamation site. It might also be that huge dredgers, like trailer suction hopper dredgers (TSHD), will be used. These ships can dredge and transport the sand to the reclamation site, after which they can unload themselves as well. These ships need a larger navigation depth, so a canal has to be dredged to make sure these ships can make it to the reclamation site.

1.2 **Define activities**

As the different phases are mainly the same, the activities in these phases are the same as well. The formation of a coastline is not necessary in all phases; this depends on whether the bund of these areas is the coastline to be. To know what the activities might be a ***hierarchical activity scheme*** for this project has been made and is visible in Figure 5. On top is the main project visible, the further downwards, the more specified the activities and work tasks get. First the different activities are written down and explained, this can be seen in Table 1.

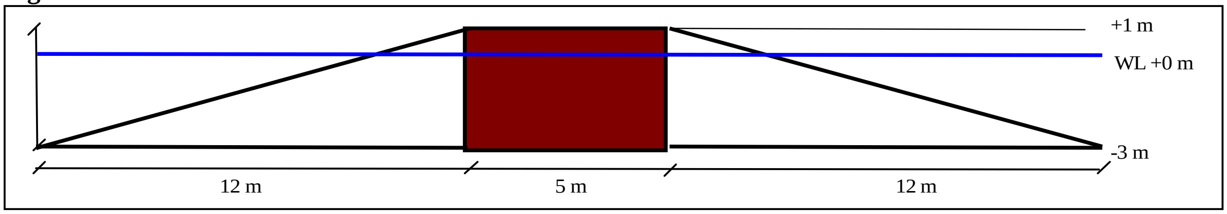
Table 1 Activities

Phase	Activities
Bund construction Layer 1	Layer 1 till +1.50m BD
Hydraulic fill - Layer 1	
Install vertical drainage	
Install horizontal drainage	
Bund construction Layer 2	Layer 2 till +5.30m BD
Hydraulic fill - Layer 2	Start of consolidation
Consolidation	
Remove surcharge	
Deep compaction	
Surface compaction	
Forming coastline	Temporary embankment protection
Ready for construction	

Bund construction

First of all bunds will be made at the boundaries of each stage and after that the stages will be filled with sand. The principle of this method is as follows: first sand is delivered (either by boat or by truck) and put down in the water on the boundaries of the stage area, after that a crane will compact the sand and construct the bund. The way the bund looks like can be seen in Figure 3.

Figure 3 Form and size of a bund

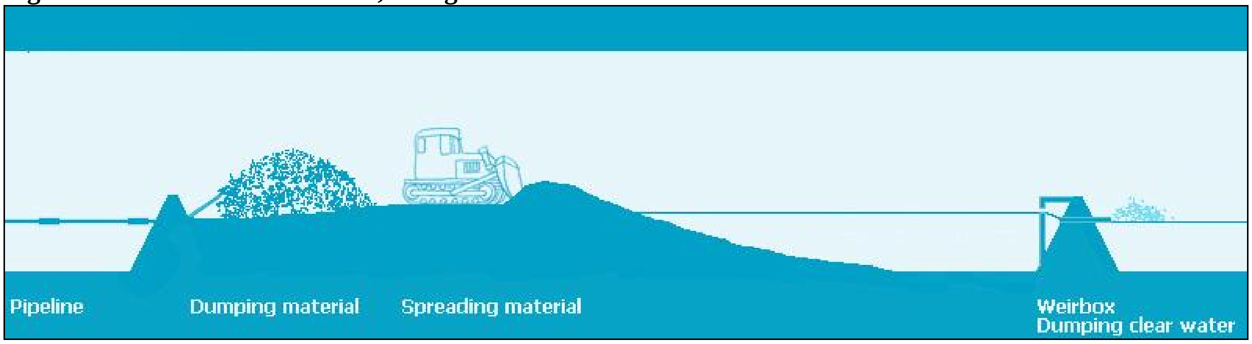


As can be seen the first bunds will be constructed up to +1.00 m or +1.50 m. The bund has a flat area in the middle on which the crane moves, this area is 5 meter wide. The banks have a slope of 1:3. That results in the example figure to a width of 12*2+5 = 29 m. A higher bund will thus also increase the width and the total volume.

Hydraulic fill – layer 1

Once the bund is finished, the rest of the area can be filled, this can be done just like is shown in Figure 4. The pipeline is then attached to a quay on which the barges or dredgers can moor.

Figure 4 Reclamation of the area, filling the area with sand



Install drainage

To fasten the settling of the sand particles vertical drainage has to be installed, this results in a lot of water that is being brought to the surface. Therefore also horizontal drainage has to be installed. The vertical drainage is hard to implement as big cranes are needed, this takes a lot of time to do, for the horizontal drainage tractors can be used which are very fast.

Create Bund & Layer 2

After the drainage is installed the second layer can be constructed. The bunds look just like the first bunds, only thing is that these bunds are on top of the previous ones and are somewhat smaller. This layer includes the surcharge needed. Surcharge is a layer of sand that comes on top of the reclaimed island in order to speed up the settling of the sand particles and to attach pre-stress to the ground so it is ready for construction earlier.

Consolidation & Remove surcharge

The surcharge is used to speed up the consolidation, so after the consolidation it can be removed. The sand can be used for constructing the other phases.

Compaction

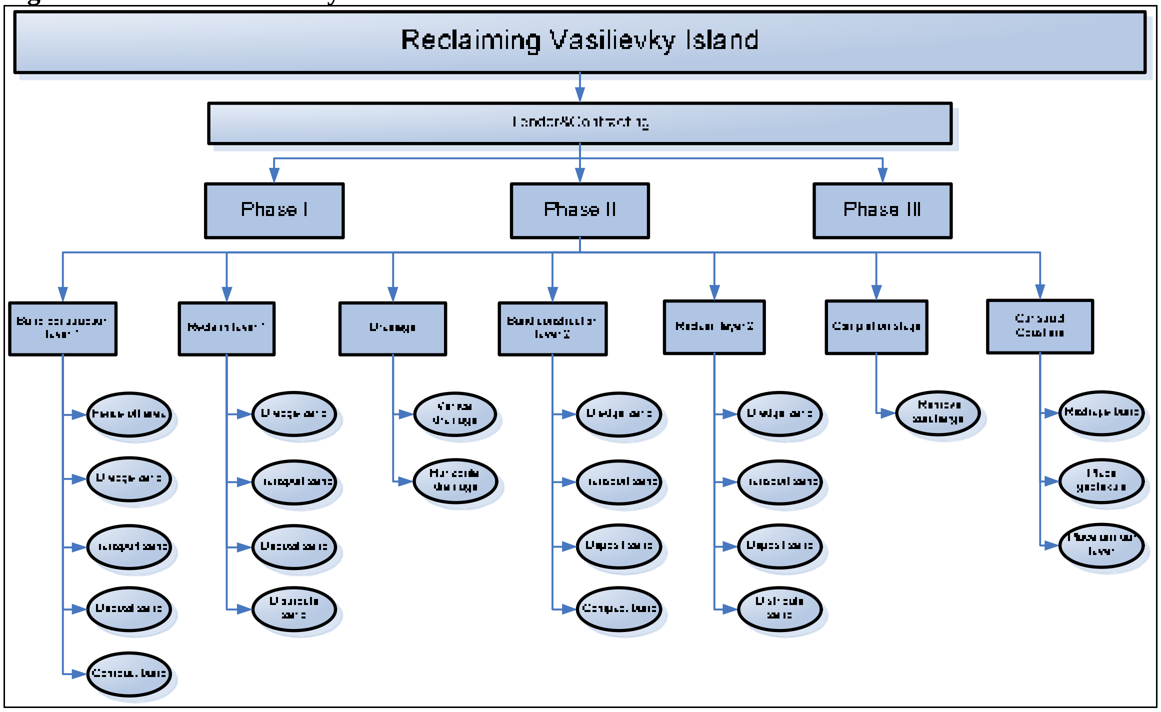
After removing the surcharge, the sand particles have to be compacted to make it really ready for construction. This result is reached in two stages; first deep compaction is used, after that surface compaction. Deep compaction is done via a big crane that lifts a heavy block and drops it several times on the ground, the energy put into the ground results in compaction of the particles. After this is finished the deep compaction can start, this is done via a tractor that pulls a heavyweight triangle. This method also puts energy into the ground and makes it possible for the upper particles to compact.

Forming the coastline

As a part of the bunds will be the boundary on the seaward end of the new island, this has to be protected against the sea. This is why a coastline has to be constructed. It concerns a temporary (maximum 5-10 years) coastline, when the construction of buildings starts on the island it might be removed and replaced with a permanent coastline, but that is outside the scope of this project.

This can all be implemented in the hierarchical activity scheme to have an overview of the activities (see Figure 5).

Figure 5 Hierarchical activity scheme



1.3 Define relations between activities

As now all activities are clear what has to be done, the relations between them can be written down, in order to implement all this in the planning program.

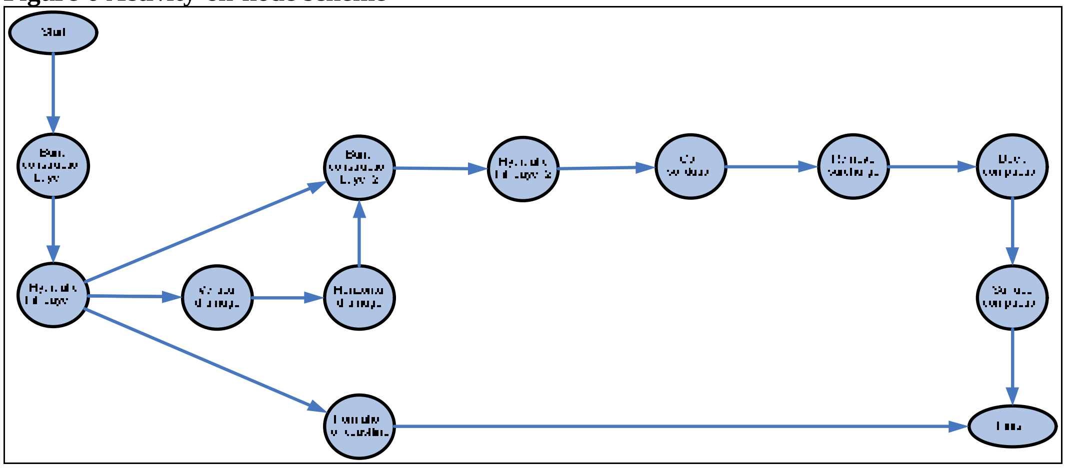
All main activities might change a bit per phase as for example formation of a coastline is only necessary in the phases where land is reclaimed which will be at the end of the extension of the island, and thus which will be the new coastline.

Table 2 Relations between activities

Activity	Description	Predecessors	Remark
A	Bund construction	-	
B	Hydraulic fill - Layer 1	A	
C	Install vertical drainage	B	
D	Install horizontal drainage	C	
E	Bund construction	B, D	
F	Hydraulic fill - Layer 2	B, E	
G	Consolidation	F	
H	Remove surcharge	G	
I	Deep compaction	H	
J	Surface compaction	I	
K	Forming coastline	B	This can be started when the first layer is finished
L	Ready for construction	All	

These activities can be put into a relation scheme; here an activity-on-node scheme is used, this is shown in Figure 6.

Figure 6 Activity-on-node scheme



As can be seen in the figure, almost all activities follow after one another. As can be seen it might be possible to already start with the formation of the coastline after the hydraulic fill of layer 1 has been finished. This results in a shorter construction period than if it is constructed as last part of the project. However, forming the coastline might be easier and cheaper to do at once and not after each part of the phases. But it is not recommended to construct the coastline as last, because for a long period the reclaimed land will be unprotected.

1.4 Estimate duration of activities

The duration of the activities will be done according to deadlines given by the Client. For example each phase has to be finished in one year. Keeping the weather, and thus the extreme winter period, into account the time left have to be used for creating the island. The long winter period might also be used for the settlement of sand particles (this takes several months due to the extra surcharge, the more surcharge is used, the shorter the settlement period gets and vice versa) so this period can be used efficiently and is not totally unusable. The time needed for each phase has to be determined in the next phase of the document, when the real quantities of sand are known which are necessary for all phases and how much sand is available during the years.

1.5 Estimate required resources

When all activities and relations have been inserted in the planning program, the amount of resources can be changed in order to shorten the time for construction. As every phase has its own size and its own quantity of sand and work, the estimation of the required resources is done per phase in the next chapters. Goal is to use about the same number of resources for every phase, so there are about the same numbers of men and equipment on the site during the whole project. This in order to keep problems with communication (large numbers of men result in a more complex communication situation) low as well as costs. This might result in slight changes in finish dates; probably the phases will be finished earlier. Off course the deadlines given by the client have to be taken into account.

1.6 Estimate duration of total project

The estimation of the duration of the total project depends on the durations of the diverse activities and their relations. Changing the amount of resources and the relations might result in a faster or slower realization of the activities and of the total project. The estimation will be done via the program and is presented in the following chapters.

Chapter 2 **Choose planning program to work with**

In the construction business basically two planning programmes are being used, Microsoft Project and Primavera Project Planner (P3). There are off course several similarities between the programmes, in the end both are planning programmes. But the differences between them are the interesting parts that will lead us to a conclusion which program to use.

Microsoft Project is easy to use and can be used very easy in combination with other Microsoft programs like Excel and Word. Problem is however that there is a limit of options that can be addressed to the program. Primavera Project Planner on the other hand can handle an enormous amount of options and possibilities, but the problem in this program is that there are far too many options available and is not easy to use, what results in a program that is not understand easily and therefore not suitable for this assignment. Furthermore, Witteveen+Bos uses Microsoft Project as well as the other participants in this project, this results in the choice for Microsoft Project. A description of Microsoft Project is given in Appendix III.

The implementation in Microsoft Project was not that easy as the different types of resources (man, crane, bulldozer, etcetera) are not exchangeable. Problem in this is that it is not possible to change the durations in Microsoft Project as the hours of work are not exchangeable: 1 hour of work for a man is not the same as 1 hour of work for a crane. Project sees a task as a certain amount of hours work and divides that between the resources but the program cannot see the unit rates of the resources and cannot see the differences between them. Therefore the determination of the amount of equipment needed has to be implemented in Excel first. An excel sheet was made in which every task is attached to certain resources needed, in this sheet the unit rates can be implemented by an expert. The fastest resource is kept as a basis.

For example when for a certain task 100 m^3 needs to be removed, a crane and a bulldozer are needed. The crane has a unit rate of 20 m^3 per hour and the bulldozer 10m^3 per hour. This results in a task of 5 hours for the crane and 10 hours of work for the bulldozer. What is done in Excel is that the fastest unit rate is kept as a basis, so in this example 1 crane and 2 bulldozers will be used to finish the task in 5 hours. In total this is thus 15 hours of work. If this is implemented in Project it is possible to create the same amounts of work. Problem is however when the amounts of resources are being changed. If now you would use only 1 bulldozer, Project would divide the 15 hours of work into two (as 2 resources have been assigned, 1 crane and 1 bulldozer) and the result is 7.5 hours of work. This is off course incorrect as the crane has a higher unit rate and cannot even do the job of a bulldozer. The crane can now remove 150 m^3 of sand and the bulldozer only 75m^3.

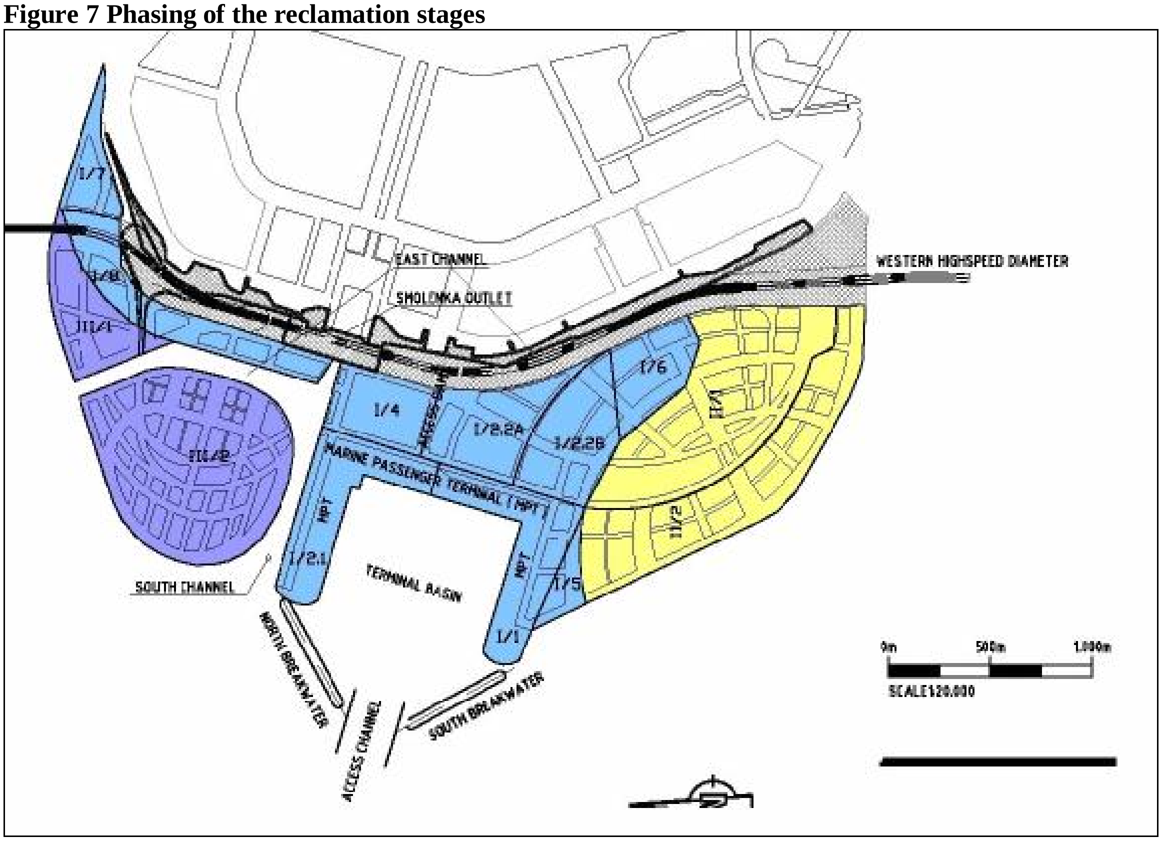
To solve this problem the amounts of resources and the durations of a certain task will be determined and calculated with Excel and after that be implemented in Project.

Chapter 3 **Project description**

3.1 **General**

For these large-scale reclamation works a timeline has been given by the Client. The construction of the extension of the island is divided into three main phases which are on their turn divided into sub phases. The extension is in total approximately 477 ha, this includes the construction of a 2200 m long quay for cruise vessels (Marine Passenger Terminal), which is already under construction and planned to be ready half 2008. These various stages are presented in Figure 7. The colours all represent another stage, light blue is Phase I (middle part), yellow is Phase II (southern part) and finally dark blue relates to Phase III (northern part).

Figure 7 Phasing of the reclamation stages



In Table 3 the deadlines of the various stages are presented. As can be seen Phase I is already partly under construction, it consists of several sub phases (phase I-1 to I-8) whereof some have started already and are planned to be finished in 2008. Because W+B is not designing the complete reclamation, but only a part of Phase I and the complete Phases II & III, the planning for Phase I-5 to I-8 is to be done in this document, as is the planning for Phase II and Phase III.

Table 3 Phases and sub phases with their deadlines

Reclamation stage	*Developing period*
Phase I	**2006-2009**
Phase I-1	2006-2007
Phase I-2.1	2007-2008
Phase I-2.2A	2007-2008
Phase I-2.2B	2008-2009
Phase I-4	2008-2009
Phase I-5	2007-2008
Phase I-6	2008-2009
Phase I-7	2008-2009
Phase I-8	2008-2009
Phase II	**2009-2011**
Phase II-1	2009-2010
Phase II-2	2010-2011
Phase III	**2008-2012**
Phase III-1	2008-2010
Phase III-2	2011-2012

The volumes which are needed for these stages are shown in Figure 8. These are also written down in Table 4.

Figure 8 Sand (V) and surcharge volumes (V_{sc}) and surface area (A) of construction stages

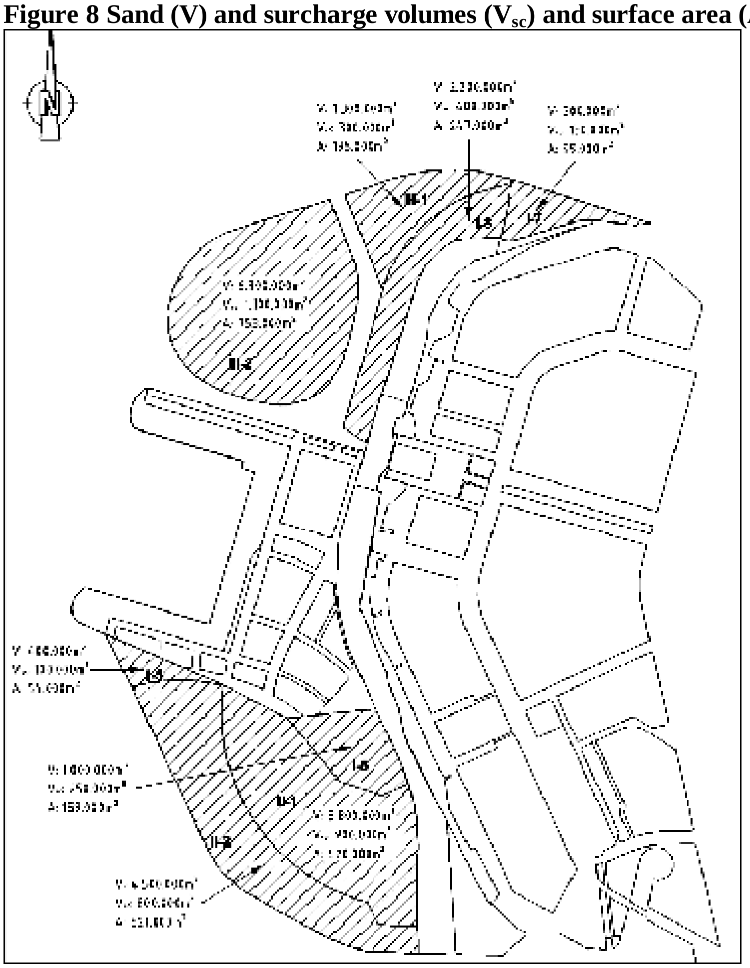
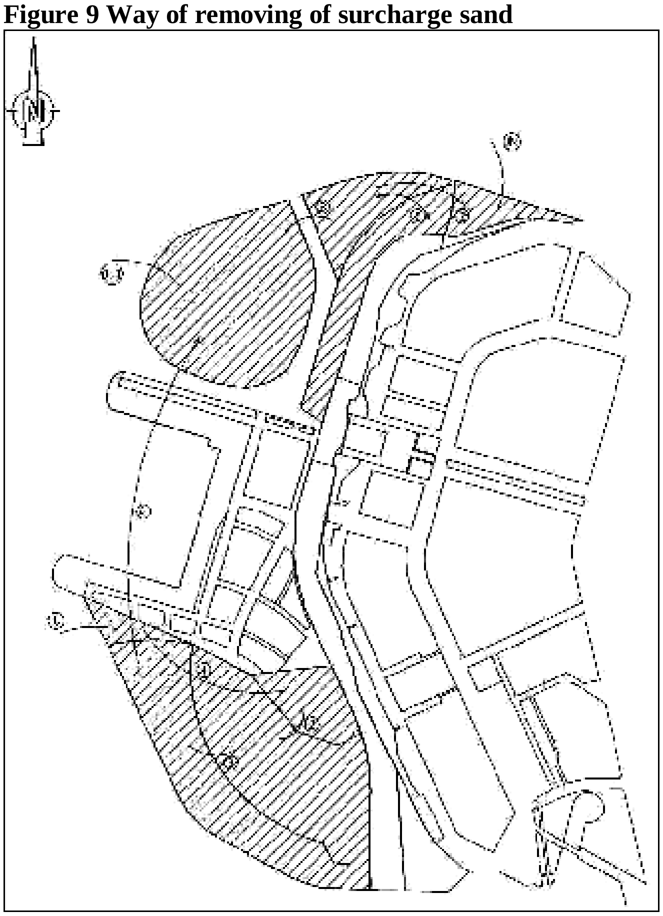


Table 4 Characteristics of the various stages

Phase	Deadline	Surface area [m2]	Total reclamation volume [m3]	Volume surcharge [m3]
Phase I-5	2008	54.000	400.000	100.000
Phase I-6	2009	159.000	1.000.000	250.000
Phase I-7	2009	99.000	500.000	150.000
Phase I-8	2009	247.000	2.200.000	400.000
Phase II-1	2010	620.000	3.800.000	900.000
Phase III-1	2010	521.000	1.300.000	300.000
Phase II-2	2011	195.000	4.500.000	800.000
Phase III-2	2012	753.000	6.300.000	1.100.000
Total		*2.648.000*	*20.000.000*	*4.000.000*

Something which has to be remarked is that Phase III-1 needs to be constructed earlier than Phase II-2, as can be seen in Table 4. The total surface area which has to be reclaimed in this part of the design (so Phase I-5 to Phase III-2) is 265 ha. Furthermore, for optimal use of sand every year the extra surcharge of sand which is put on top of layer 2 will be removed to another area. This is also to be taken into account in the planning. The ‘route’ of the surcharge is visible in Figure 9.

Figure 9 Way of removing of surcharge sand



3.2 Assumptions

As yet not all options have been determined which will be used during the construction period, some assumptions have been made in order to make the planning. The idea is that the planning will be made in such a way that if some parts, like choices for equipment or amounts of sand, are changed the planning should easily respond to these changes.

The client has given deadlines per phase, but for now it is not sure in what part of the year the deadlines will be. Furthermore, it is not clear whether it is the deadline for the sand delivery or the deadline for the phase to be ready for construction.
Assumption: the deadlines are set on the 31st of December for each year, this regards only the delivery of the sand.

Because during the ice periods (assumed is December 1st to April 1st) no land can be reclaimed and no drains can be installed, it is taken preferred to finish these works before the ice period starts. The ice period can then be used as consolidation period, assumed is the following:
During the ice period the next tasks cannot be executed:

- creating bunds
- reclaiming land
- install vertical drainage

Horizontal drainage might be done during ice period
Compaction should be done during the ice period if possible to reduce construction times.

Another assumption is that (most of) the sand will be delivered by boat (barge or dredger), unloading will be done via pipelines. The canal which probably needs to be dredged for large dredge vessels (like a Trailer Suction Hopper Dredger (TSHD)) is not taken into account.

During a certain construction year first thing to do is to reclaim the first layers (so the first layers of all phases that have to be reclaimed during that year). After that the drainage works can start (first vertical drainage and after that horizontal drainage), this results in a joined working period wherein the amount of drainage equipment is being kept to a minimum for a period as long as necessary. The idea behind this is to reduce the costs (less equipment and a longer renting period normally result in lower costs).

For creating the bunds it is necessary to know the lengths of the boundaries per phase, these have been determined according to the latest documents provided by Witteveen+Bos (substantiating document 15.1.2+3, page 2, figure 1-1).

Table 5 Length of bunds and coastlines

Phase	Length of bund [m]	Length of bund including WHD [m]	Length of coastline [m] (= part of bund)
Phase I-5	780	780	280
Phase I-6	810	1.230	-
Phase I-7	1.060	1.890	780
Phase I-8	1.840	3.230	890
Phase II-1	1.840	2.560	-
Phase III-1	1.450	1.450	1.450
Phase II-2	2.390	2.500	2.390
Phase III-2	3.170	3.170	3.170
Total	*13.400*	*16.900*	*9.000*

As for now it is not sure whether the Western Highspeed Diameter (WHD) is already constructed or not on the time different phases will be constructed, the lengths of the bunds that will be taken into account are the longest (thus WHD included). This means that on the eastern side of the project area, where the WHD will be build, also bunds will be constructed to. Assumption: the lengths of the bunds including WHD and lengths of the coastlines as given in Table 5 will be used.

On top of the second fill layer, an extra layer is placed, the surcharge. This is in order to speed up the consolidation period and to give an extra preload to the ground, for later construction of buildings. The surcharge is assumed to be on the whole island and will be 1.50 m high.

Compaction speeds are given in deliverable 15.1.7 [9]. Assumed is that for deep compaction the dynamic compaction method is used (19 days per ha), after that surface compaction is done via an impact roller with a speed of 0.2 day/ha.

For some phases a temporary (maximum of 10 years) coastline has to be made, the assumption is that this coastline can be constructed after layer 1 is reclaimed, this in order to create the coastline as soon as possible, because the newly reclaimed land needs to be protected.
The vertical drainage works can start 2 weeks after removal of surcharge has started, this means a part of the reclaimed island needs to be excavated, so drainage works can start.

Chapter 4 **Results optimized scheme**

4.1 General

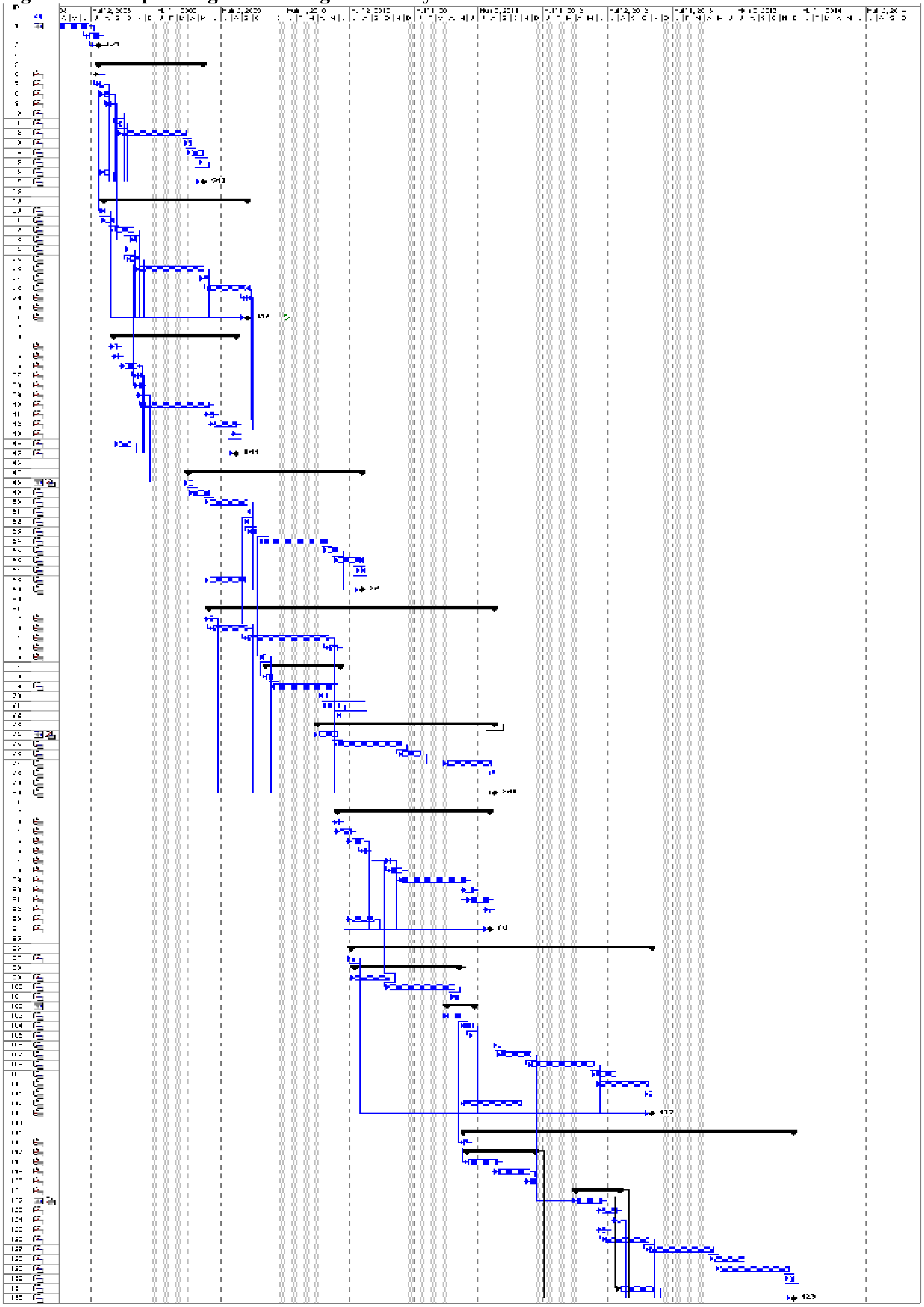
The order of constructing the different stages is determined by the deadlines given by the client. This is the basis for making the schedule.
As the transporting and delivery of sand is the biggest job (divided into several tasks like bund construction and fill layers), the goal is to keep the equipment amounts the same during the years. In substantiating document 15.1.2+3 [6] an optimized scheme has been made to deliver the sand. This results in a fixed amount of dredge equipment, what might result in lower costs. This scheme is the base of this schedule. Furthermore, due to preparation and contracting works only 5 weeks should be available for construction in 2008, this is changed to 16 weeks, because that looks more real; therefore the start date of the construction period will be about August 1st.

In Appendix IV the assumptions and calculations of sand delivery are explained. With the information of this chapter the determination of the durations of constructing is done. The durations have been rounded up to whole days, the durations for constructing the bunds have been doubled in the schedule, this is done because constructing the bunds is more than just deliver sand. Assumed is this will be enough time for constructing these bunds.

4.2 Planning

In the figure below the planning for the whole project is visible, after that the planning is explained per year. The grey parts are the ice periods, as can be seen hardly any work can be done in this period.

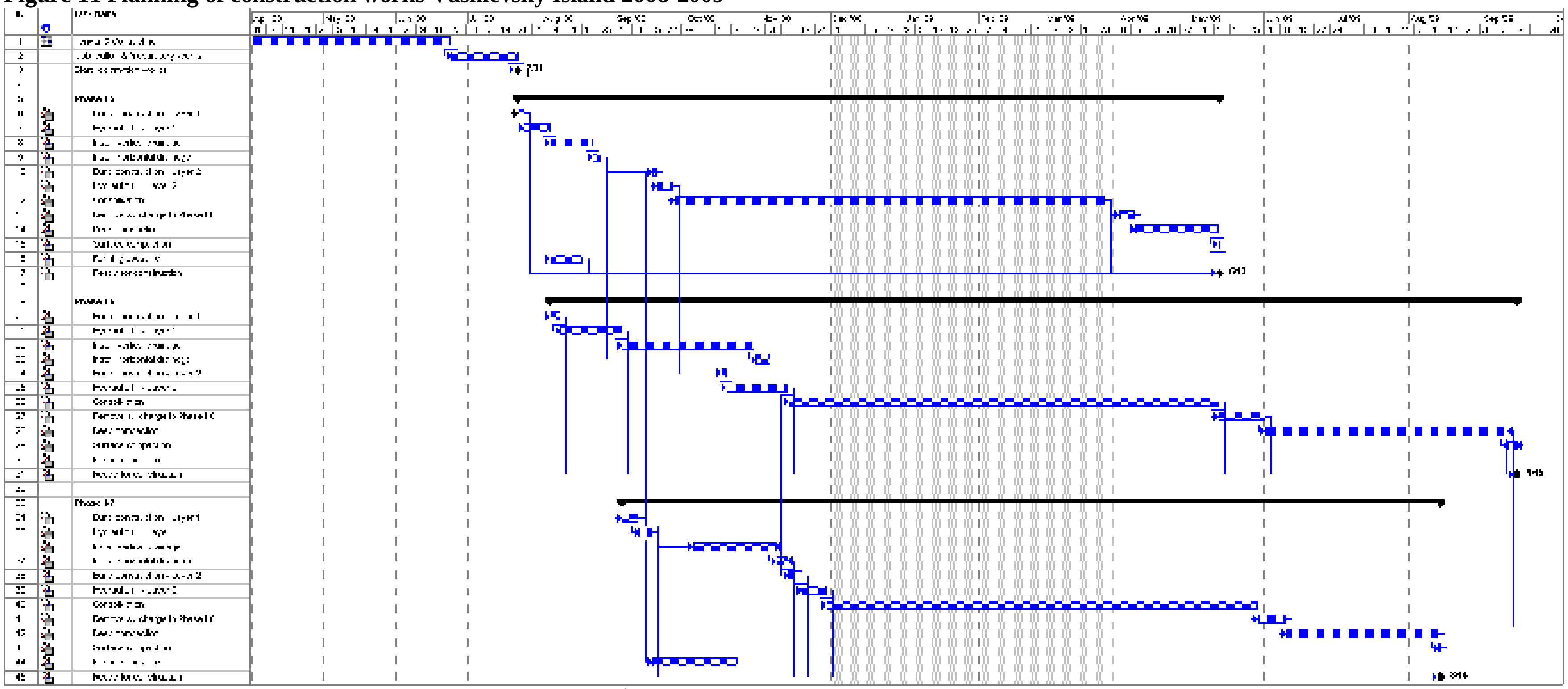
Figure 10 Total planning constructing Vasilievsky Island



4.3 Explanation of the schedule

4.3.1 2008

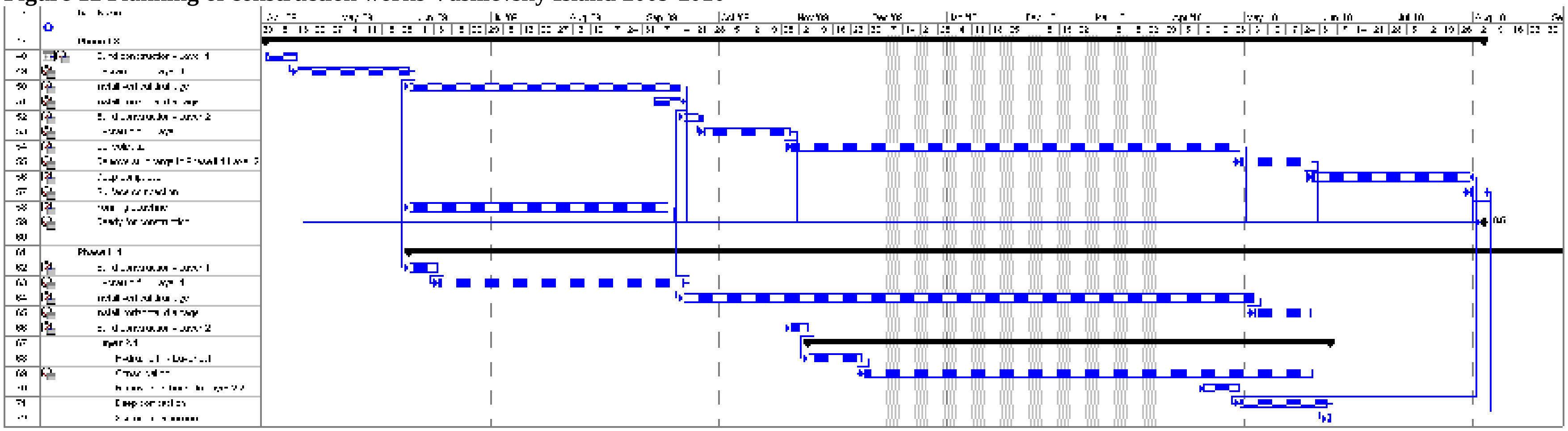
Figure 11 Planning of construction works Vasilievsky Island 2008-2009



As said before the assumption was that about August the 1st the reclamation works could start. It starts with reclaiming the bunds of Phase I-5, after that the first layer of this phase is reclaimed. The next step is reclaiming the bunds and layer 1 of Phase I-6 and after that I-7. When this is finished the second bund and layer 2 of Phase I-5 are reclaimed and then I-6 and I-7. The reason to this in this particular way is that in the mean time the drain works can start and will be finished before the second layer is laid down. It is with the present unit rates of the vertical drainage machines not possible to use a fixed amount of cranes during the whole project. This because the idea is to have an equal amount of sand delivered per year and the rest of the activities have to suite this idea. Cranes are cheaper and easier to arrange for a shorter period than barges or dredgers.

4.3.2 **2009**

Figure 12 Planning of construction works Vasilievsky Island 2009-2010



The bunds for constructing Phase I-8 follow up the reclamation of layer 2 of Phase I-7. There is however a constraint given wherein is said that it may not be started before the first of April of this year. When the ice period is later than 1 December 2008, it might be a good idea to start already with the reclamation of the bund and the first layer of Phase I-8. However, keep in mind that this bund will have a longer period of exposure to the sea and wind.

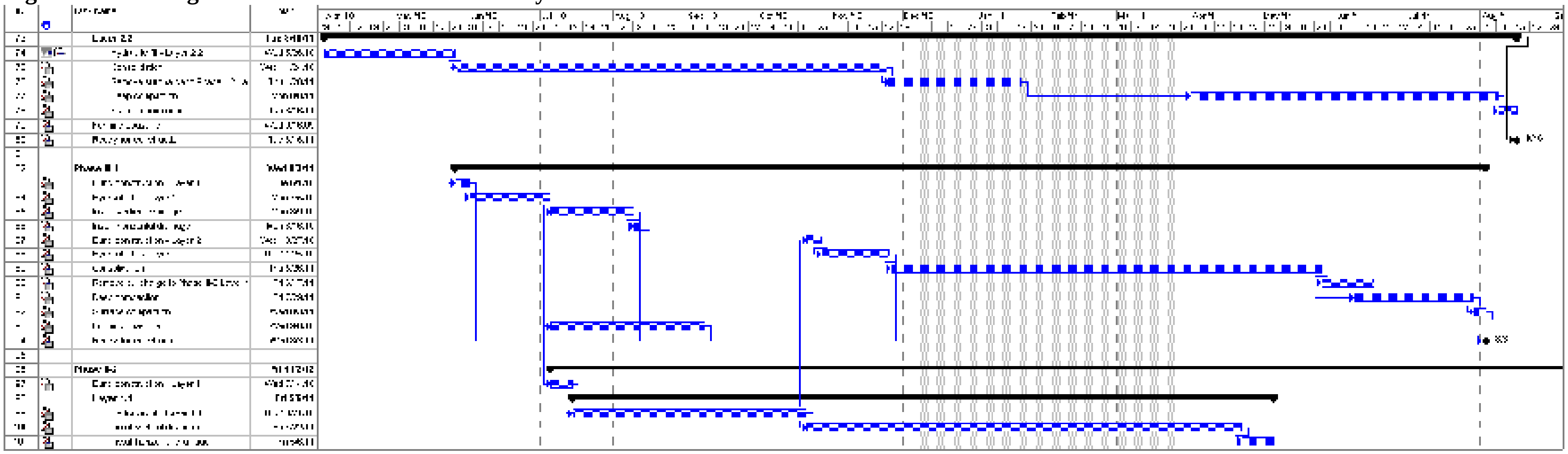
Because the surcharge layer of 2008 can be removed this year, there is an extra sand input for Phase I-8. The surcharge from Phase I-5 is used for the bund and the surcharge from Phase I-6 and I-7 are used for fill up soil for the first layer.

The second layer of Phase II-1 cannot be finished this year; therefore it is divided into two stages, so a part of it has to be done in 2010.

After layer 1 of Phase I-8 is finished the drainage works start, because the reclamation of layer 1 of Phase II-1 takes a lot of time, there are only 4 drain machines needed to finish this job on time. After this period they can work at Phase II-1. In this area more cranes are needed, because it is a large area. Off course the current Phase II-1 could be divided into more sub phases, in that case the drainage works could be started earlier in a part of this Phase II-1. After the first sub phase they can easily move to another sub phase. In this option it might be better to use more cranes in Phase I-8, so they can move on to the next phase earlier.

4.3.3 **2010**

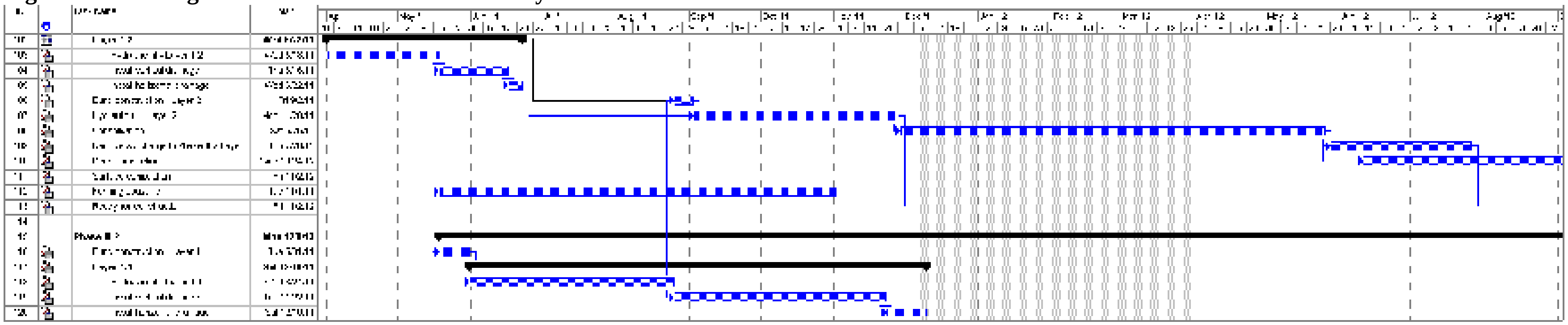
Figure 13 Planning of construction works Vasilievsky Island 2010-2011



This time the surcharge of Phase I-8 is used for the fill of Layer 2.2 (so the second half of the second layer) of Phase II-1. This is also valid for Layer 2.1, which will be reclaimed in 2009.

4.3.4 **2011**

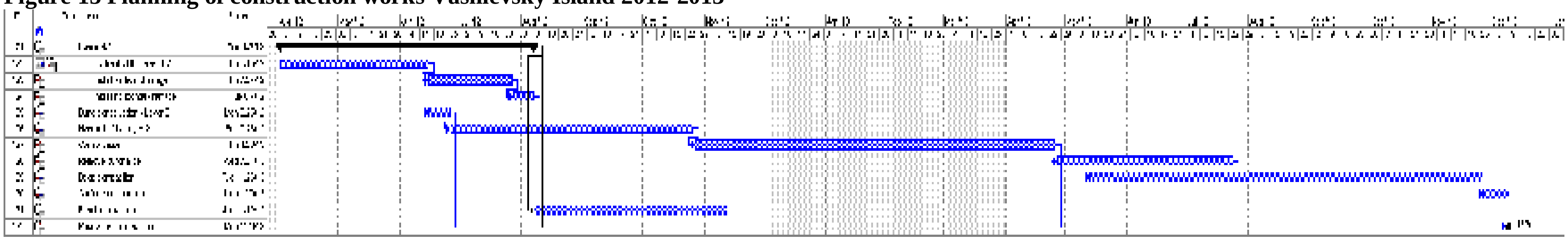
Figure 14 Planning of construction works Vasilievsky Island 2011-2012



In this year the surcharge can be used as well. Chosen is to use the surcharge from Phase I-8 & III-1 for reclamation of Phase III-2. This phase is in a slightly later stage than II-2, but the distance is very short, so less equipment and time is needed.

4.3.5 **2012**

Figure 15 Planning of construction works Vasilievsky Island 2012-2013



The surcharge from Phase II-2 is used to fill layer 1.2 of Phase III-2. At the end there will be surcharge left from Phase III-2. This surcharge might be used more properly, but then the island has to be divided in more sub phases. As can be seen from the picture above the construction works should be finished before the ice period starts in December 2013.

Conclusion

Depending on the definition the client has for the deadline, some parts of the project might not be finished on time. Considering the assumptions that have been made to deliver the sand within the deadlines is however possible. The conclusions made here are based on the assumptions made earlier in this document.

Phase I-5 will not be finished in 2008. The main reason is that the construction cannot start early enough and in the planning a period of 26 weeks (6 months) is present for consolidation which results in a long (too long) total construction period.

This is valid for all phases, the reclamation of the different parts of the island can be done in time, but because of the surcharge the construction period is most times doubled what results in a finish of the construction works most times one year after the phases have been reclaimed.

Furthermore, installing vertical drainage takes a lot of time, more than expected, even with 10 cranes at a time these construction works take too much time. The compaction works cost a lot of time as well. Despite all these long construction periods of the different tasks, the total project can be finished before the deadline that was given by the Client, whether it is just sand delivery or ready for construction works.

The sand delivery seemed to be dominating before the schedule was made, but now is clear that vertical drainage works and deep compaction cost a lot of time. Reducing the material needed or increasing the speed of the equipment have large effects on the schedule. Therefore it is necessary the right unit rates are implemented. For now the production speeds and materials used are very conservative chosen, the schedule made is therefore also conservative.

Something that is not taken into account yet is the exposure time of the bunds to the sea. As some bunds have a rather large exposure time it might be a good idea to protect them. In Table 6 the exposure times of the bunds to the sea can be seen.

Table 6 Exposure times of bunds

Phase	Finish date bund	Finish date Coastline	Exposure time to the sea [months]	Next Phase	Finish date next phase	Exposure time to the sea [months]
Phase I-5	July 2008	August 2008	1	Phase II-2	July 2010	24
Phase I-6	August 2008			Phase II-1	June 2009	10
Phase I-7	September 2008	October 2008	1	Phase I-8	April 2009	7
Phase I-8	April 2009	September 2009	5	Phase III-1	June 2010	14
Phase II-1	June 2009			Phase II-2	July 2010	13
Phase III-1	June 2010	September 2010	3	-		
Phase II-2	July 2010	November 2011	17	-		
Phase III-2	May 2011	December 2012	19	-		

<u>Explanation of Table 6:</u>
Some phases will be constructed on the seaward end and have a (part of the) bund that becomes a coastline. For these bunds the finish dates and exposure times of the sea can be seen in column 3 and 4. As can be seen for some phases (I-5 to II-1) the construction of the next phase is determinant for protection for a part of the bund, this is why the exposure times are rather long. Furthermore it is a good idea to start the construction of the coastline for phase II-2 and III-2 earlier, immediate after the bunds are created. Now the coastline is constructed after layer 1 is totally reclaimed, as these phases are quite large this results in too much exposure time.

Recommendations

The idea was to keep to sand delivery equal during the years, this was a good idea and it is recommended to stick to this idea as it is far more easy and cheaper to arrange an extra crane for compaction or drainage works, a barge or dredger on the other hand can be (very) hard.

Some bunds have a rather large time in where they are exposed to the (threads of the) sea. Perhaps some temporary dams should be built in order to protect these bunds. This construction time is not implemented in the current schedule; it might be a good idea to see what this extra task will do to the schedule, probably it will not or hardly influence the project as it can be done just after the bunds are finished. It might however also be done as the first task, so first creating a temporary coastline and then will the limited area with sand, in this case the first bunds are not needed anymore. These temporary dams have to be removed after the next phase it filled; this has to be taken into account.

It is recommended to reduce the amounts of vertical drains if possible; this will reduce the construction time a lot.

If possible, also try to change the compaction method, or the speed of the equipment. This because deep compaction is also a very large part of the construction works. Reducing the time needed per m^2 will have a large influence on the total time of the project.

Something that is not taken into account but is probably a part of the project is the construction of a quay for the barges and dredgers to moor. A pipeline has to be installed to transport the sand from the quay to the reclamation site. As dredgers have a large navigation depth the area around this quay should be dredged as well as the canal to reach this quay.

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Books

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2. Hinze, J.W. (1998). Construction Planning and Scheduling. New Jersey: Prentice Hall.
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Substantiating documents for designing Vasilievsky Island, written by Witteveen+Bos

5. Deliverable 15.1.1: Formation of a new coastline;
6. Deliverable 15.1.2+3: Justification of land reclamation planning and process flow sheet and determination of reclamation phases and period of work;
7. Deliverable 15.1.4+5: Arrangement of surface water drainage and forecast of ground water level during construction works;
8. Deliverable 15.1.6: Basic reclamation volumes;
9. Deliverable 15.1.7: Determination of amount of settlement for sub-soils and filled-up soils and measures for compaction and consolidation;
10. Deliverable 15.1.8: Development of program for geotechnical monitoring;
11. Deliverable 15.1.9: Environmental protection measures.

Websites

12. http://www.witteveenbos.nl
13. http://office.microsoft.com

Appendix I Making a construction planning

In this chapter background information on how to make a planning is given.

The construction process is a challenging and important activity in the management and building of constructions. The planning is one of the several parts of a construction process and how to make a planning is described in this chapter.

I-1 General

Before it is time to actually start making the planning, it is important to know what the options are for constructing the several parts of the design and which ones will be chosen, this in order to know what the different choices have as effect on the result.

To come to a planning it is essential to follow the next steps:

1. Choose construction method and techniques
2. Define activities
3. Define relations between activities
4. Estimate duration of activities
5. Estimate required resources
6. Estimate duration of total project

The first four steps are more suitable for a global planning, after that fine-tuning can be done by executing step 5+6 to create a detailed planning. To make an optimal planning these steps should be followed according to iteration.

Traditional schematisation can result in controlling the duration of different construction phases, this can be achieved by arranging them and find out which phases should get a priority. Which phases are critical for determining the duration of the project (critical path scheduling) and which for using the equipment in the most efficient way (job shop scheduling). In large and complex projects a combination can be made between these two, resulting in an optimised use of resources to keep the costs as low as possible and to finish the project within the given timeframe.
How much detail is needed depends on the goal of the planning.

I-2 Choose construction method and techniques

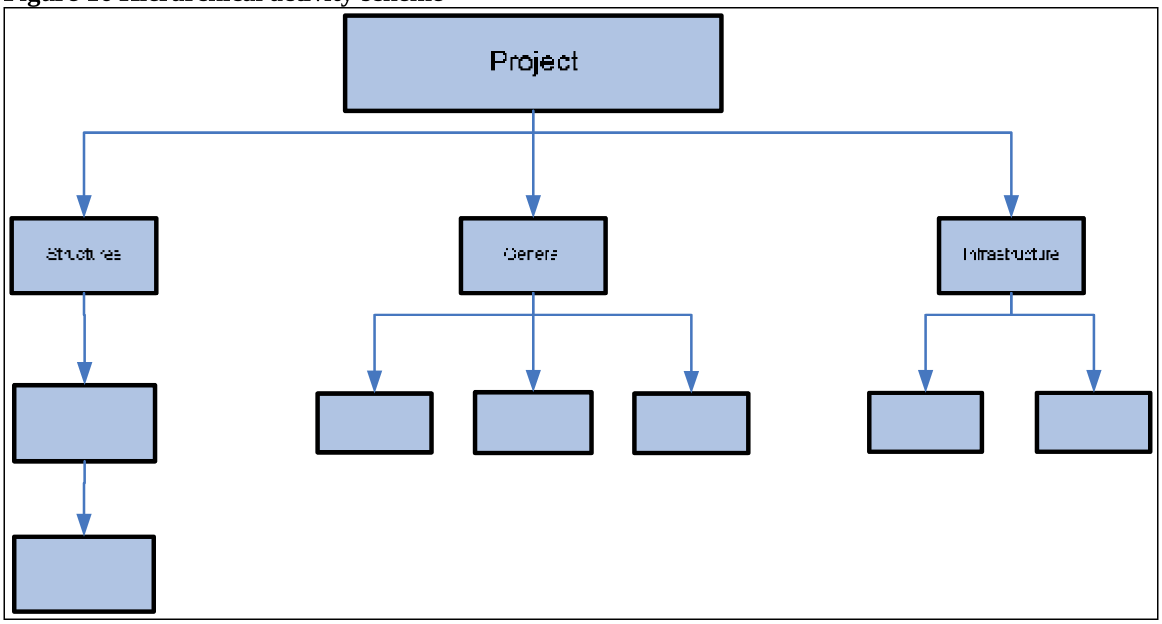
The choices for the construction method and techniques which will be used are the basis for the planning. Choices which are made now will influence the costs and duration of the construction. The different techniques can be reviewed regarding costs, duration and impact on the planning. Off course the different techniques all have their pros and contras and depend on several boundary conditions within the project.

I-3 Define activites

Together with choosing the construction method and techniques, the activities can be defined which have to be accomplished during the project. Each work task gives the amount of work which has to be done to complete the project, this can be used to plan all construction phases. The total project can be divided into diverse activities, all consisting of a certain amount of time, money and resources. First all activities should be determined on a general scale, after that all parts can be viewed more closely and can be planned with more detail. A way to do this is using the hierarchical activity scheme, in which the project first is divided into different main activities and subsequently written down into a smaller scale. For all boxes in the scheme tasks will be worked out.

In Figure 16 an example of this scheme is presented.

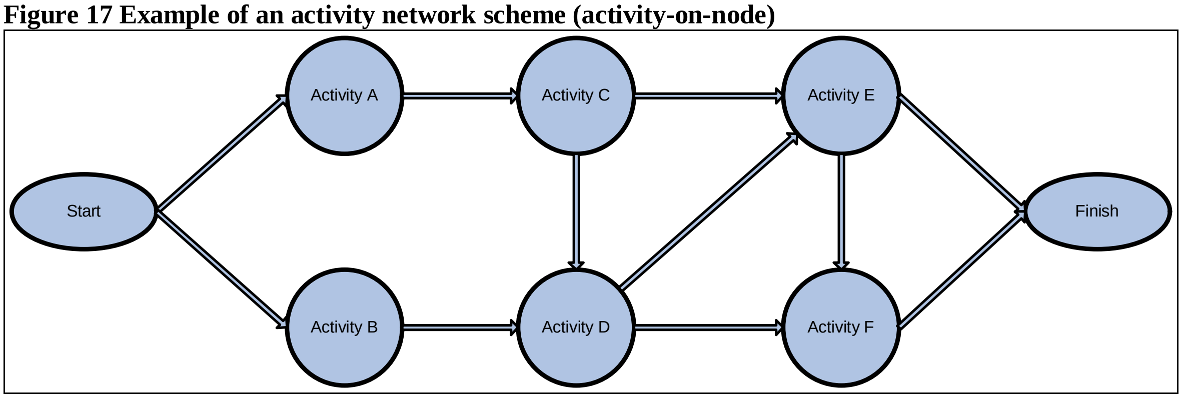
Figure 16 Hierarchical activity scheme



I-4 Define relations between activities

When different activities have been defined, relations between them can be determined. One way to do this is via a network scheme, in which different activities are connected to see the relations between them. An example is given in Figure 17.

Figure 17 Example of an activity network scheme (activity-on-node)



This scheme can be put into a table in which all direct en indirect successors (activities which come before this certain one) and predecessors (activities that come after this certain one) can be seen. In this table it is possible to see which activities have direct influence on other activities and thus which parts will have to be postponed if a direct predecessor has a delay. Table 7 corresponds with Figure 17.

Table 7 Example of direct and indirect predecessors and successors of an activity

Activity	Direct successor	All successors	All predecessors
A	C	D, E, F	-
B	D	E, F	-
C	D, E	F	A
D	E, F	F	A, B, C
E	F	-	A, B, C, D
F			

I-5 Estimate duration of activities

To know what the duration of the project might be, first the duration of all various activities should be determined.

A way to formulate the duration of an activity is to use Equation 1:

Equation 1 Determination of the duration of an activity [1]

$$D_{ij} = \frac{A_{ij}}{P_{ij} \cdot N_{ij}}$$

In this formula the meaning of the parts are as follows:
D_{ij} = the duration of the activity
A_{ij} = the required quantity of work
P_{ij} = the average production of a standard crew in this task
N_{ij} = the number of crews assigned to this task

As can be seen in the formula, it is possible to decrease the duration of the activity by reducing the amount of work (not common), increasing the average production per crew or increasing the number of crews. Normally the quantity of work is determined by the final design. The number of crews can be adjusted to influence the duration; perhaps also some extra fee may be presented to increase the average production. When increasing the amount of crews, the difficulty of smooth construction is increasing. More communication has to be made because of the increasing number of people in charge and working on the site. Furthermore, some project teams might be specific teams for this (part of the) project, therefore more crews might simply not be possible. Special equipment can also be hard to get and it might thus not be possible to accelerate the duration by implementation of more equipment as it is not available.
Something else that has to be taken into account is the weather, it influences the days on which can be worked and thus the amount of time which is available for construction.

It is also possible to consider the variability of the duration of an activity. This can be done via the probability distribution (indication of the chance of duration of an activity) or by choosing the expected (or most likely) duration. Which of these estimates is used depends on who is making the planning, with what purpose and to what detail.

When the normal distribution is used to predict the duration of an activity, two parameters are needed, μ (average duration) and σ (standard deviation of the duration). The standard deviation is used to determine the variance of the distribution. When making a planning for the most likely duration, also historical data is needed, but in this case you just need the average and multiply that by a certain safety factor. The formula for the parameters for the normal distribution is given in Equation 2.

Equation 2 Defining average duration and its variance [1]

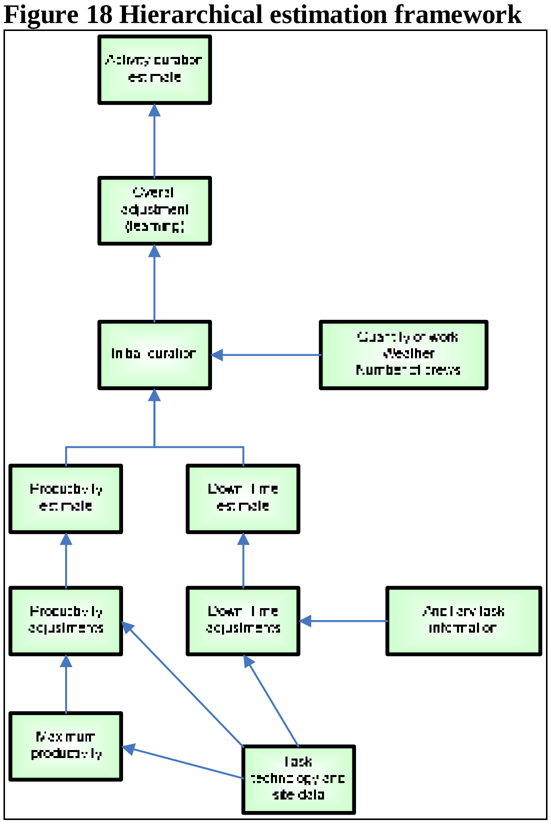
$$m \approx \bar{x} = \sum_{k=1}^{n} \frac{x_k}{n}$$

$$s^2 \approx \sum_{k=1}^{n} \frac{(x_k - \bar{x})^2}{n-1}$$

With: n = number of observations
x = random variable (in this case duration of activities)

To see what the influences are on the duration of an activity, it is wise to put it in a scheme or framework, so it becomes clear what the relations are. An approach to decrease the problem of estimating the duration is the hierarchical estimation framework (Figure 18)[1].

Figure 18 Hierarchical estimation framework



I-6 Estimate required resources

To define the amount of required resources, first the amount of resources per activity should be determined. This can be done using Equation 3.

Equation 3 Typical estimation equation [1]

$$R_{ij}^{k} = D_{ij} N_{ij} U_{ij}^{k}$$

With: D_{ij} = duration of activity ij
N_{ij} = number of standard crews for activity ij
U_{ij}^{k} = amount of resources of type k used per standard crew
R_{ij}^{k} = resources of type k required for activity ij

To define the amount of resources needed, the most important thing to do is to choose what type of technology and equipment is needed and what number of crews is best. This is done in step 1 *Choose construction method and techniques.*
As said before, attaching more crews can result in a faster way of fulfilling the task, but more people also means more communication and a higher density of people on the construction site; this might slow the project down.

I-7 Estimate duration of total project

In the activity scheme (Figure 16) the main activities are shown, if the duration and relation of all these activities are known, it is possible to determine the duration of the total project. This can be done the same as has been done with all activities. All activities are divided into smaller activities and work tasks, these together are the main activities. The main activities combined result in the total project. It is possible to just sum the durations of all activities, but most times several activities can be executed at the same time which reduces the total duration. Furthermore, what has to be kept in mind, it might be that completing a certain activity sooner might not result in a faster completion of the total project.

Appendix II **Performing time calculations**

In planning programs the critical paths can easily be shown, the program calculates it and via a push on the button the critical path is visible. For planners, however, it is good to know how a critical path is calculated. Here an arrow diagram is used, which is different from the activity-on-node diagram. Now the nodes are more or less points in the project and the arrows the activities to reach those points. In an activity-on-node diagram the activities are the nodes and the arrows the way to reach the next activity.

Creating the critical path is done for an imagined project with 17 activities (activity A till activity O). The result is shown in Figure 19 and Figure 20. Looking at the last figure gives the idea of far too many numbers and information, therefore it is not usable for presentations, the first one is. But off course the idea of the second figure is to show how the critical path can be found. Critical means that a delay of a certain activity results in a delay of the total project. The critical path is the path from the first to the last activity in a project in which every activity (or task) has a total float of 0. In Figure 21 and Table 8 the numbers and abbreviations are explained on how to read the arrow diagram (and thus how the critical path is calculated).

Figure 19 Arrow diagram with durations, Early Start and Finish. Critical path is the red line

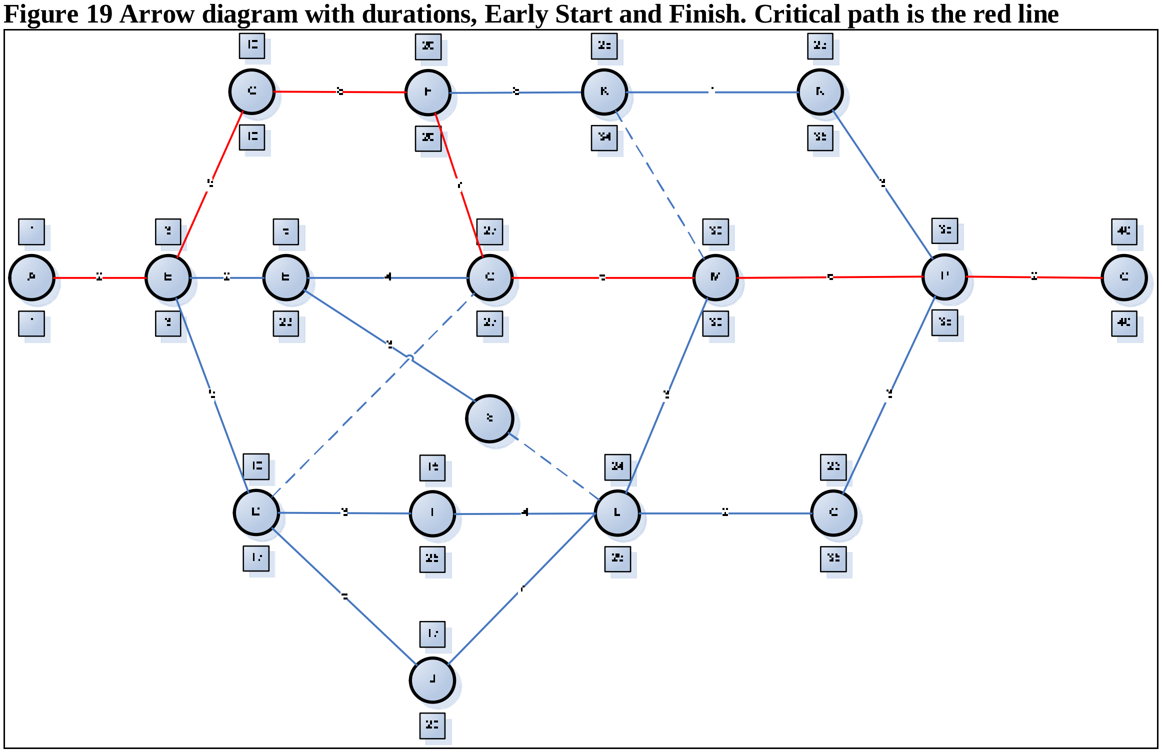


Figure 20 Arrow diagram with time calculations

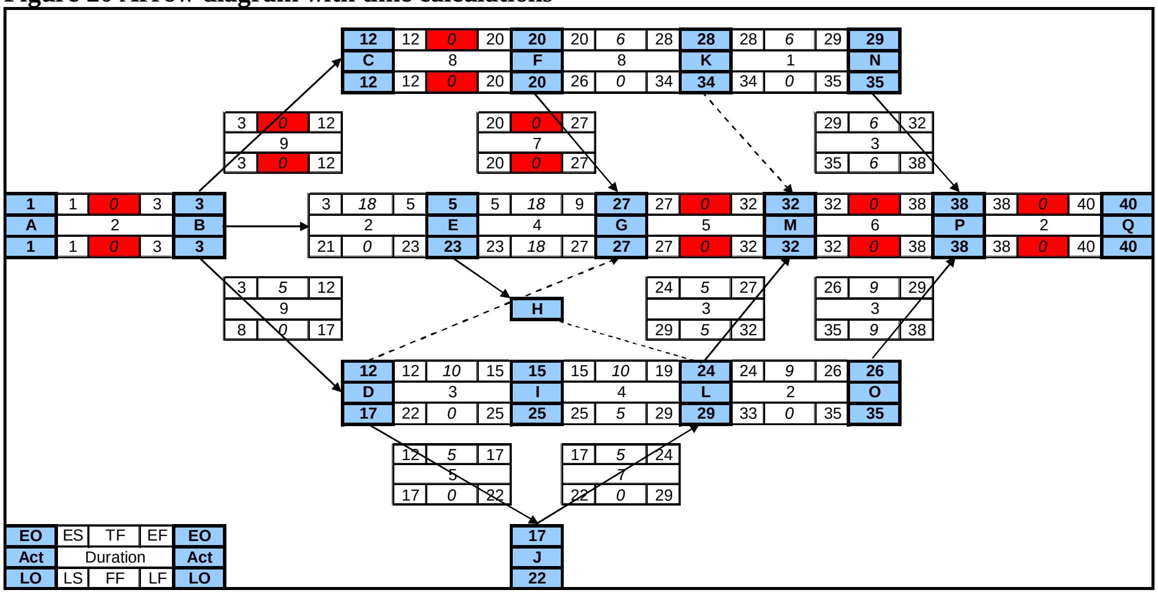


Figure 21 Abbreviations arrow diagram

EO	ES	TF	EF	**EO**
Act	Duration			**Act**
LO	LS	FF	LF	**LO**

Table 8 Abbreviations and explanations of arrow diagram

Abbreviation	Meaning	Remark
Act	Activity	
ES	Early Start	First day possible of starting with activity according to one previous activity.
EF	Early Finish	First day possible of finishing activity. EF (B) = ES (A) + Duration (A-B)
EO	Early Occurrence	First possible day of starting with activity when all previous activities are finished. EO (P) = maximum of EF (N), EF (M) and EF (O)
LO	Late Occurrence	Last possible day of starting with activity when all previous activities are finished. LO (D) = minimum of LS (D-I) and LS (D-J)
LF	Late Finish	Last day possible of finishing activity. LF (B) = LO (B)
LS	Late Start	Last day possible of starting with activity. LS (B) = LF (B) – Duration (A-B)
TF	Total Float	Maximum number of days an activity can be delayed without delaying the project
FF	Free Float	Maximum number of days an activity can be delayed without delaying the ES of a (direct) successor

First the diagram is filled with all durations of the activities, with this the EF and ES can be calculated for each option. If an activity has only one predecessor (previous activity) than the

Early Occurrence is the same as the Early Finish. But when there is more than one predecessor, the latest Early Finish is the Early Occurrence (as all previous activities should all be finished before getting started with this activity). This process is called the forward pass.
Now the same has to be done in the opposite direction, also known as the backward pass. After this the differences can be seen between the Early and Late Starts and Finishes. The difference between the Early Finish and the Early Occurrence is the Free Float. This means the start of this activity can be delayed this number of days without disturbing the Early Start of the next activity. The Total Float is the number of days an activity can be delayed without delaying the total project.

Appendix III Description of the program Microsoft Project

In this part some things are explained how MS Project works. Not the total program is being explained or reviewed; just some interesting parts are highlighted.

Duration

In Microsoft Project the duration is calculated as follows, see Equation 4:

Equation 4 Determination of the duration of an activity [13]

$$D_{uration} = \frac{W_{ork}}{R_{esources}}$$

In this formula the meaning of the parts are as follows:
$D_{uration}$ = the duration of the activity (in a certain time unit, e.g. hours)
W_{ork} = the required quantity of work (in a certain time unit, e.g. hours)
$R_{esources}$ = the number of resources assigned to this task

Resigning multiple types of equipment for the same task

As far as I know there is no option in Microsoft Project where it is possible to implement the amount of sand that has to be replaced per phase. Otherwise all resources could be implemented regarding unit rates (now it has to be calculated in Microsoft Excel).

There is a limitation in Microsoft Project when it comes to doing certain tasks. In this case the resources can handle an average amount of work which has to be defined by the planner. If the amount of work is for example 80 hours, using a normal calendar (with 5 days a week of 8 hours a day) this would take 10 days or two weeks. Assigning more resources (like different types of equipment) will normally decrease the duration (when the amount of work stays the same). So resigning 2 resources will shorten the duration to 5 days or 1 week. But if more than one different kind of equipment (e.g. crane, bulldozer) has to be used, it has to be calculated by the planner. If, for example, for a certain job $1000m^3$ sand has to be removed, which will take about 80 hours, and to do this job you need as well a crane as a bulldozer to do it, the total amount of sand has to be doubled to get the right duration, or (as they both have to work 80 hours to finish it) the calendar has to be changed to work 16 hours per day.

In Table 9 is shown how the different options react to the various types of variables. We want to do a certain job in 2 weeks, it takes 80 hours to finish it, we need a bulldozer and a crane, they both have to work 80 hours to finish the job.

Table 9 Duration of a task and assigning various resources

Resources	*Calendar (hours per day)*	*Hours of work*	*Days*	*Weeks*	*Remark*
1 resource	8	80	10	2	Initial situation
2 resources (crane, bulldozer)	8	80	5	1	Same work, shorter duration, same calendar
2 resources (crane, bulldozer)	8	160	10	2	Same duration, more work, same calendar
2 resources (crane, bulldozer)	4	80	10	2	Same duration, same work, different calendar (resources work half as hard as they can)

What can be seen is that you have to change either the hours of work or the hours of work per day (calendar) to get the same duration.

What is done is to link all resources needed (different kinds of equipment and men) to the resource that works hardest (e.g. the one that can replace the most sand per hour). This is now done in Microsoft Excel, after this the amount of resources is implemented into Microsoft Project. This is shown in Table 10. This way it is visible how much work has to be done, for example replacing 8000 m^3 of sand means 80 hours of work for the barge.

Table 10 Required resources per task

Required resources	Unit rate per hour	Factor relative to hardest worker
Barge	100	1
Crane	40	2,5
Bulldozer	25	4
Man	10	10

If the task has to be done within two weeks, 1 barge is needed for 80 hours, 10 men for 80 hours (or 1 man for 800 hours, but then it is not realistic, because he has to work for 60 hours a day) etcetera. When this is implemented in Microsoft Project the duration can stay the same (choose fixed duration), but the amount of work increases (as the program sums the hours of the men, the barge, the crane and the bulldozer).

Appendix IV Determination and calculation of sand delivery

In this chapter is described how the delivery of the sand is determined and what the delivery amounts per day will be and thus what the length of time will be for a certain construction.

First of all the surface areas and volumes needed for reclamation have been used from deliverable 15.1.2+3 [6]. With this information the real depths per stage have been determined, resulting in amounts of sand per bund and layer. This can be seen in Table 11.

What has been done was to follow the idea of optimised use of equipment and thus a consequent amount of sand to be delivered. The idea in deliverable 15.1.2+3 of the substantiating documents was to deliver every week 150.000 m^3 of sand over the years, taking a work period of 34 weeks a year into account (due to the long ice period). The timing of constructing the several stages can be seen in Table 12. This is a slightly changed scheme than the one in the deliverable, mainly caused by a longer construction period in 2008 (16 instead of 5 weeks).

This delivery scheme results in a deliverance of 30.000 m^3 sand per day. The durations of construction of the different phases are shown in Table 13 in days and in hours, assuming a day will consist of 8 hours.

Table 11 Volumes stages (BL = Bottom Level)

A	B	C	D	E	F	G	H	I	J	K	L	M	N
					=D+E	=F/C	=G-5,3		=(1,5m+H)*C-I				=I+J+K+L+M
Phase	**Deadline**	**Surface area [m2]**	**Total reclamation volume [m3]**	**Volume surcharge [m3]**	**Total volume [m3] (till+5.30m)**	**Total height [m] (till+5.30m)**	**Actual Depth [m]**	**Volume Bund 1 [m3]**	**Volume Layer 1 (BL to +1.50)**	**Volume Bund 2 [m3]**	**Volume Layer 2 excl surcharge (+1.50 to +3.80)**	**Volume Layer 2 (+3.80 to +5.30) (surcharge)**	**Total volume**
Phase I-5	2008	54.000	400.000	100.000	500.000	9,3	4,0	65.000	229.800	49.000	75.200	81.000	500.000
Phase I-6	2009	159.000	1.000.000	250.000	1.250.000	7,9	2,6	103.000	542.800	77.000	288.700	238.500	1.250.000
Phase I-7	2009	99.000	500.000	150.000	650.000	6,6	1,3	158.000	115.800	118.000	109.700	148.500	650.000
Phase I-8	2009	247.000	2.200.000	400.000	2.600.000	10,5	5,2	269.000	1.392.400	202.000	366.100	370.500	2.600.000
Phase II-1	2010	620.000	3.800.000	900.000	4.700.000	7,6	2,3	214.000	2.130.000	160.000	1.266.000	930.000	4.700.000
Phase III-1	2010	195.000	1.300.000	300.000	1.600.000	8,2	2,9	121.000	738.000	91.000	357.500	292.500	1.600.000
Phase II-2	2011	521.000	4.500.000	800.000	5.300.000	10,2	4,9	209.000	3.111.200	156.000	1.042.300	781.500	5.300.000
Phase III-2	2012	753.000	6.300.000	1.100.000	7.400.000	9,8	4,5	264.000	4.274.600	198.000	1.533.900	1.129.500	7.400.000
Total		*2.648.000*	*20.000.000*	*4.000.000*	*24.000.000*			*1.403.000*	*12.540.000*	*1.060.000*	*5.040.000*	*3.980.000*	*24.000.000*

Table 12 Volumes per stage and production per year (optimized scheme)

Phase	year	Volume Bund 1 [m3]	Volume Layer 1 (BL to +1.50)	Volume Bund 2 [m3]	Volume Layer 2 excl surcharge (+1.50 to +3.80)	Volume Layer 2 (+3.80 to +5.30) (surcharge)	Subtotal volume	Surcharge reuse	Total volume	weeks	production /week	total production
Phase I-5	2008	65.000	229.800	49.000	75.200	81.000	500.000			16	150.000	2.400.000
Phase I-6		103.000	542.800	77.000	288.700	238.500	1.250.000					
Phase I-7		158.000	115.800	118.000	109.700	148.500	650.000	-	2.400.000			
Phase I-8	2009	269.000	1.392.400	202.000	366.100	370.500	2.600.000					
Phase II-1		214.000	2.130.000	160.000	278.400	185.600	2.968.000	468.000	5.100.000	34	150.000	5.100.000
Phase II-1	2010	-	-	-	987.600	744.400	1.732.000					
Phase III-1		121.000	738.000	91.000	357.500	292.500	1.600.000					
Phase II-2		209.000	2.115.100	-	-	-	2.324.100	556.100	5.100.000	34	150.000	5.100.000
Phase II-2	2011	-	996.100	156.000	1.042.300	781.500	2.975.900			34	150.000	5.100.000
Phase III-2		264.000	2.897.000		-	-	3.161.000	1.036.900	5.100.000			
Phase III-2	2012	-	1.377.600	198.000	1.533.900	1.129.500	4.239.000	781.500	3.457.500	23	150.000	3.457.500
Total		*1.403.000*	*12.535.000*	*1.051.000*	*5.040.000*	*3.972.000*	*24.000.000*	*2.842.500*	*21.157.500*			*21.157.500*

Table 13 Volumes and required delivery time per stage (assuming 150.000 m3 sand per week, working period of 5 days a week and 8 hours a day)

Phase	Volume Bund 1 [m3]	Days	Hours	Volume Layer 1 (BL to +1.50)	Days	Hours	Volume Bund 2 [m3]	Days	Hours	Volume Layer 2 (+1.50 to +5.30)	Days	Hours	Subtotal volume	Days	Hours
Phase I-5	65.000	3	17	229.800	8	61	49.000	2	13	156.200	6	42	500.000	17	133
Phase I-6	103.000	4	27	542.800	19	145	77.000	3	21	527.200	18	141	1.250.000	42	333
Phase I-7	158.000	6	42	115.800	4	31	118.000	4	31	258.200	9	69	650.000	22	173
Phase I-8	269.000	9	72	1.392.400	47	371	202.000	7	54	736.600	25	196	2.600.000	87	693
Phase II-1	214.000	8	57	2.130.000	71	568	160.000	6	43	2.196.000	74	586	4.700.000	157	1.253
Phase III-1	121.000	5	32	738.000	25	197	91.000	4	24	650.000	22	173	1.600.000	54	427
Phase II-2	209.000	7	56	3.111.200	104	830	156.000	6	42	1.823.800	61	486	5.300.000	177	1.413
Phase III-2	264.000	9	70	4.274.600	143	1.140	198.000	7	53	2.663.400	89	710	7.400.000	247	1.973
Total	*1.403.000*			*12.535.000*			*1.051.000*			*9.012.000*			*24.000.000*		